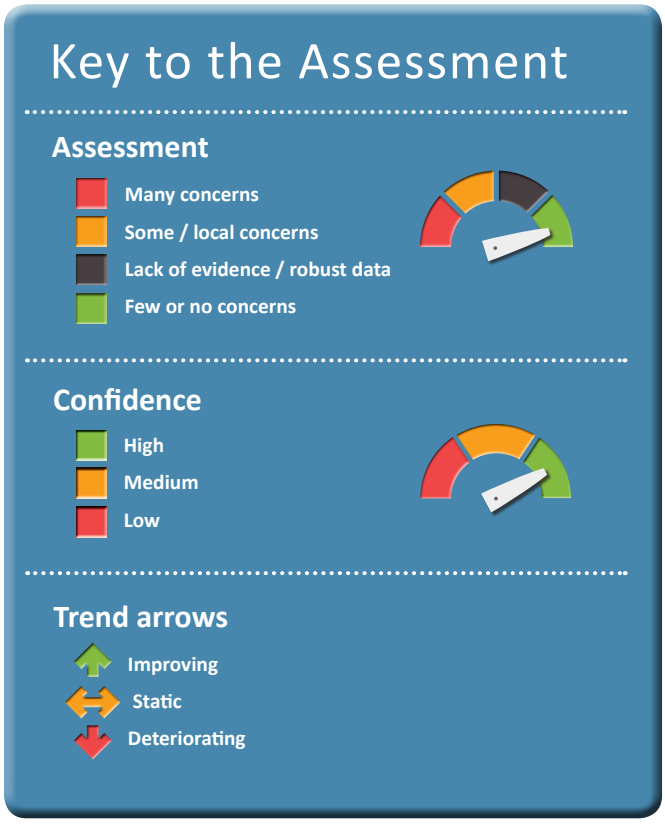
Clyde Marine Region Assessment 2017



Clyde Marine Planning Partnership

Identifying issues relevant to regional marine planning

Turn over this flap to use the key as you read.



Assessment

Confidence

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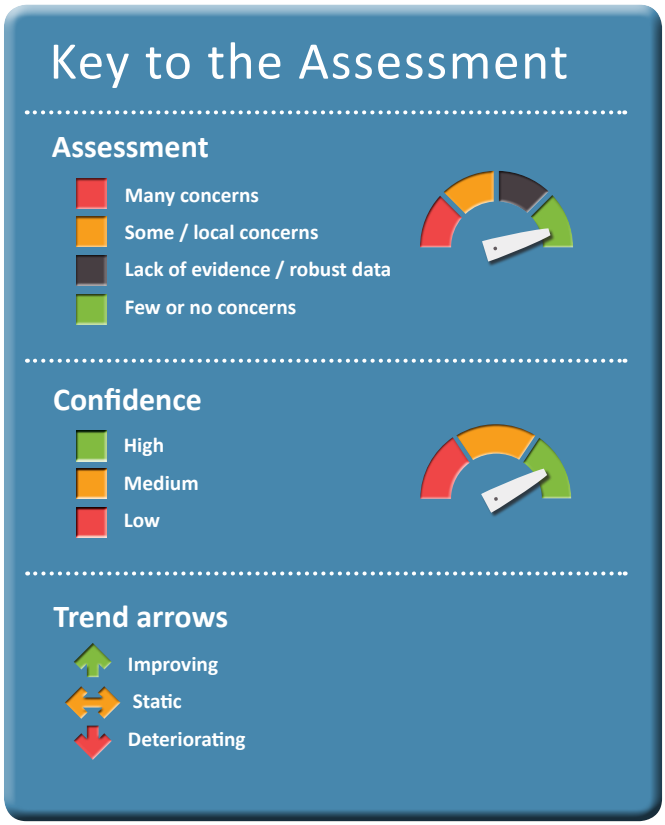
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The Clyde Marine Planning Partnership would like to thank all those who were involved in developing this Assessment and in particular the following people: Martyn Cox, Anna Donald and Drew Milne from Marine Scotland, Matt Gubbins from Marine Scotland Science, Dr. Chris Leakey and other Coastal and Marine Ecosystem Unit staff from Scottish Natural Heritage, Morgane Westley from Scottish Environment Protection Agency, Chris Kelly from Ekos, members of the Clyde2020 Research Advisory Group (see section 1.4) and attendees of the MASTS review workshop – Lucy Greenhill and Dr. Paul Tett from the Scottish Association for Marine Science; Dr. David Green, Dr. Tavis Potts, Dr. Jacqueline Tweddle from the University of Aberdeen and Dr. Tim Stojanovic from the University of St. Andrews.

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Foreword

I am delighted to present to you this Assessment of the Clyde Marine Region, which is a significant milestone in the process of developing a Regional Marine Plan.

The Clyde is a diverse, vibrant and beautiful place, but it is under pressure from increasing demands from more and more users of its seas and coastline. Better, and more informed planning and management is now essential to realise its full potential, and Scottish Ministers have given responsibility to the newly established Clyde Marine Planning Partnership to develop this Regional Marine Plan.

In line with the Marine (Scotland) Act 2010, the Partnership staff have developed the Assessment with the support of data and insight from many different organisations, including government agencies, members of the Partnership and community groups active in the Clyde. It has also been through a rigorous review process involving expert advice.

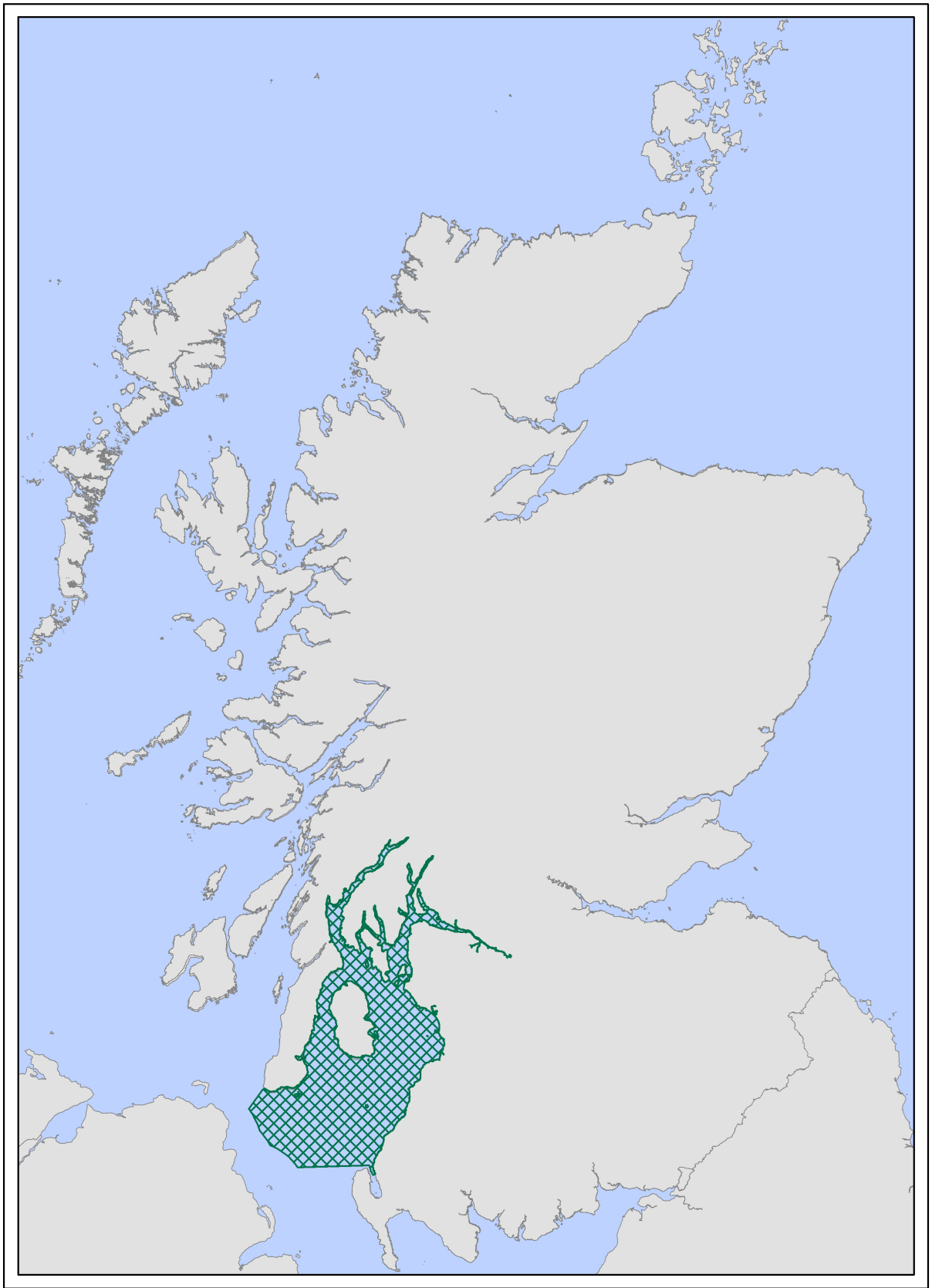
Thanks to this, the resulting Assessment is an up-to-date and comprehensive review of environmental, social and economic trends and issues at the Clyde Marine Region level. It provides us with a baseline from which to measure progress and identifies issues which need to be addressed in the region and which may be suitable for policy within the Regional Marine Plan.

I would like to thank all who have been engaged so far with this process, and, in particular, thank the three members of the Partnership staff who have developed and written this Assessment. It is an invaluable first step towards the Regional Marine Plan for the Clyde.

Isabel Glasgow

Chair of the Clyde Marine Planning Partnership

Map 1. Location of the Clyde Marine Region within Scotland



NOT FOR NAVIGATION. Created by Scottish Government (Marine Scotland) 2015. © Crown Copyright, All rights reserved. OceanWise License No. EK001-201404001. Ordnance Survey License No. 100024655. Projection: Transverse Mercator. Scale 1:1,980,193

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Abbreviations and acronyms

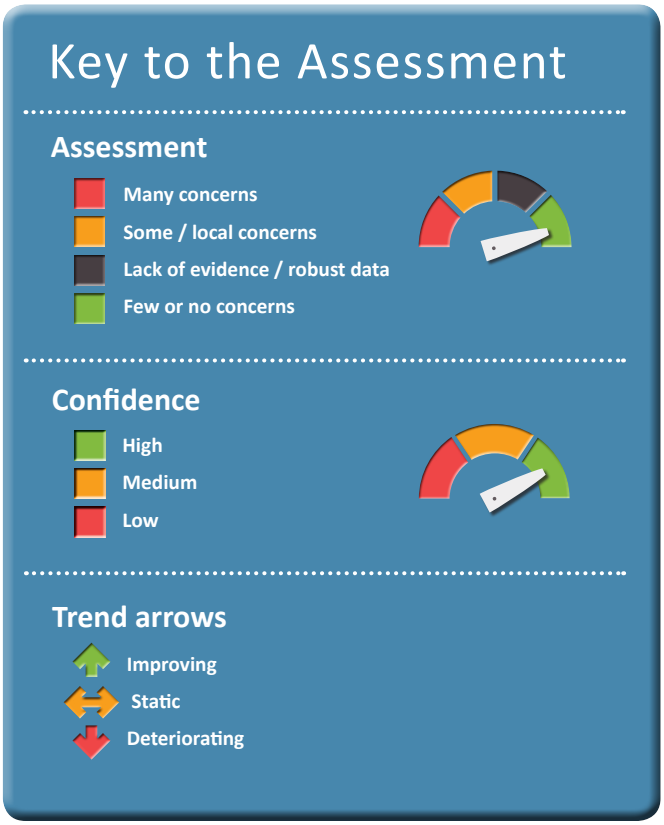
AAG	Area Advisory Group
ABBF	Argyll and Bute Beach Forum
ABS	Annual Business Survey
ACOPS	Advisory Committee on Protection of the Sea
AFRC	Advanced Forming Research Centre
AHA	Associated Harvesting Area
BTO	British Trust for Ornithology
CAR	Controlled Activities Regulations
CAS	Census Area Statistics
CFA	Clyde Fisherman's Association
CFP	EU Common Fisheries Policy
CMAL	Caledonian Maritime Assets Ltd
CMMP	Clyde Marine Mammal Project
CMR	Clyde Marine Region
COAST	Community of Arran Seabed Trust
CPR	Counter Pollution and Response
CPUE	catch per unit effort
CSEMP	UK Clean Seas Environment Monitoring Programme
CSHA	Classified Shellfish Harvesting Areas
DM	Defence Munitions
EEZ	Exclusive Economic Zone
EFF	European Fisheries Fund
EcP	Ecological Potential
EROD	7-Ethoxyresorufin-O-deethylase
EU	European Union
F	Fishing Mortality
FFL	Fishing for Litter
FMSY	Maximum Rate of Fishing Mortality
FSC	Field Studies Council
FSS	Food Standards Scotland
GBR	General binding regulations
GBBG	Great Black-Backed Gull
GDP	Gross Domestic Product
GEcP	Good Ecological Potential (under WFD)
GEcS	Good Ecological Status (under WFD)
GES	Good Environmental Status (under MSFD)
GRAB	Trust - Group for Recycling in Argyll and Bute
GRT	Gross Register Tonnage
GVA	Gross Value Added
HE/FE	Higher and Further Education
HMNB	Her Majesty's Naval Base
HMWB	Heavily Modified Water Body
HWDT	Hebridean Whale and Dolphin Trust
ICES	International Council for the Exploration of the Seas
IMO	International Maritime Organization
INNS	Invasive Non-Native Species
IPCC	Intergovernmental Panel on Climate Change
ISLES	Irish-Scottish Links on Energy Study
IUCN	International Union for the Conservation of Nature
JAMP	Joint Assessment and Monitoring Programme
JNCC	Joint Nature Conservation Committee
LBBG	Lesser Black Backed Gull
LCA	Length Cohort Analysis
MAIB	Marine Accidents Investigation Branch
MASTS	Marine Alliance for Science and Technology Scotland
MCA	Maritime & Coastguard Agency
MCA	Maritime and Coastguard Agency
MCCIP	Marine Climate Change Impacts Partnership
MCS	Marine Conservation Society
MoD	Ministry of Defence
MPA	Marine Protected Area
MRCC	Maritime Rescue Co-ordination Centre
MSFD	Marine Strategy Framework Directive
MSS	Marine Scotland Science
MSY	Maximum Sustainable Yield
NAG	National Advisory Group
NCN	National Cycle Network
NGO	Non-governmental organisation
NM	Nautical Mile
NMPi	National Marine Plan interactive
NNS	Non-native species
NPF3	National Planning Framework
N-RIP	National Renewables Infrastructure Plan
ORE	Offshore Renewable Energy
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAH	Polycystic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ethers
PCB/CB	Polychloronated biphenyl hydrocarbons
PMF	Priority Marine Feature
POP	Persistent Organic Pollutant
Ramsar	Convention of the international treaty for the conservation and sustainable use of wetlands
RBMP	River Basement Management Plan
RET	Road Equivalent Tariff
RMP	Representative monitoring Point
RO-RO	Roll on – Roll off
RSPB	Royal Society for the Protection of Birds
RYA	Royal Yacht Association
SAC	Special Areas of Conservation
SAIC	Scottish Aquaculture Innovation Centre
SAMS	Scottish Association for Marine Science
SCU	Salvage Control Unit
SEPA	Scottish Environment Protection Agency
SFC	Scottish Funding Council
SIC	Standard Industrial Classification
SMP	Seabird Monitoring Programme
SMRTS	Scottish Marine Recreation and Tourism Study
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SPRI	Scottish Pollutant Release Inventory
SPT	Strathclyde Partnership for Transport
SRC	Shoreline Response Centre
SRD	Sewage Related Debris
SSACN	Scottish Sea Angling Conservation Network
SSB	spawning stock biomass
SSPO	Scottish Salmon Producers Organisation
SSSI	Site of Special Scientific Interest
SSTP	Scottish Shark Tagging Programme
SWPA	Shellfish Water Protected Areas
TAC	Total Allowable Catch
TBT	Tri-butyl Tin
THI	Townscape Heritage Initiatives
UKCP	UK Climate Projections
UKPCZ	United Kingdom Pollution Control Zone
UNEP	United Nations Environment Programme
UWTV	Underwater TV survey
UWWT	Urban Waste Water Treatment
WCRIFG	West Coast Regional Inshore Fisheries Group
WeBS	Wetlands Bird survey
WFD	Water Framework Directive
Wider CMR	Sectoral data based at planning authority level
WWT	waste water treatment

Opposite: Tarbert harbour © CLAIRE PESCOD

1. Assessment Summary

1.1 Summary – Physical, Clean and Safe, Healthy and Biologically Diverse

SECTION	CHAPTER	ASSESSMENT	CONFIDENCE
Physical	Climate change – impact on marine life	Concerns for the future / Many unknowns	Low/medium
	Climate change – sea level rise	↓	High
	Seabed and coastal geology and sediments	Not Applicable	Not Applicable
	Coastal change	Not Applicable	Not Applicable
	Water circulation	Not Applicable	Not Applicable
	Landscape – Seascape	Not Applicable	Not Applicable
Clean and safe	Water Framework Directive – transitional and coastal waters	↑	High
	Hazardous substances including biological effects	↔ Clyde estuary, Inner Firth, Holy Loch, Garroch Head / ↑ Other lochs and outer Firth	High
	Microbiological contamination – Shellfish water protected areas	↔	High
	Microbiological contamination – Bathing waters	↑	High
	Eutrophication	↑	High
	Oil and chemical spills and accidents	↑	High
	Dissolved oxygen	↑ Inner Clyde Estuary / ↔ Rest of CMR	High
	Marine litter	↓	Low/medium
	Noise	↔	Low
Healthy and biologically diverse	Habitats – Intertidal rock and sediments	↓	High
	Habitats – Sub-tidal rock	↔ Sub-tidal rock / ↓ Biogenic reefs	Medium
	Habitats – Shallow and shelf subtidal sediments	↔	Medium
	Marine fish (demersal and pelagic) and shellfish	↔	Medium
	Sharks, skates and rays	↑ Basking sharks / ↓ All other elasmobranchs	Medium
	Whales, dolphins and porpoises	↔	Low
	Seals	↑	High
	Seabirds and water birds	↓ Seabirds – some species / ↓ Water birds – some species	High
	Protected areas – nature conservation	↔ Others / ↓ Seabirds	High
	Marine non-native species	↓	Medium



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Trends

The coloured arrows indicate whether the overall trend is improving, deteriorating, or static.

Any variation in scoring to the Marine Atlas Clyde assessment is indicated and explained at the start of each chapter where relevant.

1.2 Summary – Productive

This summary should be treated with caution. There are differences in base years and comparison periods. Also some figures are strictly Clyde Marine Region, whilst others are only available at the Wider region which includes all activity in Argyll and Bute (a large portion of which is not part of the Clyde Marine Region). It should also be noted that some industries, whilst perhaps smaller, are particularly important to rural communities.

Sport, Recreation and Tourism figures include wider tourism activity, not just marine activity. To provide context it is estimated that between 10 % and 50 % can be attributed directly or indirectly to marine activity. It should be noted that almost £1bn of the £2bn turnover is attributed to the Glasgow local authority area – most likely from service sector activities such as restaurants and accommodation providers, and therefore unlikely to be directly attributable to marine activity.

Note that data are not available for the following chapters: Historic environment and cultural heritage (included within Sport, recreation and tourism); Energy, subsea cables and pipelines; Wastewater treatment and industrial outfalls; Water abstraction; and Marine management, education, research and development.

It should be noted that any Forward Look in the Productive section does not take into account any of the implications of the UK leaving the European Union.

Sea Fisheries

INDICATOR	VALUE 2013/14	% OF SCOTLAND	CHANGE 2010-14
WIDER CLYDE MARINE REGION			
Employment (nos.)	600	16%	+24%
Turnover*	£36.2m	11%	+14%
GVA*	£13.2m	12%	-18%
CLYDE MARINE REGION			
Tonnage	5,742	9%	-12%
Value of landings	£14.8m	10.5%	+12%
Effort (kW days)	23,500	–	+6%

*2009 – 2013 and adjusted to 2013 prices

Aquaculture

INDICATOR		VALUE 2013/14	% OF SCOTLAND	CHANGE 2010-14
WIDER CLYDE MARINE REGION				
Employment (nos.)		160	8%	-16%
Turnover*		£30.1m	11%	+21%
GVA*		£11.5m	10%	+51%
CLYDE MARINE REGION				
Tonnage	Mussels	300	4%	0%#
	Oysters and Scallops	500,000 shells	13%	-75%
	Salmon	11,000	8%	+40%
Value – Salmon		£45m	–	+44%*

* based on combined two year figures due to two year cycles in salmon harvesting. 2009 – 2013 and adjusted to 2013 prices.
# using 2005 as a base year as 2010 was a peak year that skews the assessment.

Processing – Fisheries and Aquaculture

INDICATOR	VALUE 2013/14	% OF SCOTLAND	CHANGE 2010-14
WIDER CLYDE MARINE REGION			
Turnover*	£175.7m	11%	+46%
GVA*	£40.1	10%	+48%
CLYDE MARINE REGION			
Employment (nos.)	440	5%	+60%

*2009 – 2013 and adjusted to 2013 prices

Sport, Recreation and Tourism

INDICATOR	VALUE 2013/14	% OF SCOTLAND	CHANGE 2010-14
WIDER CLYDE MARINE REGION			
Turnover*	£2bn	30%	-19%
GVA*	£1bn	29%	+0.3%
CLYDE MARINE REGION			
Employment (nos.)	35,150	18%	+7%

*2009 – 2013 and adjusted to 2013 prices

Defence

INDICATOR	VALUE 2015	% OF SCOTLAND	CHANGE 2010-14
WIDER CLYDE MARINE REGION			
Employment (nos.)	4,970	Not known	-9%

Shipping and transport

INDICATOR	VALUE 2013/14	% OF SCOTLAND	CHANGE 2010-14
WIDER CLYDE MARINE REGION			
Employment (nos.)	4,750	32%	-10%
Turnover*	£1.08bn	35%	-17%
GVA*	£314m	27%	-23%
CLYDE MARINE REGION			
Freight tonnage	16,300	24%	+23%
Freight ship calls	3,485	18%	+41%
Cruise ship passengers (2012 to 2015)	110,000 (2015)	25%	+66%
Ferry passengers*#	4.1m	-	-12%
Ferry cars*#	1m	-	-11%

*2009 – 2013 and adjusted to 2013 prices
Decline in passenger numbers driven by significant decline and change of service on subsidised Gourock to Dunoon route

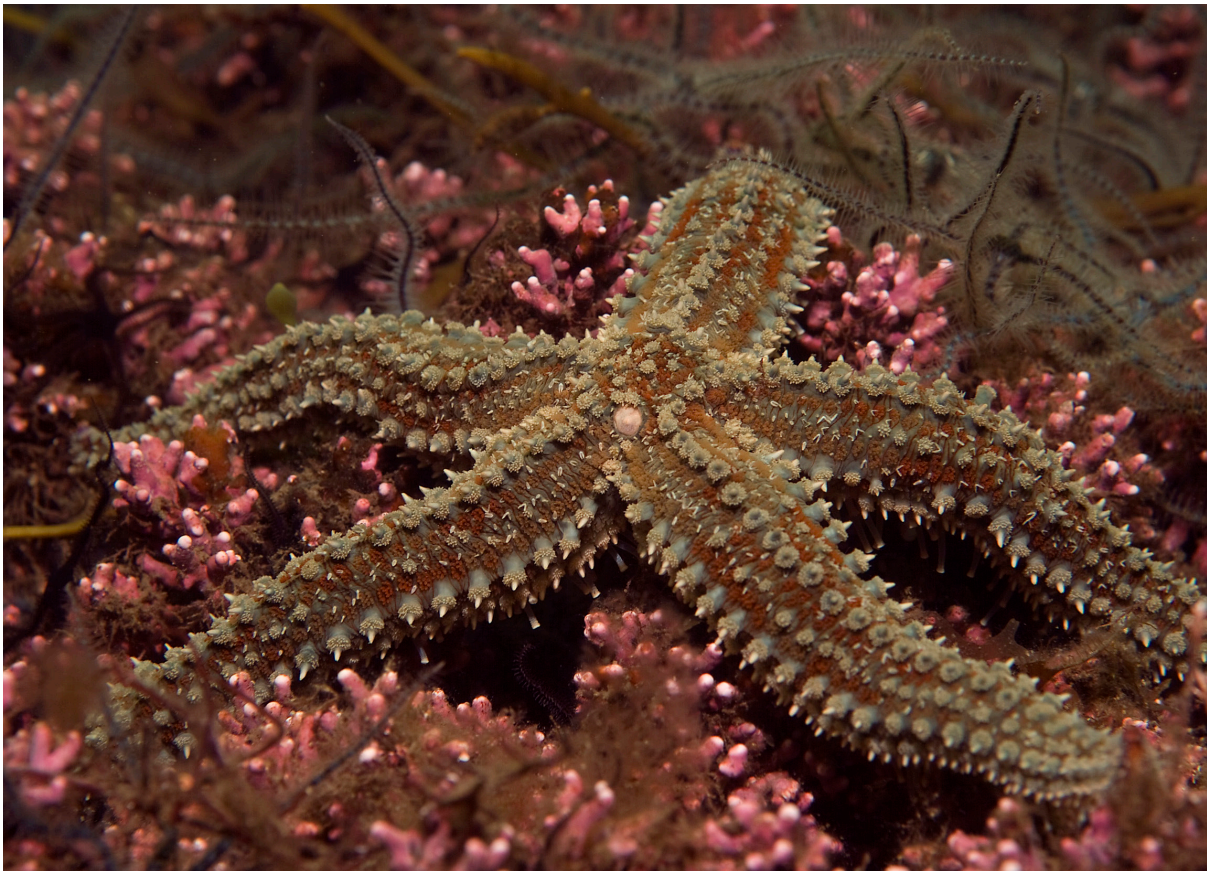
1.3 Summary – Ecosystem Services

An ecosystem is a community of interacting living organisms and their physical environment. Ecosystem Services provide benefits to people from the ecological functions of healthy ecosystems. The UK National Ecosystem Assessment defines them as 'the benefits provided by ecosystems that contribute to making human life both possible and worth living'. The services are further divided into the four descriptors shown below.[1]

In order to follow the Ecosystem Approach, the marine plan should consider the functioning of Ecosystem Services in their region. For each chapter of the Physical, Clean & Safe and Healthy & Biologically Diverse sections, wherever relevant, a table has been included to capture relevant Ecosystem Services for that chapter and any known issues with their functioning. Not all types of ecosystem service are relevant for every chapter and therefore some chapters only address e.g. Cultural Services. The state of provision of Ecosystem Services within the Clyde Marine Region (CMR) is given in the table on page 8. For more information on Ecosystem Services see Appendix I.

Ecosystem Services

ROLE	SERVICES
Provisioning	Products obtained from ecosystems. For example food provision (wild and farmed fish, shellfish), fish feed, algae, ornamental materials, water storage and provision, fertiliser and biofuels, medicines and biotechnology.
Regulating	Benefits obtained from the regulation of ecosystem processes. For example biological control, natural hazard regulation and protection, waste breakdown and detoxification, carbon sequestration, climate regulation.
Cultural	Non-material benefits. Recreation, tourism, aesthetic, education and research, spiritual and cultural.
Supporting	Services necessary for the production of all other ecosystem services. For example primary production, larval and gamete supply, nutrient cycling, water cycling, formation of: species-habitat, physical barriers, seascape.

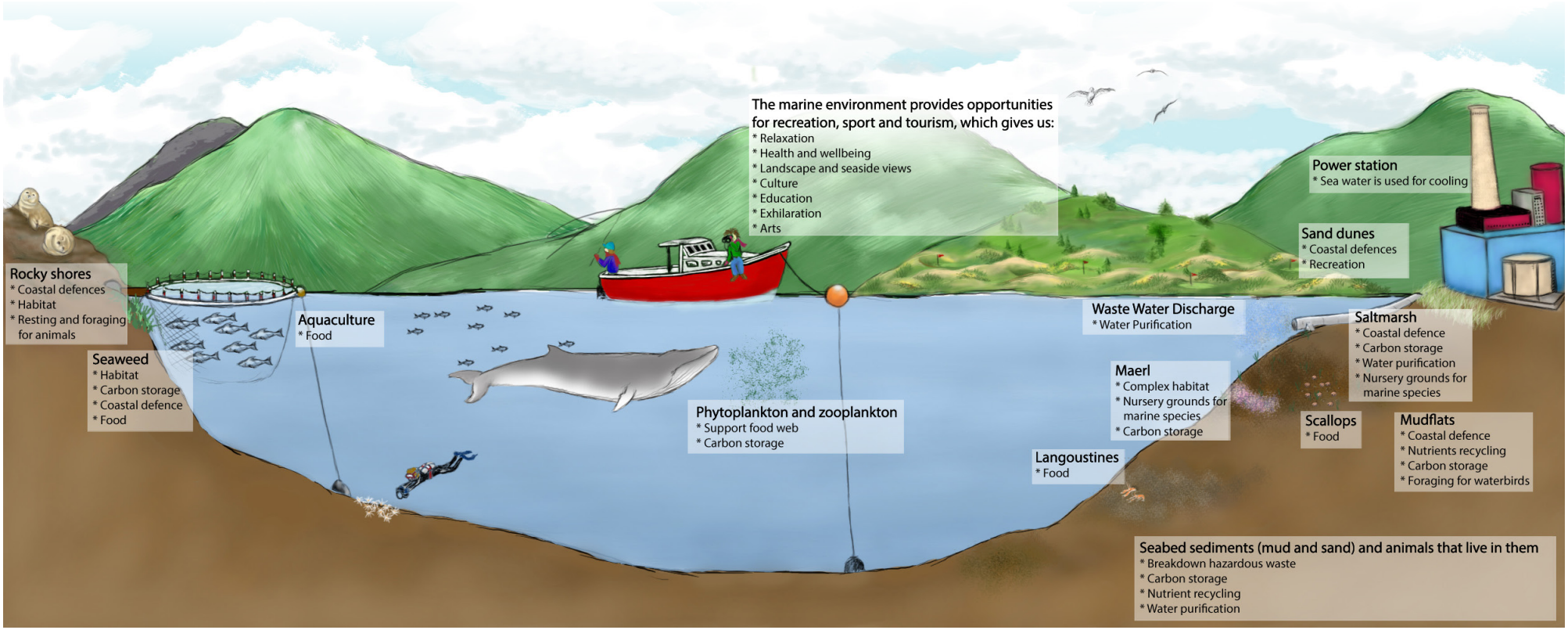


Spiny starfish on a maerl bed © GRAHAM SAUNDERS, MARINE SCOTLAND

1. Adapted from the conceptual framework of the UK NEA, 2011.

Aspects of the Clyde Marine Region and Associated Ecosystem Services

This diagram illustrates elements of the marine ecosystem and the goods and services they provide



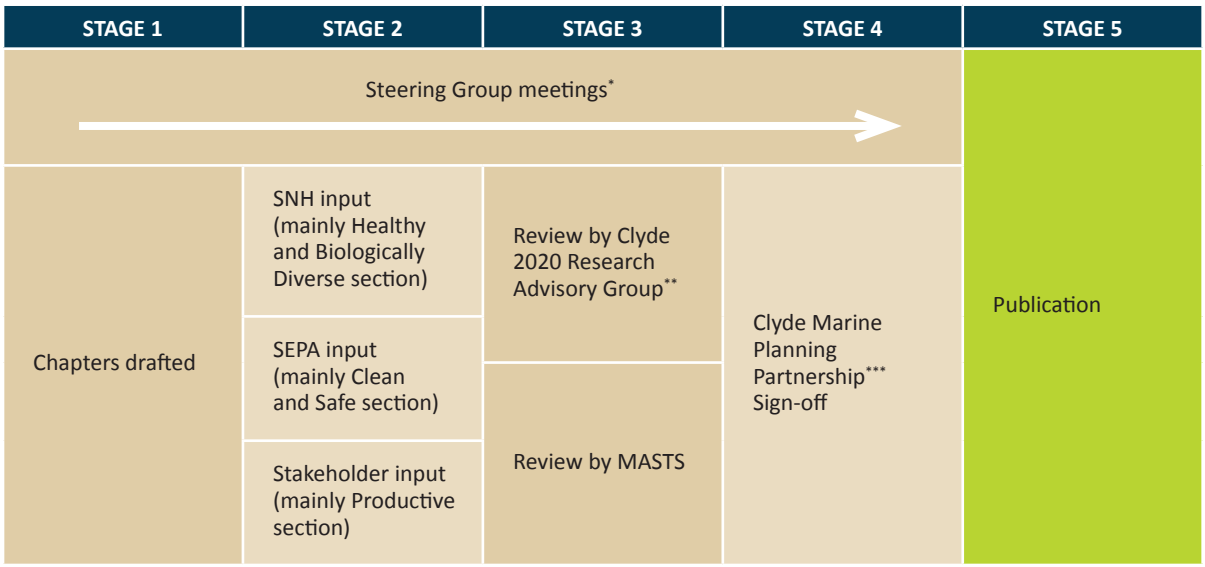
© DR L MCWHINNIE

Ecosystem Services Overview Assessment of the Clyde Marine Region

ROLE	SERVICES
Provisioning	• There is concern over richness and evenness of demersal and pelagic fish species that have previously been targeted by commercial fisheries. There is no demersal and pelagic fishery due to depletion of fish stocks. The impact of this on the wider ecosystem and food webs is not fully understood. • There is a sustainably managed *Nephrops* fishery, largely for export markets. • There are concerns over the sustainability of the scallop fishery due to lack of official stock assessment and management. • There are concerns over micro plastic ingestion by species (incl. *Nephrops*) limiting growth and resistance to disease. This is not an issue exclusive to the Clyde. • Contamination by hazardous substances in the Clyde estuary and inner Firth limits consumption of filter feeders, e.g. mussels. Classified Shellfish Harvesting Areas occur in the inner and outer Firth and the lochs – some are A/B which means treatment is required due to E.coli being too high for direct human consumption (although there are currently no CSHAs where harvesting is not permitted). • Levels of PCBs in biota (plaice) are at unacceptably high levels in several parts of the Clyde Marine Region. • Climate change will impact which species of fish, shellfish and algae will be available to both wild fisheries and aquaculture operations. • The Landings Obligation may lead to an increase in supply to fish feed (from quota species below Minimum Conservation Reference Size).
Regulating	• The Clyde estuary coast has been morphologically altered due to the construction of quay walls, industrial, residential and transport infrastructure developments. This limits the ability of the natural coastline (saltmarsh, mudflats, sand dunes) to protect coastal areas from storm damage and to adapt to sea level rise. Some areas exist that may be suitable for managed realignment. • The decreasing extent of saltmarsh impacts the provision of waste breakdown, wave energy reduction, protection against erosion and carbon sequestration. • The ecosystem can provide waste breakdown and detoxification services up to a point, however, sensitive areas (e.g. lochs) or areas with legacy of contamination such as the Clyde estuary and Inner Firth can become overloaded. • There are declining trends in numbers of key apex predators (e.g. cetaceans, sharks, skates, rays and seabirds) which may both impact the healthy functioning of the ecosystem and act as an indicator that other ecosystem services are compromised. • Whilst non-native species are on the rise, there is no evidence of detrimental impact on ecosystem services as yet; however, this may be due to a lack of research into this area.
Cultural	• The CMR is unique in the Scottish coast in terms of the amount and expanse of sea broadly contained by the mainland. There is a complexity and variety of seascapes which, coupled with industry and coastal development have contributed to the natural and cultural landscape much appreciated by locals and visitors to the CMR. • The seascape and landscape character of the CMR has aesthetic properties that have inspired a wealth of literature and art and form part of the cultural heritage. • Generally there has been improvement over the last 5 years in the water quality of bathing waters, although diffuse pollution and combined sewer overflows at certain points in Ayrshire exceed the capacity of plants and micro-organisms to assimilate, buffer or process faecal contaminants. This prevents effective waste processing and water purification services. • Marine litter is an increasing problem on the shoreline and can have an impact on ecosystem services. It can lead to a loss of amenity for local residents and detrimentally impact tourism and recreation activities. Careful planning of development should provide increased opportunities for tourism, recreation, education and research in the coastal zone. • Concerns over declining trends in numbers of key apex predators (e.g. cetaceans, sharks, skates, rays and seabirds) may impact the wildlife tourism sector, as has happened to the sea angling sector.
Supporting	• In general, supporting services are functioning: primary production occurs which sustains secondary zooplankton production (which in turn feeds an active food web). • The condition of phytoplankton has been of concern in Loch Long and Loch Goil. This is probably caused by diffuse pollution, combined with the long flushing time for these enclosed lochs. Recent monitoring shows a general improvement. • Climate change is the greatest unknown in terms of likely impact on the type, amount, location and timing of phytoplankton and zooplankton production. • Historic input and persistence of hazardous substances in sediments may impact the ability of the sediment to provide full nutrient cycling services at particular parts of the CMR, in particular the Clyde estuary, Garroch Head and Holy Loch. • Water bodies in the south Bute to east of Arran corridor have highlighted concerns until very recently over the condition of benthic invertebrates which provide nutrient cycling services. • Complex habitat, such as maerl beds and reef forming species are in decline which may compromise the ability of the environment to supply habitat (including nursery habitat) for species and may inhibit recovery of fish stocks. Some vulnerable subtidal sediments have been impacted by fishing activities. • Levels of oxygen within the inner and outer Clyde estuary are improving. The inner Clyde is now reaching levels which will support most ecological processes.

1.4 Process

This chart shows the process followed to develop this Assessment.



*Marine Scotland, SNH, SEPA, MASTS, JNCC, Shetland and Clyde MPP staff.

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Royal Society for the Protection of Birds,
Royal Yachting Association Scotland,
Scottish Canals,
Scottish Coastal Forum,
Scottish Environment LINK,
Scottish Natural Heritage,
Scottish Sea Anglers Conservation Network,
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The Scottish Salmon Company,
Visit Scotland,
West Coast Regional Inshore Fisheries Group.

Where possible, the CMPP has endeavoured to utilise knowledge co-produced from community and volunteer groups within the assessment. Examples of where this has been done are as follows: information provided from the Clyde Marine Mammal Project; volunteers from local bird groups contributed to data within the seabirds and waterbirds chapter; information from local marine litter groups; and inputs from the Community of Arran Seabed Trust.

The report of the review by MASTS is available at www.masts.ac.uk/research/research-forums/marine-planning-governance-forum/.

Many maps in this Assessment are sourced from National Marine Plan interactive (NMPi).[2] www.gov.scot/Topics/marine/seamanagement/nmpihome, which is an interactive tool designed to assist in the development of national and regional marine planning.

2. Marine Scotland, 2016a



Emergency services on the Clyde © PETER SANDGROUND

2. General Overview

2.1 Physical characteristics

The Firth of Clyde has a coastline of over 1,200km and includes eight sea lochs, five estuaries and numerous islands including Arran, Bute and the Cumbraes.[3] The diverse nature of the area largely results from its underlying geology and the subsequent effects of glaciation during the last ice age. The Firth is bisected by the Highland Boundary Fault; the southern part is relatively un-indented and low in relief whilst the coastline in the northern part is more resistant to erosion, resulting in a more indented and dramatic landscape.

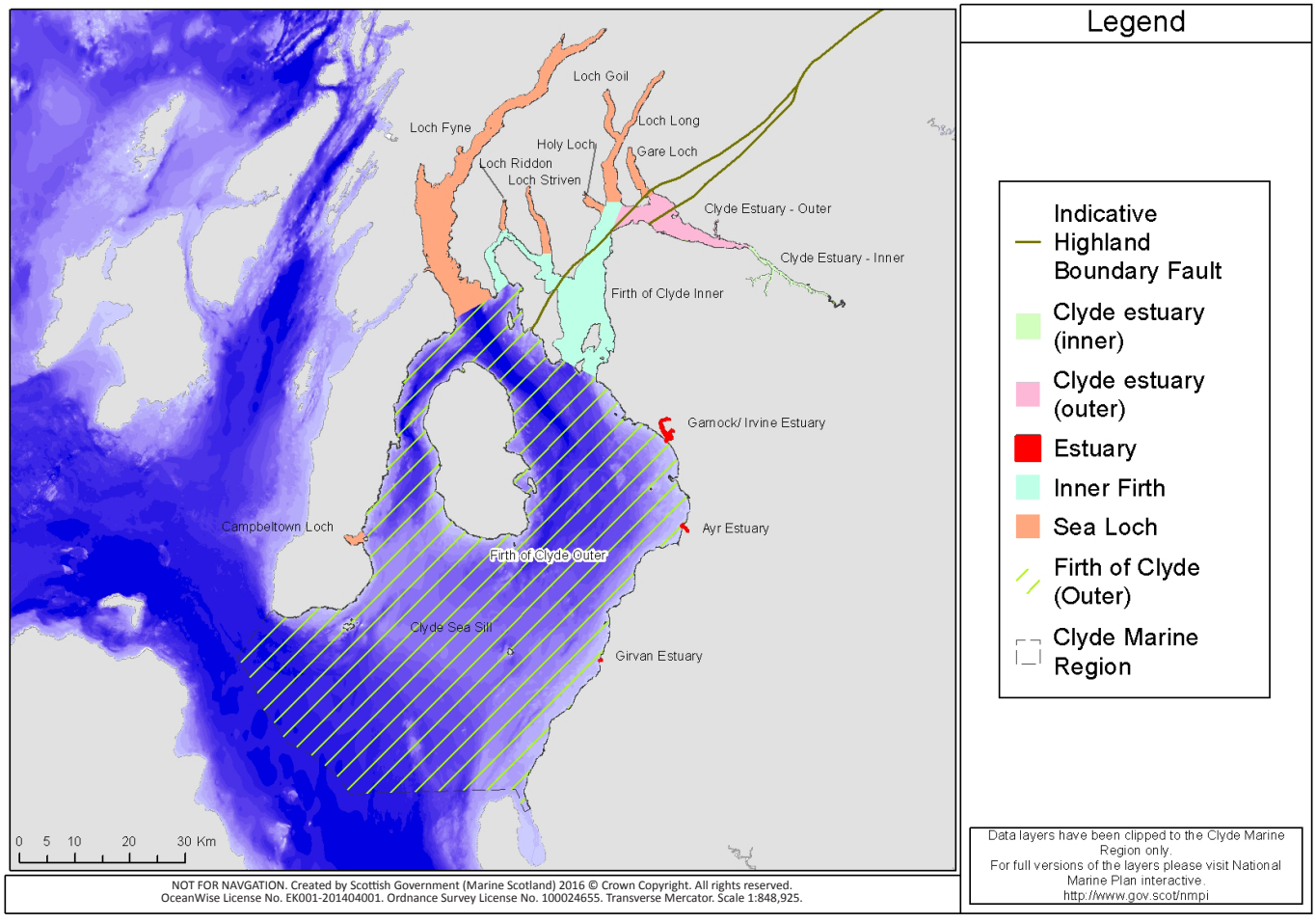
The sea lochs branch from the northern and western shores of the Firth into the mountains of Argyll and Dunbartonshire. Several of them are fjordic in nature being long, narrow and deep with shallow sills at their mouths. The steep-sided profile of the land above the water continues below the water.

Figure 2.1 Gourock



© PETER SANDGROUND

Map 2. Clyde Marine Region indicating Highland Boundary Fault zone, sea lochs, estuaries, inner and outer Firth, and Clyde Sea Sill.



NOT FOR NAVGATION. Created by Scottish Government (Marine Scotland) 2016 © Crown Copyright. All rights reserved.
OceanWise License No. EK001-201404001. Ordnance Survey License No. 100024655. Transverse Mercator. Scale 1:848,925.

3. As measured at 1:50,000 scale using Mean High Water mark (OS meridian coastline) and including all the islands.

Figure 2.2 Loch Long



© PETER SANDGROUND

Estuaries lie on the southern and eastern side of the Firth. The largest of these is the Clyde estuary which has been heavily modified by humans over the last 250 years. Other estuaries along the Ayrshire coast are at Garnock/Irvine, Ayr, Girvan and Stinchar.

Within the outer Firth, sand dunes exist in the low lying bays around Irvine, Troon and Ayr and there are extensive shingle shores which include present shores as well as raised shores deposited at the end of the last glaciation.

Glacial action has created a broad underwater sill with an average depth of 40-50m which divides the North Channel from the Arran Basin, known as the Clyde Sea Sill.[4] This area has been designated a Nature Conservation Marine Protected Area (NCMPA) for, amongst other things, its marine geomorphology and fronts (see Appendix I).

The sheltering effect of the Kintyre peninsula and Arran, coupled with deep waters and a moderate tidal range, leads to a seabed dominated by mud (see chapter 3.3 Seabed geology and sediments). The area does, however, contain a range of habitats with long sandy stretches along the Ayrshire coast and hard ground along the edge of the deep channels in the North Channel and Loch Fyne. There are also rocky shores and sandy bays in the sea lochs.[4]

The inner Firth, around the islands of the Cumbraes and Bute, is a sheltered area with a relatively small tidal range and speed. The outer Firth is more exposed but remains reasonably sheltered due to the protection provided by Northern Ireland and Kintyre from the prevailing south-westerly winds. Water circulation is weak, with the direction of movement dictated by the wind when it exceeds 14 knots. Under conditions of gentler winds, the water circulation is a weak northwards movement as part of the general circulation of the Firth.[5]

The climate is temperate and tends to be very changeable, but not normally extreme. It is warmed by the 'North Atlantic Deep Water' ocean current and is therefore warmer than areas on similar latitudes in other parts of the world. The sea surface temperature varies from 4°C in winter to 18°C in summer and lags behind the atmospheric temperature by around 1°C per month[6] – more detail can be found at National Marine Plan interactive (NMPi).[7]

Figure 2.3 Troon beach



© PETER SANDGROUND

Figure 2.4 Isle of Arran



© PETER SANDGROUND

Figure 2.5 Kames Bay, Isle of Cumbrae



© DYLAN TODD, SNH

4. McIntyre *et al.*, 2012
5. Ross *et al.*, 2009
6. Baxter *et al.*, 2011
7. Marine Scotland, 2016a

2.2 Environmental characteristics

Scotland's seas, positioned between sub-polar and subtropical influences, are among the most biologically productive in the world. The CMR plays its part and supports a rich and varied marine and coastal wildlife. Beneath the waves a variety of shallow water habitats exist including maerl beds, seagrass and flame shell beds where many other species can find shelter and protection.

The deeper mud habitats of the Clyde support many burrowing creatures including the shellfish 'nephrops', the current mainstay of the Clyde fishing industry. During the summer months the upwelling of nutrients provides rich feeding for larger mobile species; sightings of minke whale and basking shark are regular. The Clyde contains three Nature Conservation Marine Protected Areas (nMPAs); the Clyde Sea Sill, South Arran and Upper Loch Fyne and Loch Goil (see Chapter 5.9 Protected areas). These have been designated for a range of features including flame shell and horse mussel beds, maerl and seagrass beds, seabed muds and gravels containing various burrowing species including the spectacular fireworks anemone.

The Clyde is important as one of the most northerly west coast estuaries used by migrating birds. The intertidal muds regularly support a wintering population of 20,000 waterfowl in the inner estuary, including internationally important numbers of overwintering redshank. For these reasons the Inner Clyde Estuary has been notified as a Special Protection Area (SPA) under the EC Wild Birds Directive. The birds of the estuary feed on the eelgrass, mussel beds, and on the abundant invertebrate fauna of the intertidal mudflats, sandflats and saltmarsh.

Other important wildlife sites within the CMR include Ailsa Craig SPA designated for its gannet population, and a number of Sites of Special Scientific Interest (SSSIs) around the coast, and on the islands of Arran, Bute and Great Cumbrae (see Appendix II).

Figure 2.6 Inner Clyde Estuary SPA



© CMPP

Figure 2.7 Clydeport Finnieston, Date uncertain



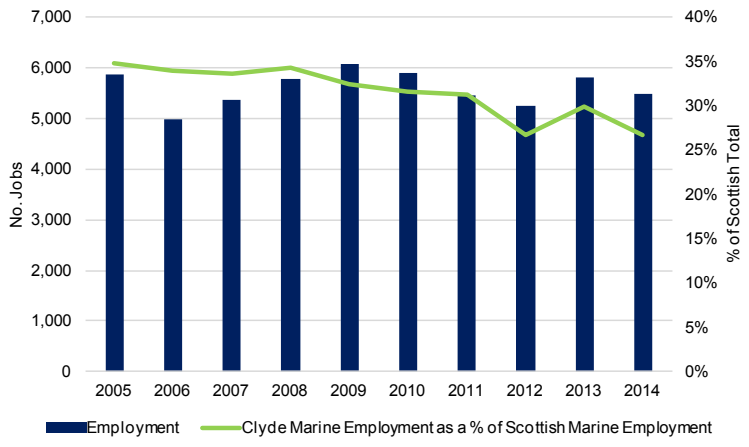
© PEEL PORTS CLYDEPORT

Phytoplankton are microscopic organisms which live in the water column and form the basis of marine food webs. Phytoplankton has been routinely monitored at Millport from 2005-2013. Diatoms follow a distinct seasonal cycle, increasing sharply in March. Densities decrease over the summer and the 'autumn diatom bloom' common in other areas is absent at this site. In spring, the community is dominated by Skeletonema marinoi. Dinoflagellates also have a distinct seasonal cycle, typical of other areas, with a high density in summer. Some phytoplankton such as *Pseudo-nitzschia, Dinophysis* and *Alexandrium* produce toxins which can be responsible for shellfish poisoning (see Chapter 4.3 Microbial contamination – Shellfish Water Protected Areas on how this is regulated in seafood). These were present at Millport mainly in low numbers and populations tend to peak over the summer months. *Pseudo-nitzschia* numbers increase over spring, however, this did not happen at Millport and overall numbers were less than at other monitoring sites outside the region.[8]

Industry has undoubtedly had a major impact on the condition of the CMR's environment since the Industrial Revolution. The River Clyde has long been central to the economy of this part of Scotland. Dredging of the Clyde's naturally shallow waters allowed the movement of commercial traffic up into Glasgow City centre. These ship movements facilitated the industrial boom associated with the Clyde from the 18th Century onwards. While both traditional heavy industries and associated contaminant input have declined in recent years, there is a post-industrial legacy of metals, oils and sewage contamination; changes to the depth and shape of the river also remain. The sediments, water column and biota remain affected, as illustrated in more detail in Section 4 Clean and Safe.

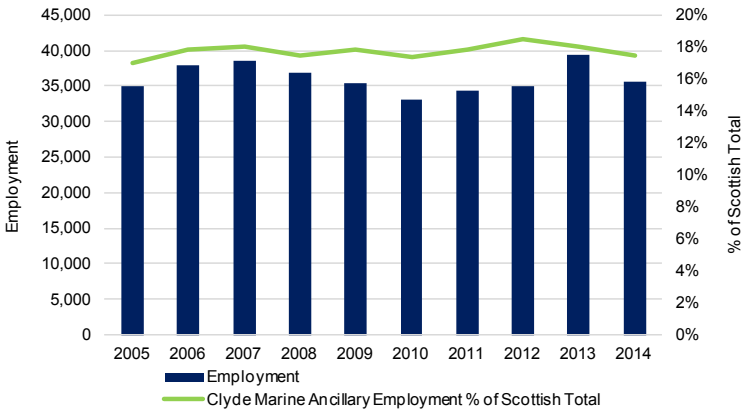
8. Brensan *et al*., 2016

Figure 2.8 Clyde Marine Region: Core Sector Employment, 2005–2014



Source: Business Register and Employment Survey & Annual Business Survey

Figure 2.9 Clyde Marine Region: Ancillary Sector Employment, 2005–2014



Source: Business Register and Employment Survey & Annual Business Survey

Commercial fisheries have been active in the Clyde for centuries. The herring fishery was active from the early 1830s and various fisheries have been active over time. Recent research into 19th century data from the UK Fishery Board indicates that traditional fishing techniques had already begun to impact inshore fish stocks on the west coast by the mid-1850s.[9] From the 1960s onwards, there were substantial landings of, in particular, cod, haddock and whiting. This has led to a changed ecosystem, where demersal fish stocks are now dominated by small whiting.[10] Trawling and dredging can also disturb the physical environment.

Further detail of all of the current pressures and impacts on the marine environment of the CMR are included in Section 6 – Productive – Economic contribution, Pressures and Impacts.

2.3. Productive economic overview

This section presents the economic overview (where data allows) of the marine sector in the CMR, with changes across economic indicators presented in table 2.1. This is based on the core marine sectors of shipping and transport, sea fisheries and aquaculture, and the ancillary marine sectors of fisheries and aquaculture fish processing, and sport recreation and tourism.

Across the core marine sectors there has been a decline in employment across the CMR over the last five years; this has been subject to some fluctuation over this period, as shown in figure 2.7.

Economic activity in the ancillary sectors is driven by the Sport, Recreation and Tourism sector and employment grew steadily from 2010 to 2013, however, has since suffered a decline post 2013.

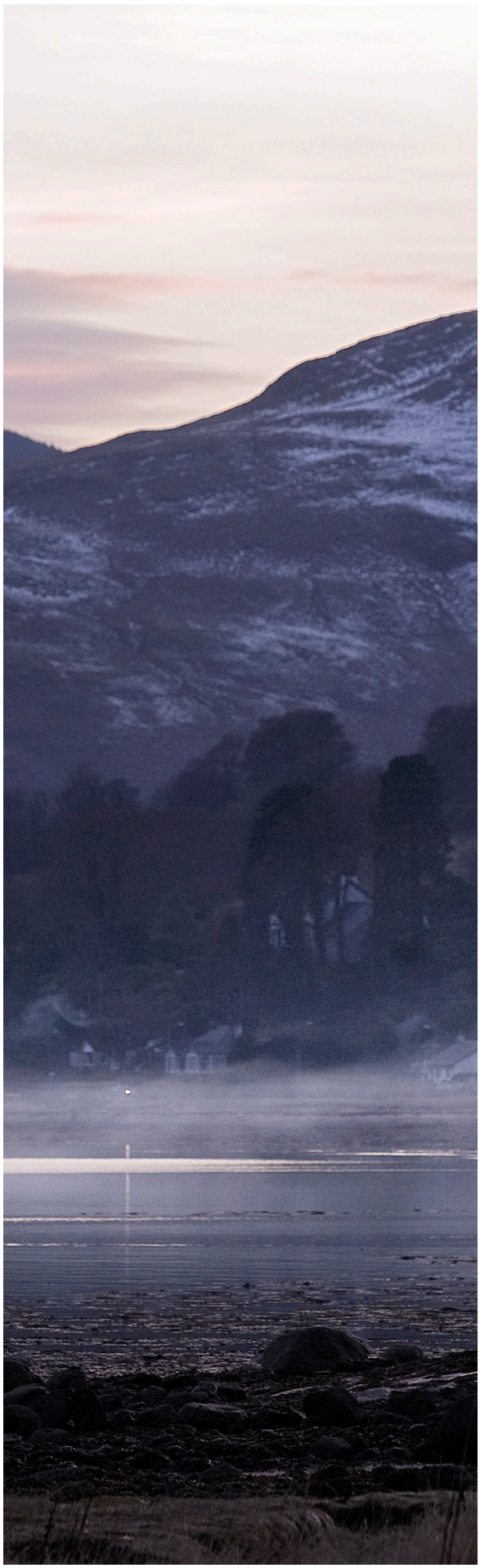
Table 2.1 Overview of the Economic Contribution of the Clyde Marine Region, 2010–2014

	EMPLOYMENT		TURNOVER		GVA	
	TOTAL	% CHANGE	TOTAL	% CHANGE	TOTAL	% CHANGE
CORE MARINE SECTOR ACTIVITY						
Sea Fisheries	600	+24%	£36.2	+14%	£13.2	-18%
Aquaculture	200	-16%	£30.1	+21%	£11.5	+51%
Shipping and Transport	4,700	-10%	£1,076.3	-17%	£314.4	-23%
Total economic contribution	**5,500**	**-4%**	**£1,142.6**	**-2%**	**£339.1**	**-9%**
ANCILLARY MARINE ACTIVITY						
Processing – Fisheries and Aquaculture	400	+60%	£175.7	+46%	£40.1	+48%
Sport, Recreation, and Tourism	35,200	+7%	£1,974.3	-19%	£1,007.0	+0.3%
Total economic contribution	**35,600**	**+7%**	**£2,150.0**	**-16%**	**£1,047.1**	**+2%**

Notes:
1. employment data are reported at the Clyde Marine Region and turnover and GVA are reported at the wider Clyde Marine Region (see Chapter 6.1 for geographic definition and map)
2. % change is considered over the period 2010 - 2014 for employment and 2009 – 2013 for GVA and turnover (based on latest available data)
3. GVA and turnover have been uprated to 2013 prices using the GDP Deflator
Source: Business Register, Employment Survey & Annual Business Survey, Scottish Government Key Sector Stats

9. Jones *et al.*, 2015
10. McIntyre *et al.*, 2012

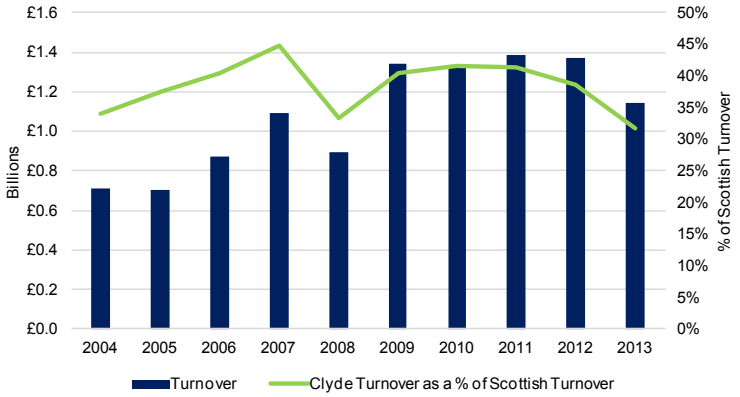
Figure 2.10 Arran



© SNH

Total turnover from core sector marine activities has been on an overall upwards trend, levelling out from 2009 onwards, although with a decline in 2013 from the previous year (figure 2.11).

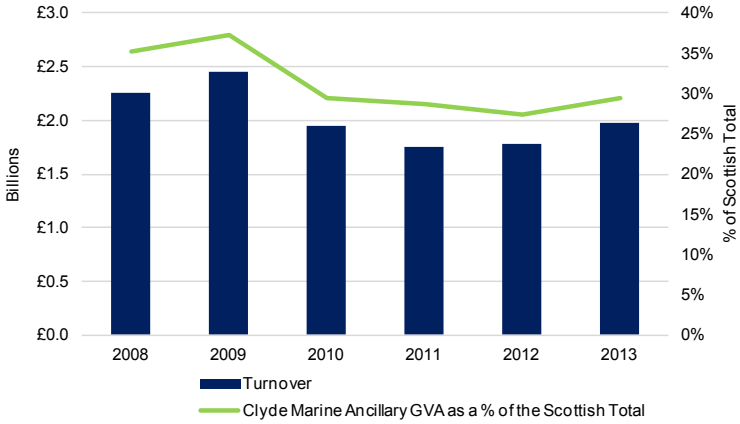
Figure 2.11 Wider Clyde Marine Region: Core Sector Turnover



Source: Annual Business Survey. Adjusted to 2013 prices.
Note: these figures include all of Argyll and Bute local authority area, see Chapter 6.1.

Across the ancillary marine sectors, turnover experienced a significant drop in the wake of the recession but has since started to recover and exhibits signs of growth.

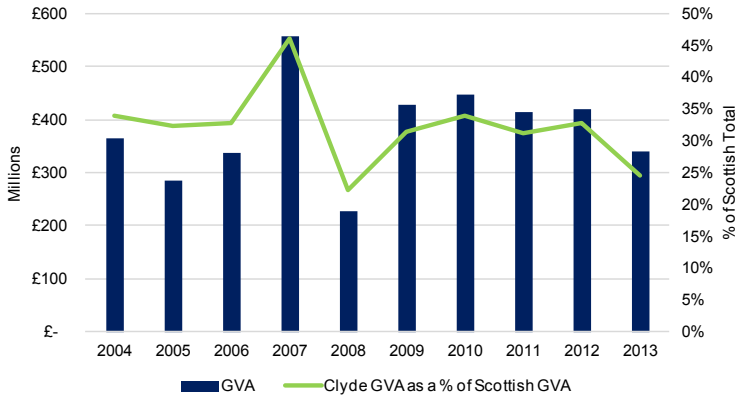
Figure 2.12 Wider Clyde Marine Region: Ancillary Sector Turnover



Source: ABS and Scottish Government Key Sector Stats. Adjusted to 2013 prices.
Note: Data only available from 2008 onwards.

Annual GVA output from core marine activities has varied considerably over this period, peaking in 2007 but then significantly declining the following year. However, as with turnover, it has levelled out since 2009 (figure 2.12).

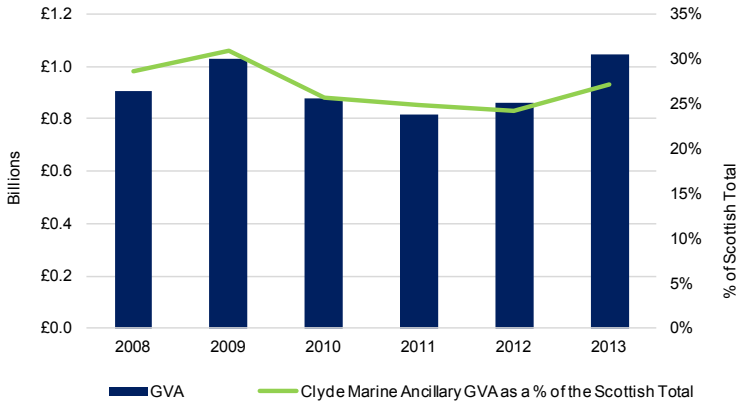
Figure 2.13 Wider Clyde Marine Region: Core Sector GVA



Source: ABS. Adjusted to 2013 prices.
Note: these figures include all of Argyll and Bute local authority area.

GVA output across the ancillary sector (fig 2.2) has followed a similar trend as turnover; decline on the back of the recession followed by steady growth from 2011 onwards.

Figure 2.14 Wider Clyde Marine Region: Ancillary Sector GVA



Source: ABS and Scottish Government Key Sector Stats. Adjusted to 2013 prices.
Note: Data only available from 2008 onwards.

The annual relationship between turnover and GVA shows a decline in the core sectors across the CMR and Scotland (figure 2.14), primarily driven by rising turnover and static/declining GVA in the Shipping and Transport Sector. This data would indicate an overall decline in productivity within the sector; input costs such as fuel and equipment have been rising at a greater rate than the growth in turnover/sales which would explain an increase in turnover and a corresponding decrease in GVA.

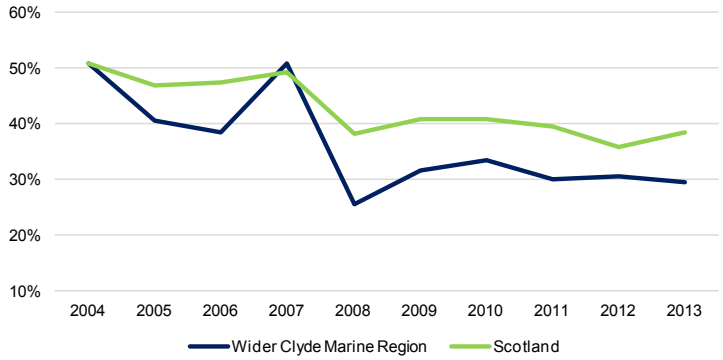
Figure 2.15 Loch Fyne





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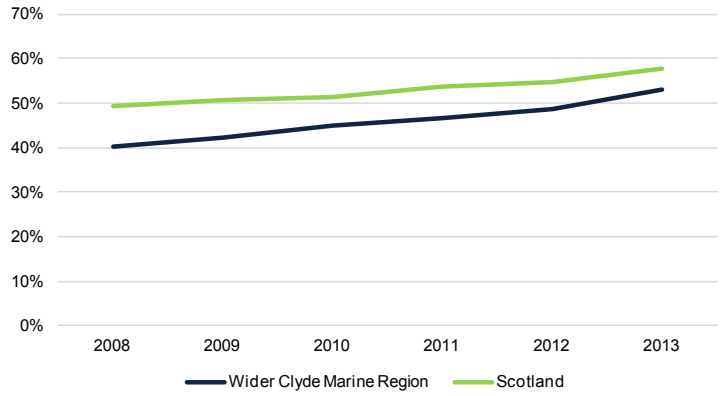
Figure 2.16 Core Marine Sectors GVA to Turnover Ratio



Source: ABS. Adjusted to 2013 prices.

Across the ancillary sectors, there has been annual growth in productivity.

Figure 2.17 Ancillary Marine Sectors GVA to Turnover Ratio



Source: ABS. Adjusted to 2013 prices.

3. Condition of the Region
PHYSICAL

3.1. Climate Change – Impacts on marine life and processes

Many unknowns



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

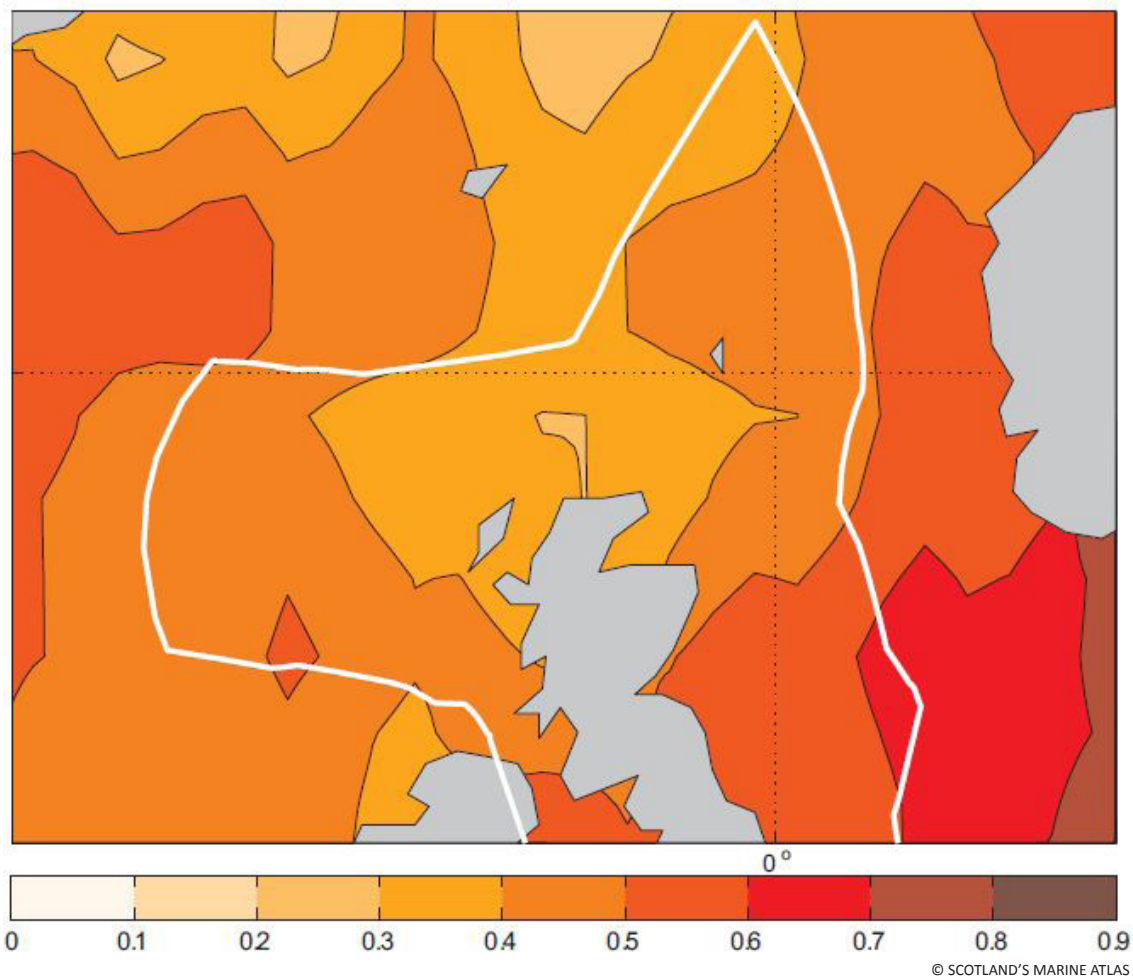
MCCIP report cards:
www.mccip.org.uk/annual-report-card/

Scotland's Marine Atlas Clyde score: No score included.

Introduction

Human activities which release greenhouse gases to the atmosphere are the major cause of the observed average increase in global temperatures over the last century. An increase in sea temperatures around the coast of Scotland has been observed. The temperature rise in the Clyde Marine Region (CMR) over the last 25 years has been between 0.4°C and 0.5°C per decade.

Figure 3.1 Twenty five year trend in sea surface temperature (°C per decade) calculated over the period 1986-2009



© SCOTLAND'S MARINE ATLAS



Lochranza Castle © PETER SANDGROUND

Climate change

The probable impacts of climate change are as follows:[11]

- Increase in sea and air temperatures.
- Ocean acidification due to increased uptake of carbon dioxide.
- Sea Level Rise due to both thermal expansion of the water (60%) and the melting of glaciers, ice caps (40%)[12] and any associated coastal erosion (see sections below).

The above impacts may lead to changes in the physical and chemical environment which can result in implications for marine life and ecosystems as follows:[13]

- Changes in overall primary productivity.
- Northward shift of cold-water species and range expansion of warm-water species.
- Changes in spawning and reproduction patterns, as this is often linked to temperature.
- Knock-on impacts through the food web, for example some species are dependent on the availability of specific food at certain times.
- Reduction in the ability of certain species to form calcareous structures such as shells and maerl.
- Increase in number and distribution of Invasive Non-Native Species (INNS).
- Sea-level rise is likely to cause coastal systems to migrate landward, through erosion of the nearshore zones and deposition in the upper zones.

Some of these impacts are better understood than others and research is underway in many areas to get a clearer view of how marine life may be affected. In 2015 the Marine Climate Change Impacts Partnership (MCCIP) produced a special report card considering the implications of climate change for marine biodiversity legislation. It concluded that whilst climate change is rarely explicitly considered in marine biodiversity legislation, mechanisms generally exist that could enable climate change issues to be addressed. In terms of the impact on Marine Protected Areas (MPAs), climate change could lead to features being gained to or lost from sites and, in certain cases, the entire network. For example 'maerl beds' is a designated feature in the south Arran MPA but these can be susceptible to temperature changes and acidification. Flexibility is required to respond to changes by abandoning sites, designating new sites and revising management measures. There could also be implications for the achievement of Good Environmental Status (GEnvS) under the Marine Strategy Framework Directive (MSFD), but further work is required to assess this.[14]

A recent Climate Change Risk Assessment for Scotland[15] concluded that:

- More action is needed to factor climate change into conservation planning and site management.
- More action is needed to deliver managed realignment of coastlines and create compensatory habitat (see following chapter).
- It is a research priority to better understand the magnitude of risk to marine ecosystems and heritage.
- More research is required to account for climate change impacts on carbon stores.
- Climate change should be accounted for in landscape character assessments (see Chapter 3.6 Landscape-Seascape).
- On invasive species, surveillance and biosecurity measures should be implemented and cross-sectoral initiatives developed for risk assessment and contingency planning (see Chapter 5.10 Marine Non-Native Species).

11. Marine Climate Change Impacts Partnership, 2015b
12. Hansom *et al.*, 2016
13. Marine Climate Chance Impacts Partnership, 2015b
14. Marine Climate Change Impacts Partnership, 2016
15. Adaptation Sub-Committee, 2016

CASE STUDY

Red-tide of summer 2016

During July 2016 members of the public reported discoloured water and dead marine life in the Loch Ryan area (outwith but neighbouring the CMR) initially, but more reports followed from along the Ayrshire coast and Bute. Samples were retrieved from Loch Ryan, Troon pier, Loch Fyne, Campbeltown Loch and Loch Striven and analysis showed exceptionally high levels of the dinoflagellate *Karenia mikimotoi* – a marine phytoplankton indicating a widespread algal bloom that is known as a red-tide.

Red-tides can deplete the environment of oxygen and indeed, around the time that the red-tide was reported, large numbers of lugworms and cockles were reported dead. As the dinoflagellates die off, the effects can still linger and during this event large numbers of dead sea urchins washed up in the Irvine area. The red-tide can cause physical smothering of gills in fish by dead cells, but the sand dwelling animals which washed up were likely to have been suffocated by the oxygen demand created by the bacteria associated with the decomposing *K. mikimotoi*, once the bloom died off.

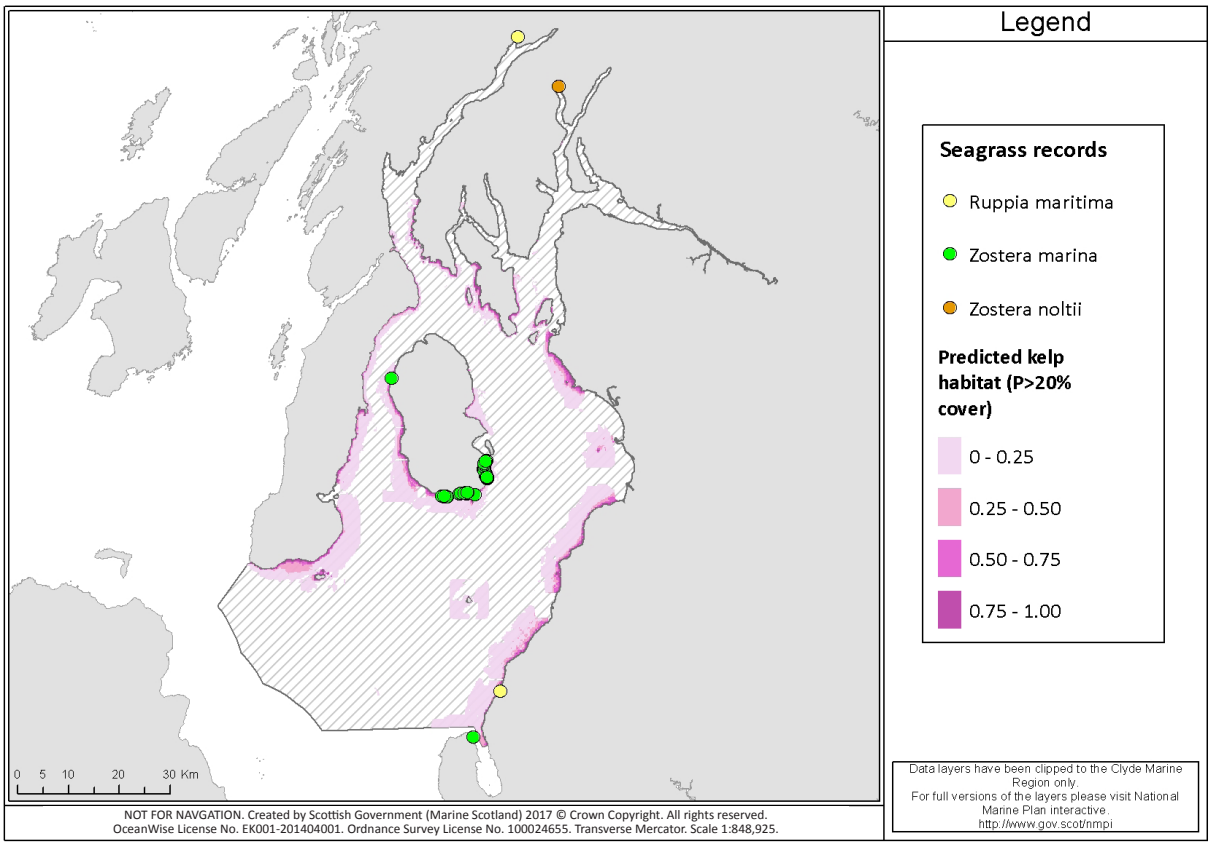
Whilst red-tides have occurred in the past and were not necessarily attributed to climate change at that time, our changing climate means that the CMR is likely to become warmer and wetter and so, as the conditions required become more frequent in future, red-tides might also become more frequent.[16]

Carbon sinks

Carbon sinks absorb and store more carbon than they release. Forests on land are one of the best known examples of this and carbon sinks can also be found in the marine environment. As well as the very important role that the waters of the oceans play in the carbon cycle and carbon storage, carbon sinks can also be found in sediment; seaweed, seagrass and saltmarsh; and animals (e.g. shells and coral). Increasing temperatures and acidification of the ocean can reduce the marine environment's ability to absorb and store carbon. Disturbed sediments can also release stored carbon. Potential carbon sinks in the CMR are mapped (Maps 3 and 4, over page).

16. Scottish Environment Protection Agency, 2016a

Map 3. Seagrass records and predicted kelp habitat



Map 4. Percentage of carbonate in the top 10cm of superficial sediments

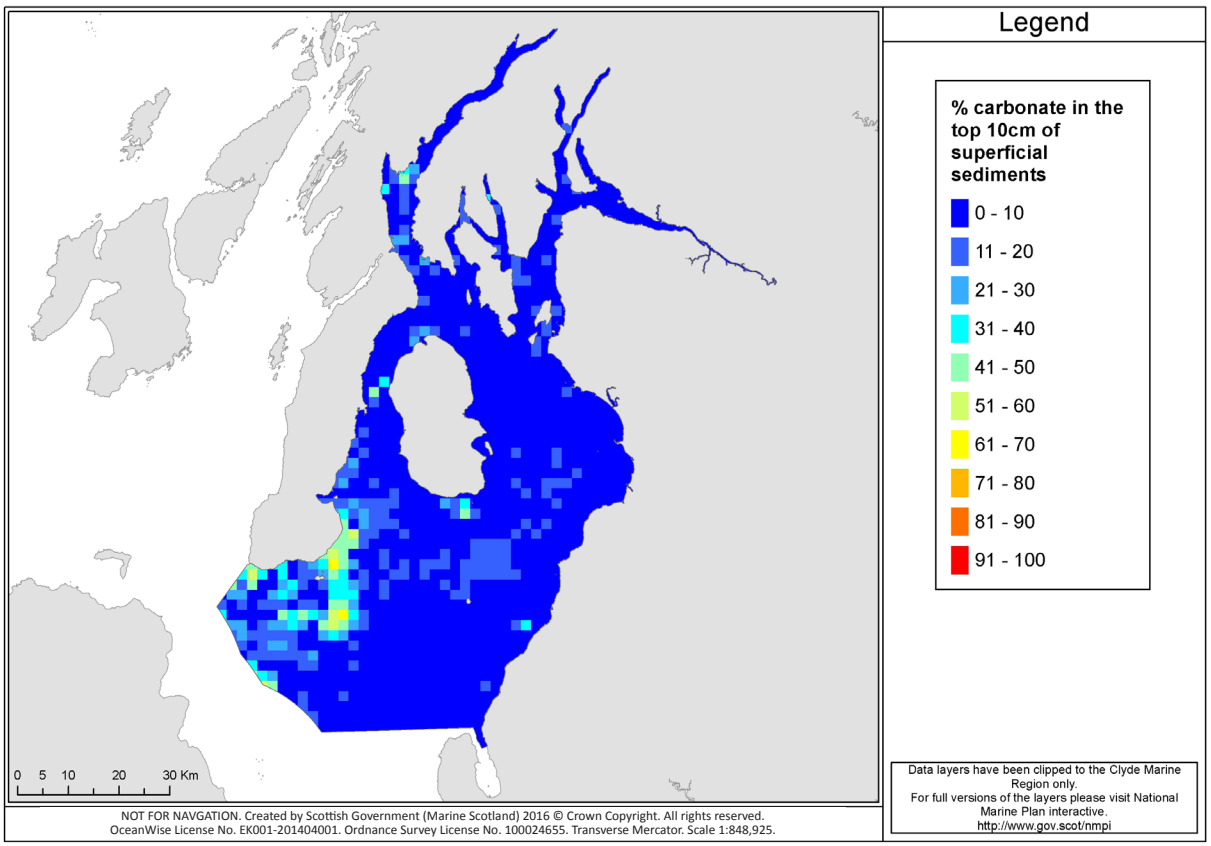


Table 3.1 Ecosystem Services

ECOSYSTEM SERVICES[17]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (fish and shellfish)	Some fish distributions have moved northwards and into deeper waters. Warmer waters are correlated with poor conditions for cod larvae and cod growth. Models suggest that cod stocks in the Celtic and Irish seas may disappear by 2100. New fisheries may develop in the longer term for new warmer water species. Ocean acidification may pose a threat to the shellfish fisheries in the Clyde (*Nephrops* and scallops), including impacts to spawning/nursery grounds; however, more research is required. New mariculture species (e.g. sea bass, bream) may be able to be cultivated. Farmed species may be more susceptible to a wider variety of diseases.
Regulating	Clean and Safe waters	An increase in the tendency for stratification of the water column could influence the developments of harmful algal blooms. Changes to phytoplankton are likely to affect carbon sequestration. Indeed climate change may reduce the ability of the marine environment to store carbon. Most bacterial vibrio species of human health relevance (cause gastro-enteritis and septicaemia) grow preferentially in warm (>15°C) sea (see Chapters 4.3 and 4.4 regarding microbiological contamination). Increasing sea temperatures are anticipated to result in an increase in these bacteria.[18]
Cultural	Tourism and nature watching	Whilst warmer weather is expected to lead to an extended tourist season in the UK, weather may generally become wetter and windier. This could have an impact on ferry services. By 2100 the range of black guillemot, common gull and Arctic tern may move north such that breeding colonies will not occur in the CMR.[19]
Supporting services underpin the provision of other services		Climate change has the potential to cause changes in the type, amount, location and timing of phytoplankton and zooplankton production. This could potentially have an impact on biogeochemical cycling. Overall, there has been a decline in cold water plankton species and an increase in warm-water/ subtropical species (which can be less abundant and less nutritional than cold water species).[20] Species that feed on plankton, including fish, have life cycles timed to make use of particular species of plankton; there is strong evidence that warming has influenced the timing of fish migration and spawning events.[21]

17. Marine Climate Change Impacts Partnership, 2015a
18. Marine Climate Change Impacts Partnership, 2015b
19. Adaptation Sub-Committee, 2016
20. Adaptation Sub-Committee, 2016
21. Adaptation Sub-Committee, 2016

3.2 Climate Change – Sea-level rise and coastal flooding



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SNH Sea-Level Rise report No. 381
SEPA Flood Risk Management work

Scotland's Marine Atlas Clyde score: No score included.

Introduction

Sea-level rise is due to thermal expansion of the water (60%) and the melting of glaciers, ice caps and polar ice sheets (40%).[22] At the height of the last glaciation, the Clyde Marine Region (CMR) was close to the thickest parts of the Scottish ice sheet in the south-west Highlands. The land has been rebounding upwards since, following the melting of the ice. In recent millennia this caused a consistent fall in sea-level in the CMR, but it is likely that this is now reversing. There is particular concern over an accelerating rise in sea-level predicted throughout the 21st century. As well as increasing the overall volume of water in the oceans and seas, sea-level rise can also modify tidal dynamics, such as changes in high tide level.[23]

A storm surge is a change in sea level that is caused by a storm. This is due to high winds pushing the sea water towards the coast. There is also a smaller contribution from the low pressure at the centre of the storm 'pulling' the water level up by about 1cm for every 1 millibar change in pressure.[24] Recent modelling work has concluded that coastal flooding in the CMR is not only caused by extreme surge events, but also by moderate surges when there is a spring high tide. There is also a funnelling effect linked to the depth and shape of the seabed in the sea lochs and estuary.[25] There is no general agreement that increasing temperatures have or will lead to an increase in storminess and wave height.[26] A recent paper, however, concluded that during the stormy winter of 2013-14, waves in the Atlantic were, on average, 40% higher than the average for the whole of the 1948-2015 timespan and recommended that coastal planners should consider increasingly stormy conditions in the north-east Atlantic, as predicted by some climate change models.[27]

Firth of Clyde Sea-Level Rise project

In 2017, SNH published the report *Sea-Level Rise and Storm Surges in the Firth of Clyde*.[28] The report concluded that by 2080 under a High Emissions scenario, sea-level rise (including negligible storm surge change) is projected to be 47cm around the CMR. The High Emissions scenario is the worst-case projection and is dependent on many factors, including mitigation factors on the global scale.

Methodology

The Intergovernmental Panel on Climate Change (IPCC), a scientific body under the United Nations, produces global sea-level rise projections for different emissions scenarios, i.e. different levels of emissions of carbon dioxide and other greenhouse gases into the atmosphere. These global scenarios are translated into the UK Climate Projections (UKCP) which gives more detailed data at the local geographical level. This study used projections from the fourth IPCC Assessment Report (AR4) as translated into UKCP09. In 2013 the fifth IPCC Assessment Report (AR5) was published, however, this is yet to be translated into local UK projections. This study used the 'High emissions' scenario at 95% confidence and storm surge at 50% confidence. Results were calculated for a 1 in 1 year flood event (100% likelihood) and a 1 in 200 year flood event (0.5% likelihood in any given year). Figures for land uplift following the last ice age (also known

Table 3.1 Results of the report showing projected sea-level rise in the Clyde Marine Region under a High Emissions scenario

	2020	2050	2080
Adopted total Sea Level Rise	6cm	24cm	47cm

22. Intergovernmental Panel on Climate Change, 2007
23. Idier *et al.*, 2017
24. Met Office, 2015
25. Sabatino *et al.*, 2016
26. Marine Climate Change Impacts Partnership, 2015b
27. Masselink *et al.*, 2016
28. Hansom *et al*, 2017

as 'isostatic bounce') were taken from UKCP09; research is currently under way at the University of Glasgow to assess whether the rate of change of vertical land movement is slowing across Scotland in which case this study's calculations are likely to be conservative. It should also be noted that views vary among scientists on the stability of the ice sheets.

UKCP09 High emissions scenario describes a world of

- very rapid economic growth,
- increasing population to a peak of 8.7 billion,
- rapid introduction of new and efficient technologies,
- large reductions in regional differences in GDP, and
- high use of fossil fuels.

On examiniation of the results, increases in sea level were very consistent across the CMR and so their values were grouped into a single figure for the whole extent of the area. In the case of storm surge changes due to climate change, the values showed higher variability with decreases generally in the north and increases in the south. However these changes were very small (millimetres) compared to those of sea-level rise. Surge results were therefore amalgamated with sea-level rise to form a single value for the CMR. It should be noted that wave impact, surface water and fluvial (rivers/streams) inputs were not included as part of the study.

Mapping

Predicted sea levels at 2080 were mapped to identify areas at risk using the 1 in 1 year and 1 in 200 year tidal flood extent. The maps are available at www.clydemarineplan.scot/marine-planning/marine-planning-projects/.

Managed Realignment

Managed realignment is a 'soft' engineering technique where river, estuary and/or coastal waters are deliberately allowed to extend beyond current flood defences.[29] This allows coastal systems to provide natural coastal protection and erosion control along with other ecosystem services such as raw materials and food, water purification, nursery habitat, carbon sequestration, education and research and tourism and recreation.[30]

Table 3.2 Managed Realignment – list of benefits and issues

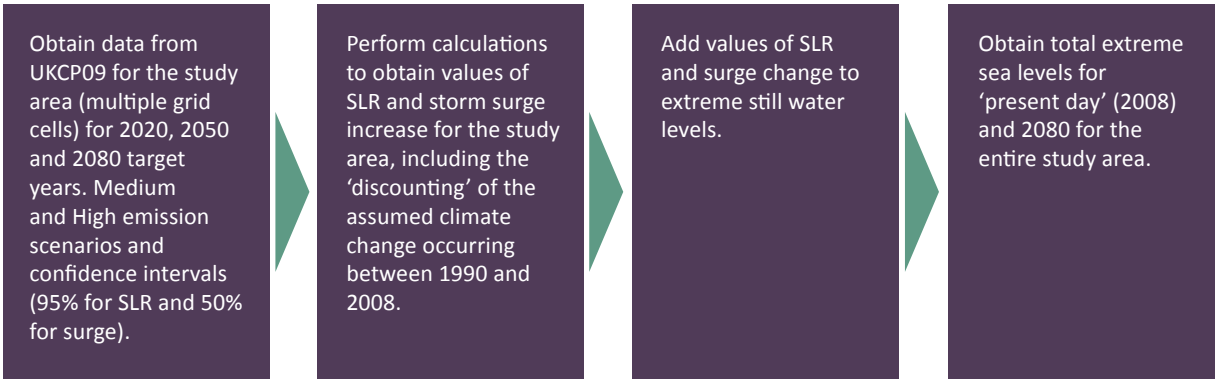
MANAGED REALIGNMENT	
POTENTIAL BENEFITS	**POTENTIAL ISSUES**
• Flood defence by providing an intertidal buffer zone • Carbon sequestration – climate change mitigation • Creating and improving habitats for associated valuable and protected species • Habitat offsetting for coastal sites lost to sea-level rise of development • Positive impacts for recreation and tourism	• Loss of land – often agricultural • Loss of freshwater habitat due to saltwater incursion • Habitat quality can be lower than natural intertidal habitat. • Negative stakeholder or public opinion if carried out without appropriate consultation

Clyde Case Study Areas

As part of the sea-level rise project, four areas in the CMR were selected for further analysis in terms of suitability for managed realignment.

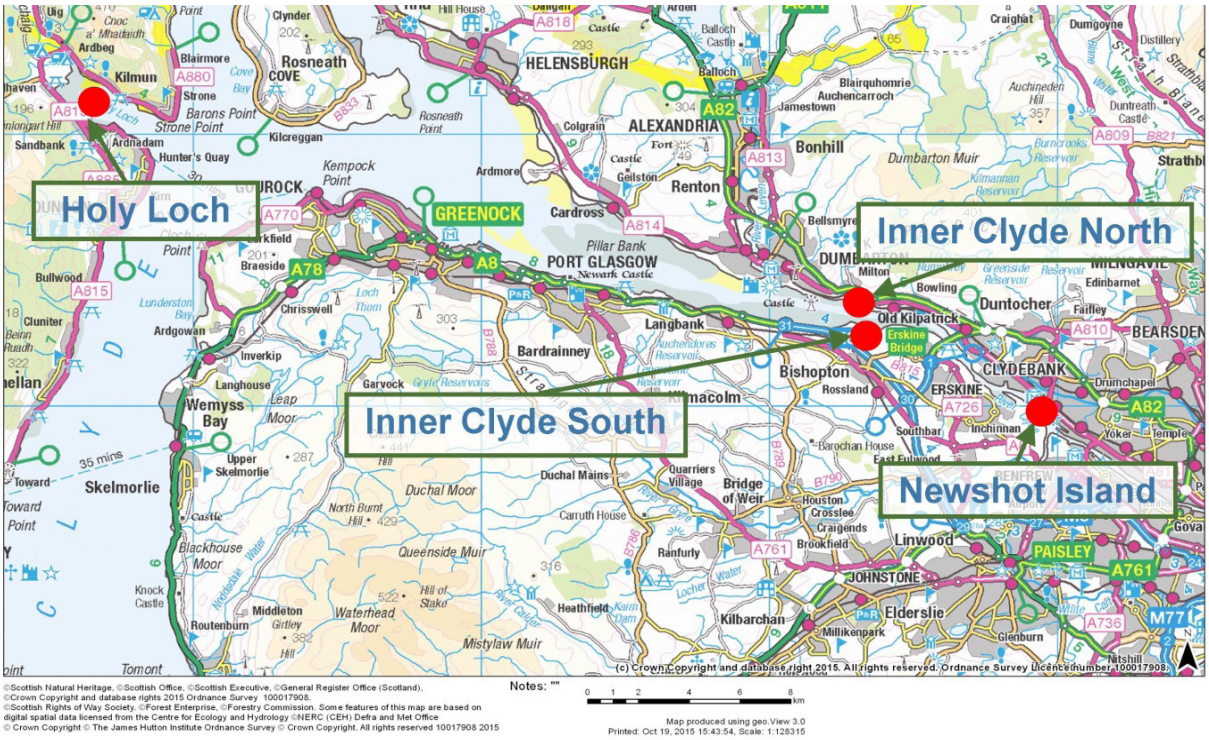
The Inner Clyde North site has significant constraints for implementing a managed realignment scheme, due to the already eroding saltmarsh coastline, and the proximity of the adjacent railway and areas of built development.

Figure 3.2 Summary of methodology



29. Hansom *et al.*, 2017
30. Barbier *et al.*, 2011

Figure 3.3 Case study locations



There may be opportunities here for alternative 'greening grey infrastructure' or bioengineering solutions that could be utilised as part of existing or future hard engineering.[31] Some of the infrastructure e.g. Bowling railway station, would currently appear to be at risk from sea-level rise and increased flooding.

Inner Clyde South, Newshot Island, and Holy Loch sites all show realistic opportunities for managed realignment projects. The parcels of land involved in all three cases are substantial, with few apparent constraints to feasibility, and all three sites could be phased over a period of time. All three sites have existing saltmarsh habitat, and there would be space and potential for keeping this, or increasing the current extent. As flood defences are absent or not fully functioning, sea-level rise will lead to 'natural' realignment, but active management of this could increase the benefits listed in table 3.2 opposite.

Land ownership, the willingness of landowners to consider managed realignment and the availability of funding or financial incentives were beyond the scope of this project, but will be critical issues to address going forward, at the sites identified in this report, or in future feasibility studies.

It is acknowledged that the scale of flooding would not be significantly reduced across the CMR, even if a number of managed realignment schemes were to be implemented, as such works would not be anticipated to significantly change the tidal prism for the Firth.

SEPA Flood Risk Management

The Flood Risk Management (Scotland) Act 2009 (FRM Act) aims to reduce the adverse consequences of flooding on communities, the environment, cultural heritage and economic activity. Flood risk is expected to increase, due to climate change causing more intense rainfall, wetter winters and rising sea levels. The National Flood Risk Assessment undertaken by SEPA brought together and analysed information on the sources and impacts of flooding in Scotland. It concluded that coastal flooding, from a combination of high tides and stormy conditions, currently accounts for approximately 17% of all predicted impacts in Scotland. It also identified Potentially Valuable Areas (see over).

In December 2015 SEPA published a Flood Risk Management Strategy for each of the 14 Local Plan Districts covering Scotland. These strategies confirm the immediate priorities for flood risk management and set out the future direction to be taken by all flood risk authorities. They identify additional risk posed by waves and also high tides coinciding with high river flows. These strategies can be found here http://apps.sepa.org.uk/FRMStrategies/.

In June 2016, the lead local authority in each Local Plan District – on behalf of all 32 local authorities in Scotland – published delivery plans clearly setting out how flood risk will be managed, coordinated, funded and delivered between 2016 and 2022. The lead local authorities in the CMR are: Glasgow City Council for the Clyde and Loch Lomond, North Ayrshire Council for Ayrshire and Highland Council for Highland and Argyll.

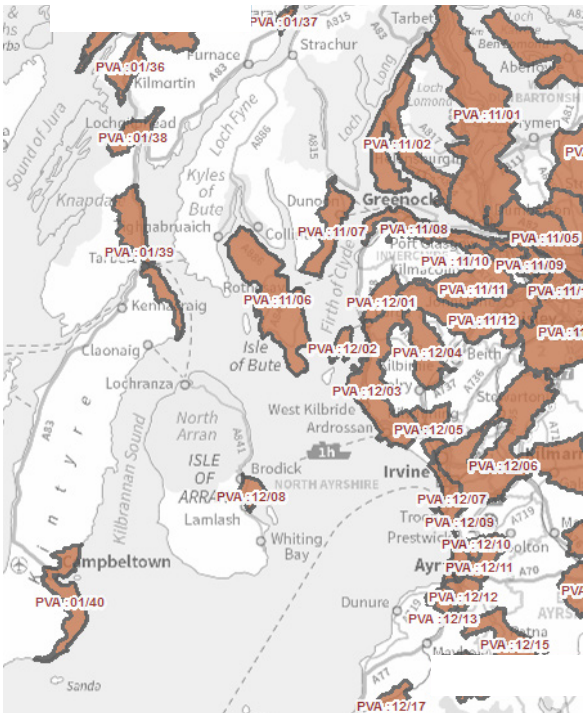
31. For example cracks and cavity features can be cast into concrete to provide habitat or a vegetated terrace fronting a hard engineered structure can provide opportunity for marginal habitat to link to adjacent habitat.

These plans can be found here:
www.glasgow.gov.uk/index.aspx?articleid=19470
www.north-ayrshire.gov.uk/resident/community-safety/flood-risk-management-plan.aspx
www.highland.gov.uk/downloads/file/16173/the_draft_highland_7_argyll_local_flood_risk_management_plan_lpd01

A recent Climate Change Risk Assessment for Scotland[32] concluded that:

- More research is needed to better understand risk to infrastructure from coastal flooding and erosion from sea-level rise and coastal change.
- Current policies should be assessed to ensure they are realistic in the context of climate change as well as value for money and affordability constraints; assets at risk should be identified where maintaining current defence lines is economically unrealistic. There is a need to avoid lock-in to a particular pathway allowing changes where long lead-in times are needed, for example the relocation or rerouting of infrastructure.
- Research is needed to better characterise the impacts from sea-level rise on coastal communities, although the current level of risk to the viability of coastal communities in Scotland is of low magnitude (high confidence). Some coastal communities in the CMR are at risk of increased storminess and wave overtopping.
- More research is needed on costs and benefits of adaptation options for businesses at coastal locations (e.g. golf courses).

Figure 3.4 Potentially Vulnerable Areas around the Clyde



Source: SEPA

ECOSYSTEM SERVICES[33]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (habitat provision for juvenile and spawning life stages)	Sea-level rise could threaten the ability of saltmarsh and mudflats to provide nursery grounds for fish species, including commercially important species.
Regulating	Sea defence	Loss of saltmarsh may reduce the provision of important natural sea defence services. Mudflats also provide a natural sea defence by absorbing wave energy and are an important sink for organic material.[34] Coastal sand dunes can protect the land behind them from wind and waves. Any future seaweed harvesting should ensure no loss of natural coastal protection.
	Clean and Safe waters	Loss of saltmarsh may reduce water purification services, i.e. breaking down waste and detoxifying water.
	Climate regulation (carbon capture and storage)	Saltmarsh is a carbon sink – sequestration rates are high, however, the net benefit is small due to the low total area of these habitats.
Cultural	Tourism and nature watching	Careful planning along the coastline using natural defence where possible could reduce overall costs and provide increased opportunities for tourism, recreation, education and research. Saltmarsh and mudflats provide habitat and prey source for wading birds.
Supporting services underpin the provision of other services		Any reduction in the extent and condition of saltmarsh could impact the ability of the habitat to provide water cycling, soil formation, nutrient production, primary production.

32. Adaptation Sub-Committee, 2016
33. Marine Climate Change Impacts Partnership, 2015a
34. Baxter *et al.*, 2011

3.3 Seabed and coastal geology and sediments

This is a purely descriptive chapter so no concern or confidence levels have been assessed.

Introduction

The physical character of the Clyde Marine Region (CMR), a combination of the underlying geology with the global and local effects of glaciation, underpins all other natural characteristics and, in turn, most of its human activities.

Some of the topography of the northern and western parts of the CMR dates back almost half a billion years. In that era, the closure of the Iapetus ocean against the ancient rocks of the Highlands formed the Highland Boundary Fault and other North-northeast - South-southwest-trending structures. After this, until around 250 million years ago, the development of the Midland Valley produced other major structures and rock types now seen in the region's landscape, including the valley of the Clyde Estuary, long East-West structures separating resistant lava uplands, and the trough containing relatively weak sedimentary rocks between the Northwest-Southeast-trending coasts of northern Arran and north Ayrshire.[35]

Effects of glaciation

The effects of repeated glaciation are overlaid on this geological framework. They began with 'over-deepening' of the major valleys and troughs by the erosive action of ice streams. This produced the 'fjords' of the CMR's Highland fringes. On an even larger scale, glacial erosion also carved out the weaker rocks separating Arran and Ayrshire, producing the seaward transition from this deep trough to the far shallower Clyde Sea Sill (see below).

Glaciation also largely determined the extent to which the Clyde's valleys and troughs are infilled with sediment. First thick sediments of gravel and sand were deposited directly from ice and the glacial meltwaters.[36] These largely filled the valleys of the Clyde Estuary and the Garnock/Irvine estuary, the bedrock floors of which are tens of metres below current sea level.

Secondly, ever since the ice sheets first began receding around 18,000 years ago there has been a complex interplay between rising global sea-level due to the melt, and upward rebound of south-west Scotland from the weight of the ice. As a result, local sea level in the CMR has risen and fallen dramatically over time. That in turn has dictated the location and nature of further infilling by marine and inter-tidal sediments over recent millennia.



Clyde fishing © PETER SANDGROUND

35. Jardine, 1986
36. Tivy, 1986

The resulting seabed of the CMR is a complex and dynamic system, with the majority of the outer basin and inner Firth made up of muddy and locally sandy habitats. Coarser sediments and rocky outcrops off the south coast of Arran and on the North and South Ayrshire coastline are associated with sandy beaches. Maps of the seabed are based on dive surveys, video surveys, grab samples and modelling. A more detailed assessment of the sediment habitats and associated species can be found in Chapters 5.1 to 5.3.

The fall in sea level since around 8,000 – 7,000 years ago also resulted in raised shorelines.[37] These former beaches, mudflats, rock platforms and cliffs are readily identifiable around the coast and are now built on or vegetated. By dictating human land-use at the coast, this after-effect of glaciation has had profound local effects on society across the CMR.

Nature Conservation Designations in the Clyde related to seabed geology and sediments

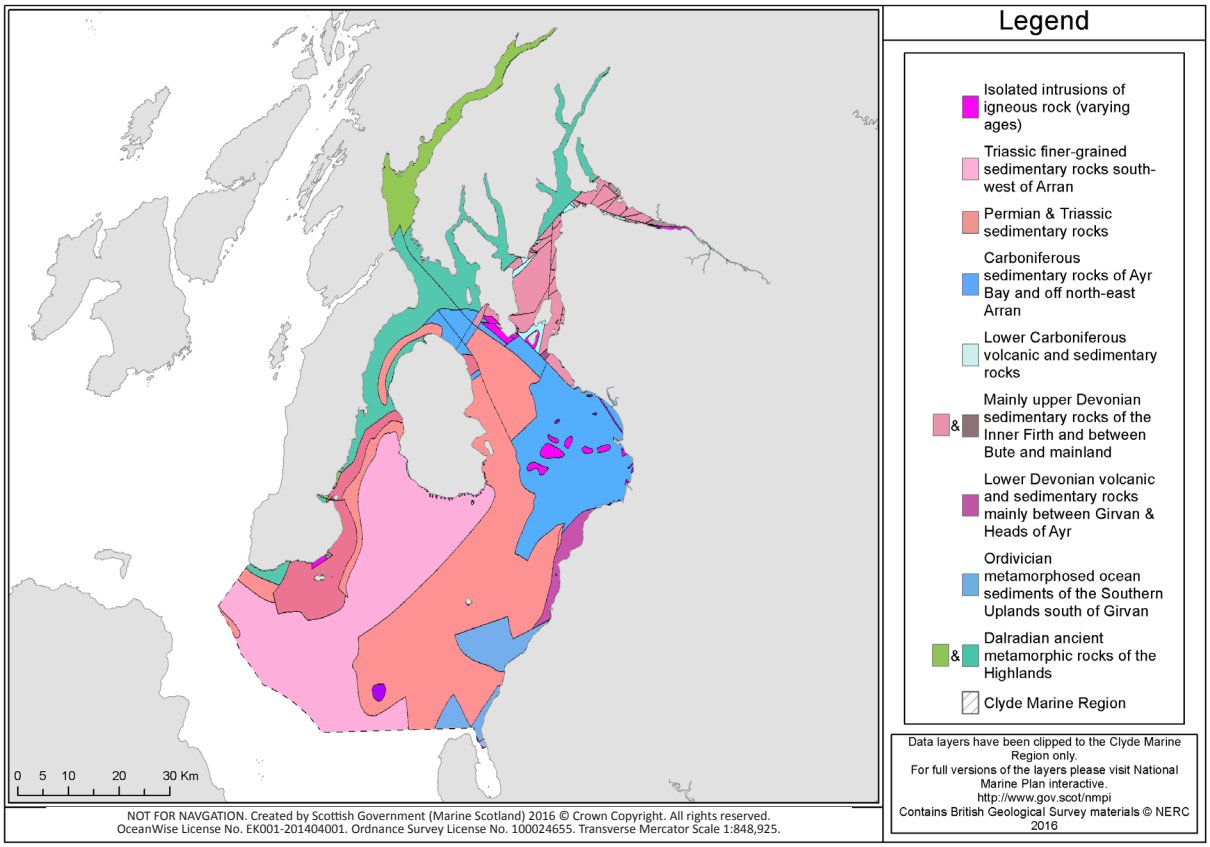
One of the protected features underpinning the designation of Clyde Sea Sill as an MPA is its geomorphology. It includes sand banks, sand ribbon fields and sand wave fields. It has 'conserve' status (see Chapter 5.9 Protected areas) meaning that it has been assessed as being in a good condition which should be maintained or 'conserved'.[38]

The geodiversity features and component interests of the Clyde Sill MPA were identified through a Department for Environment, Food and Rural Affairs (DEFRA) led research project and a subsequent SNH and Joint Nature Conservation Committee (JNCC) commissioned a desk-based review.[39, 40] SNH has also recently completed a review of geological and geomorphological features of Sites of Special Scientific Interest (SSSIs), which contribute to the MPA network in Scotland.[41] Along Arran's south coast, rock platforms exposed at low tide are cut by a multitude of striking intrusive dykes, formed when molten rock was forced upward to fill cracks in the Earth's crust. They can be seen in map 5, but due to scale they are not shown in the legend. These upstanding igneous rocks are nationally important evidence of volcanic activity in Arran around 60 million years ago (the Palaeocene), making them the youngest rocks in the marine region.

Natural changes to the seabed

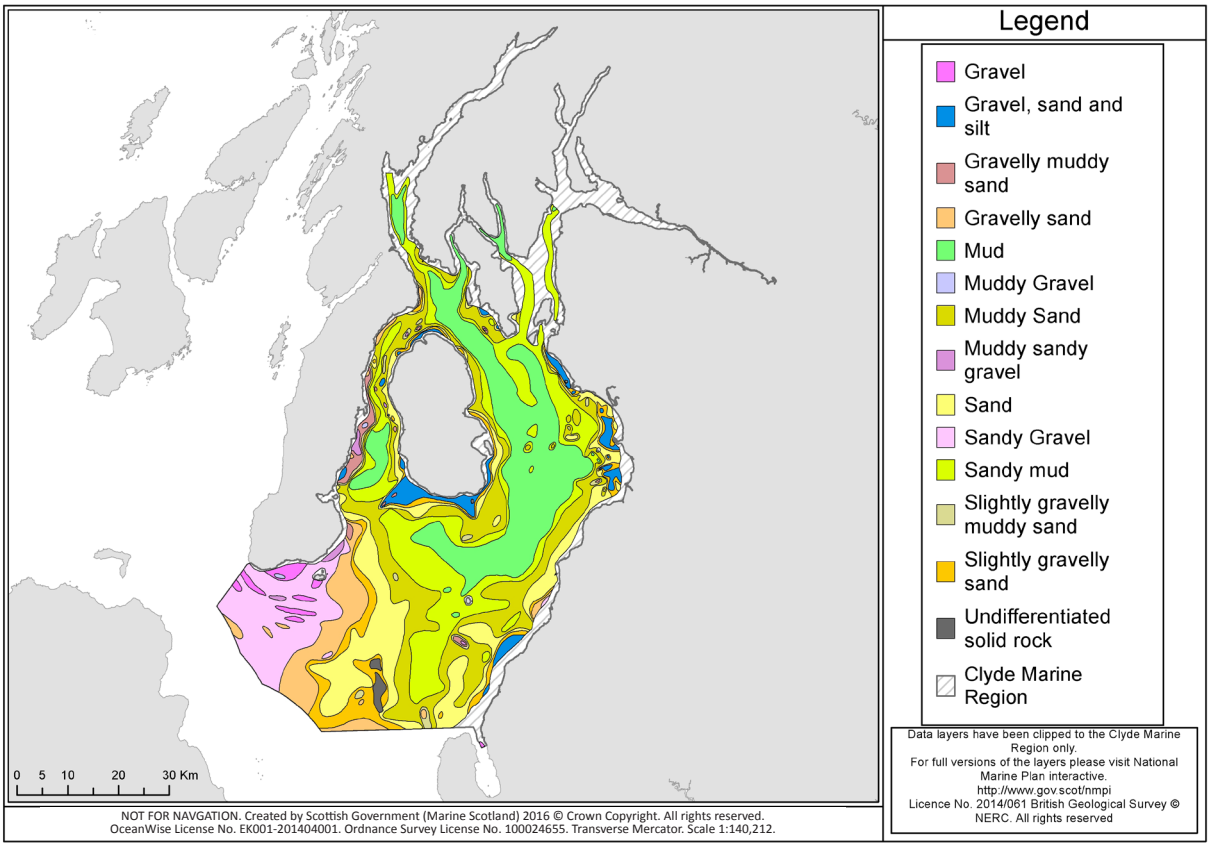
During the last glacial period (18,000 years ago to about 10,000 years ago), glaciers across the area carved out the deep rock basins of Kilbrannan Sound and between Arran and Bute. It is estimated that the

Map 5. Bedrock of the Clyde Marine Region



37. Land Use Consultants, 1999
38. Scottish Natural Heritage, 2014a
39. Brooks *et al*., 2013
40. Heath and Speirs, 2011
41. Gordon, 2016

Map 6. Seabed sediments in the Clyde Marine Region



amount of hard rock the ice sheet carved away was probably much greater than the total volume of the waters of the CMR today.

As the ice began to retreat, it deposited sand and other sediments in the deep basins it had carved out, reducing their depth by up to 80 m. Once the sea flooded in, the deposition of the muds and clays began, which again reduced the depth greatly.

Today, the land around the CMR continues to rise slowly, and deposition of silts and clays in the deep basins continues.[42]

Renewable energy installations have the potential to impact on the geology and sediments and this should be considered in any future developments.

The diversity of geology, sediments and habitats around the shores of the CMR has led to the designation of Sites of Special Scientific Interest (SSSI) along the coast. The location, feature and condition of these sites are included in Appendix II. The geological features of the sites are generally in a 'Favourable' condition except where listed in table 3.3 (over).

Human induced changes to seabed geology

In general, human-induced changes that are sufficient to have a significant effect on the seabed geology and sediments seem unlikely to occur. However, the overlying sediments have been significantly altered in some areas, specifically in the Upper Clyde, where human induced scouring and dredging has created a deepening of the Clyde channel which remains at a navigable depth. Impacts of dredge and trawl fishing are also evidenced elsewhere in the Clyde. Dredge spoil is deposited at the disposal area at Cloch Point, where it may also have altered the topography. The spoil presents an opportunity for exploring alternative uses for the material, including in realignment projects.[43]



Clyde estuary © CMPP

42. McIntyre *et al*., 2012
43. Peel Ports Clydeport, 2016

Map 7. Sediments within the Clyde Sea Sill MPA – geomorphology features are sand ribbon fields, sand banks and sand wave fields

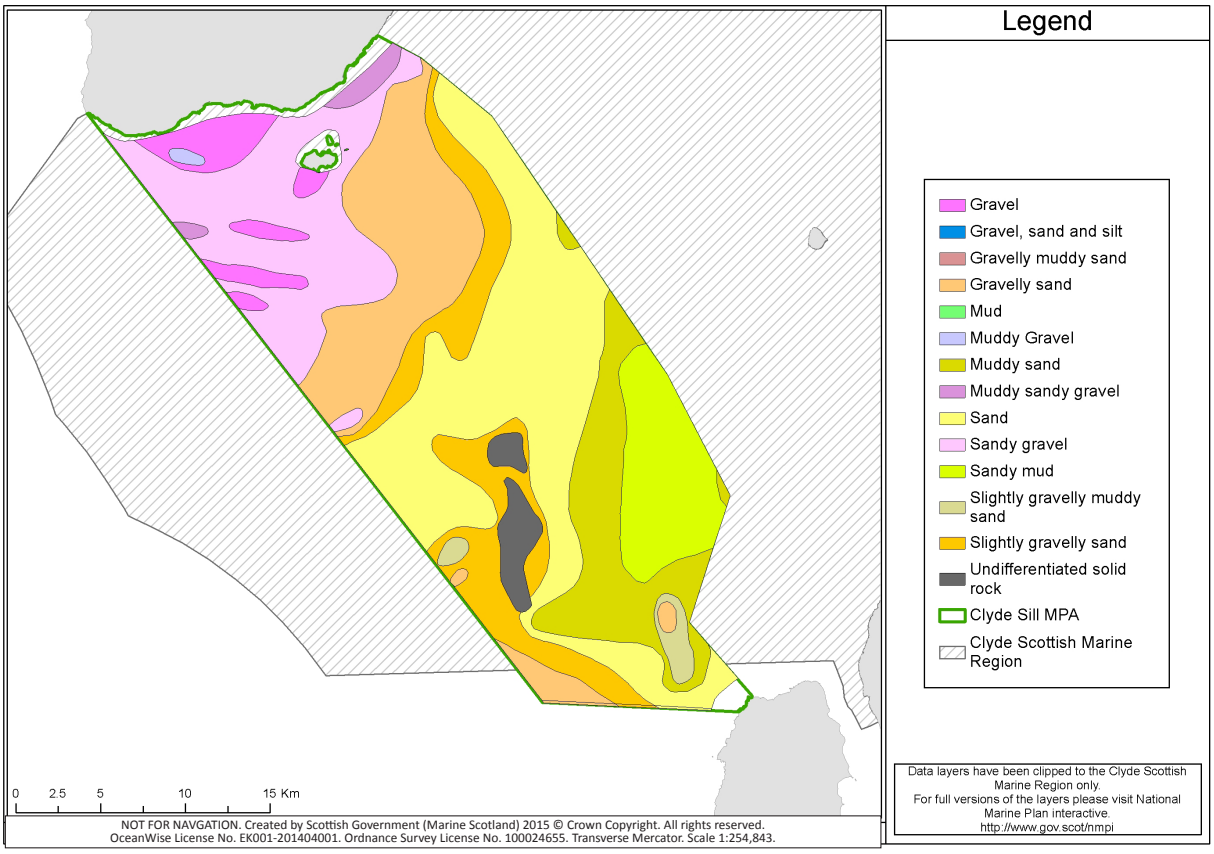


Table 3.3: Summary of SSSI's with at least one geological notified feature at the coast and where 'Favourable' condition is not currently met

SITE	ISSUE AND COMMENTARY
Ballantrae Shingle Beach	Unfavourable condition of shingle linked to nutrient enrichment through stock feeding, and both natural and anthropogenic influences affecting shingle dynamics. Management review in progress. Stock feeding has ceased.
Girvan to Ballantrae Coast Section	Ordovician Igneous feature previously considered in unfavourable condition due to illegal tipping and coastal defence works. However these have more recently been judged not to be sufficiently affecting important exposures to alter the feature condition.

ECOSYSTEM SERVICES[44]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (fish and shellfish)	Sandy and gravel substrates provide habitat for scallop and herring spawning and the soft mud sediments in the CMR provide habitat for *Nephrops*, the main fishery of the region.
Regulating	Clean water and sediments	Sediments play an important role in waste breakdown and detoxification. In some parts of the Clyde these services may be compromised, due to historic contaminations (see Chapter 4.2 Hazardous substances). Sediments also act as carbon stores.
Cultural	Tourism and nature watching	In providing source material for replenishing the beaches, the seabed geology is integral to the amenity value of the local coast. The raised beaches also provide the base for a number of world renowned golf courses in Ayrshire.
Supporting services underpin the provision of other services		Seabed geology forms the basis of the benthic habitats and source material for sediments. The underlying geology also informs the topography of the seabed and plays a significant role in tidal dynamics. The seabed contains nutrients and minerals that form the basis of the food chain. Sediments can be important for extractive industries, although these do not currently operate in the CMR.

44. Marine Climate Change Impacts Partnership, 2015a

3.4 Coastal change

This is a purely descriptive chapter so no concern or confidence levels have been assessed.

Introduction

Increases in sea level, coastal erosion and coastal flooding will increasingly affect soft coastlines around Scotland.

Management Planning

Shoreline Management Plans have been produced for only short sections of the Scottish coast which limits the information available to coastal managers. The National Coastal Change Assessment (NCCA) was commissioned by the Scottish Government and aims to establish historic coastal change and use those trends to project future coastline position. This is only for soft shoreline where the hinterland is susceptible to erosion. It does not take account of projected sea-level rise.

A recent paper looked at the effects of the stormy Atlantic conditions of 2013-2014 and concluded that they caused significant coastal erosion along Europe's Atlantic coast (France, Northern Ireland and the UK).[45] That said, the Clyde Marine Region (CMR) is, to some extent, protected from the worst of these effects by land; the Mull of Kintyre peninsula protects on its western side and Ireland protects the south-west.

The western side of the CMR (e.g. Mull of Kintyre) has some soft shoreline interspersed with rocky shores. In most of this area the shoreline has accreted or eroded by less than 10m over the last 45 years.

There is more continual soft shoreline on the eastern side of the Region in Ayrshire. In general, however, the shoreline again has accreted or eroded by less than 10m over the last 45 years, although there are pockets of more dynamic change. Erosion of between 20 to 30m in the last 45 years has occurred at Ballantrae with obvious potential impacts on the SSSI as indicated in Chapter 3.3 – Seabed and coastal geology and sediments.

The Inner Firth and Clyde estuary shorelines contain more solid infrastructure and are therefore not defined as soft shoreline. However, the NCCA map does indicate erosion into fields on the south side of the estuary to the west of Erskine Bridge which has also been picked up in the case study carried out within the sea-level rise project in that area. The head of Holy Loch also shows more substantial erosional trends of 30m or more and this area was subject to a case study within the sea-level rise project (see Chapter 3.2 Seabed and coastal geology and sediments).

More detailed consultation of the maps on NCCA along with Flood Risk considerations and the maps from the sea-level rise report, should allow Local Authorities and the Clyde Marine Planning Partnership to identify any infrastructure at risk and aid planning decisions. The information from the NCCA can be accessed via interactive mapping at www.dynamiccoast.com.

SEPA's flood risk mapping also indicates areas where there is more or less susceptibility to coastal erosion at map.sepa.org.uk/floodmap/map.htm.

North and South Ayrshire Councils are currently developing an Ayrshire Shoreline Management Plan, which is due for completion in autumn 2017. Dumfries and Galloway are also developing a Shoreline Management Plan and there will be liaison between the Plans, to ensure a joined-up approach.



Saltmarsh near Bowling © CMPP

45. Masselink *et al.*, 2016

3.5 Water circulation

This is a purely descriptive chapter so no concern or confidence levels have been assessed.

Introduction

Estuarine water circulation is influenced by the inflow of rivers, the tides, rainfall and evaporation, the wind and atmospheric pressure. Circulation patterns can also be influenced by density differences caused by changes in temperature and salinity; less dense freshwater floats over saline water and warmer water floats over colder water.

Tidal range and mixing

Water circulation in the Clyde Marine Region (CMR) is mostly influenced by the twice-daily (lunar semi-diurnal) tides; although wind and atmospheric pressure are minor factors that become more important in sea-level surges (see Chapter 3.2 Climate change – Sea-level Rise).

The Clyde Sea Sill marks a transition between the mixed waters of the North Channel between Ireland and Scotland and calmer, more stratified waters in the Outer Firth. In the Outer Firth water circulation is weak with the direction of movement dictated by the wind when it exceeds 7 ms^{-1}.[46] Under conditions of gentler winds the water circulation is a weak northwards movement as part of the general circulation of the Firth. Surface waters in the Outer Firth have a residence time of around 2 months.[47] Deep water in the Arran Deep and Kilbrannan Sound is renewed from autumn to spring, but in summer the water stays trapped below a thermocline at around 50 m. Similarly in the lochs, cold water flows in from the Outer Firth over the sea-loch sills, but in summer the deep water remains isolated by a thermocline and oxygen levels fall.[48]

In the Inner Firth, the tidal range is about 1.8m for mean neap tides and 3.1m for mean spring tides.[49] Tidal velocities are weak in this area at around 0.1-0.4ms^{-1}. This results in a relatively small tidal excursion[50] of, for example, 3.6km on a spring tide at Little Cumbrae. Tidal currents are generally even weaker within the lochs with average tidal excursions of between 1 and 2km recorded in Loch Long and Loch Fyne.[51]

The Clyde estuary is considered to be 'mesotidal', having a tidal range of 2-4m.[52] Tidal excursions vary from 1.9km at the River Kelvin to 9.6km at the River Leven, reflecting the effects of 'canalisation' of the estuary.[53] The Clyde estuary has considerable fresh water input from the River Clyde, River Kelvin, White Cart, Black Cart (including input from the River Gryfe) and River Leven. These inflows can vary substantially between seasons and depending on rainfall and snow melt.

Amphidromic point

An amphidromic point is where there is almost no tidal fluctuation on the sea surface. These amphidromic points occur at various locations throughout the world's oceans. One such point occurs to the west of Mull of Kintyre.

Hydrodynamic modelling in the Clyde Marine Region

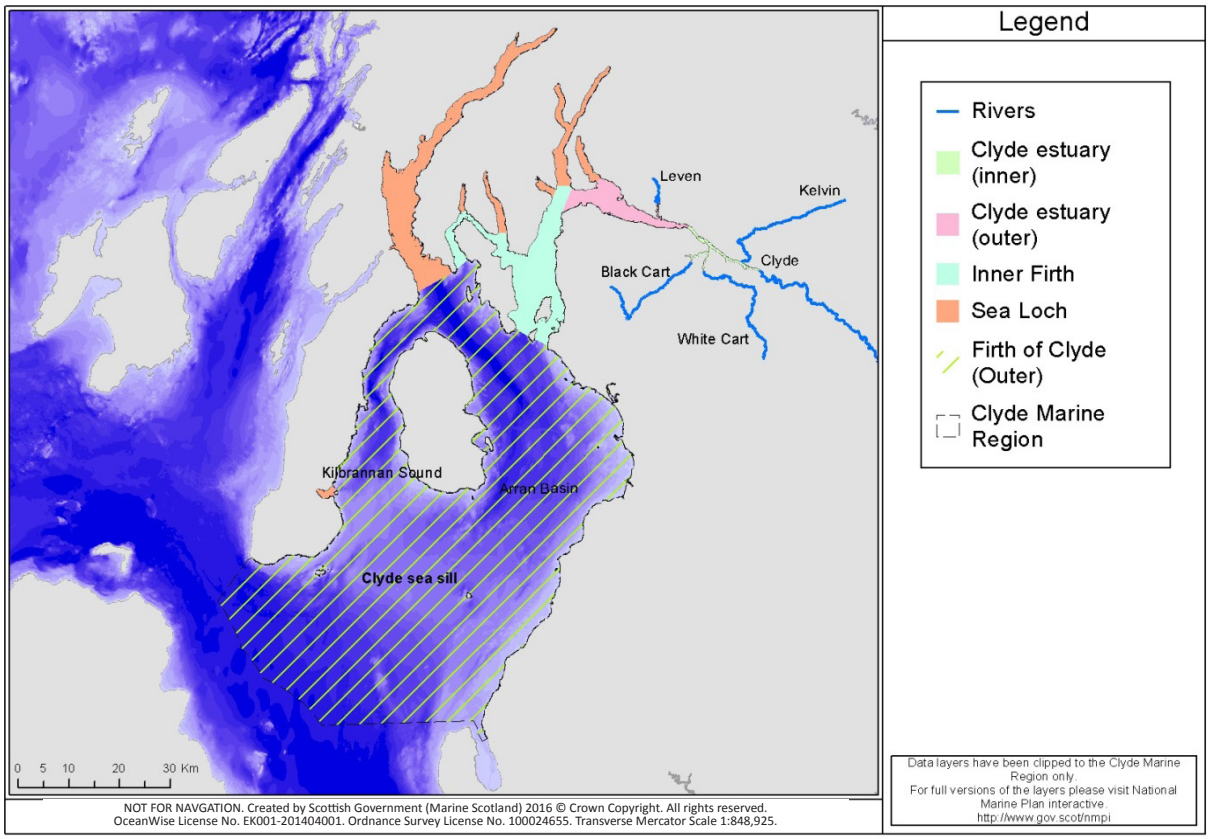
A hydrodynamic model is a tool able to describe or represent in some way the motion of water. In the past a hydrodynamic model would be a physical model built to scale. However, virtually all hydrodynamic models in use today are computer based mathematical models used to analyse the various factors that influence waves and water circulation.

Hydrodynamic modelling is challenging in the CMR, due to the many lochs, islands and estuaries. Various models have been developed over the last few decades including those developed by SEPA and work commissioned by Glasgow City Council known as the River Clyde Flood Management Study. North and South Ayrshire Council are currently developing hydrodynamic models as part of their Shoreline Management Plan.

Research recently undertaken at the University of Strathclyde has built on past work using a model developed by the University of Massachusetts for studying coastal and estuarine areas. This model matches actual tide gauge readings in the CMR more closely than previous models. According to the model, both the lunar and solar influences on the tidal current were highest around the Mull of Kintyre. The lunar component for eastward and northward currents exceeds 1ms^{-1} whilst the solar componant is above 0.5ms^{-1}. Weaker currents were found in the CMR; north of the Isle of Arran the lunar influence was <0.1ms^{-1}.

46. Ross *et al.*, 2009
47. Edwards *et al.*, 1986
48. Edwards *et al.*, 1986
49. Ross *et al.*, 2009
50. Tidal excursion is the net horizontal distance over which a water particle moves during one tidal cycle of flood and ebb.
51. Townson and Collar, 1985
52. McLusky and Elliott, 2004
53. Townson and Collar, 1985

Map 8. Rivers and areas of the Clyde Marine Region mentioned within this chapter



The work has produced a range of outputs including the following:

- Co-tidal charts of the area showing both the tidal range and the time of high and low water. Locations with the same tidal range can be connected to form lines much like the contour lines on an Ordnance Survey map. Similarly locations that have high and low water at the same time can also be linked with contour lines. (figure 3.5).
- Maps of current speed and direction at different states of the tide which reveal the locations of eddies around headlands and in bays. Whilst navigators experienced in local waters may be aware of these, the research mapped their extent and quantified the currents. (figure 3.6).

Temperature and salinity were not part of the model. The Clyde Sea can have strong stratification for long periods of time which can lead to water circulation driven by differences in density. Ongoing model work is incorporating temperature, salinity and waves.

Figure 3.5. M2 cotidal chart

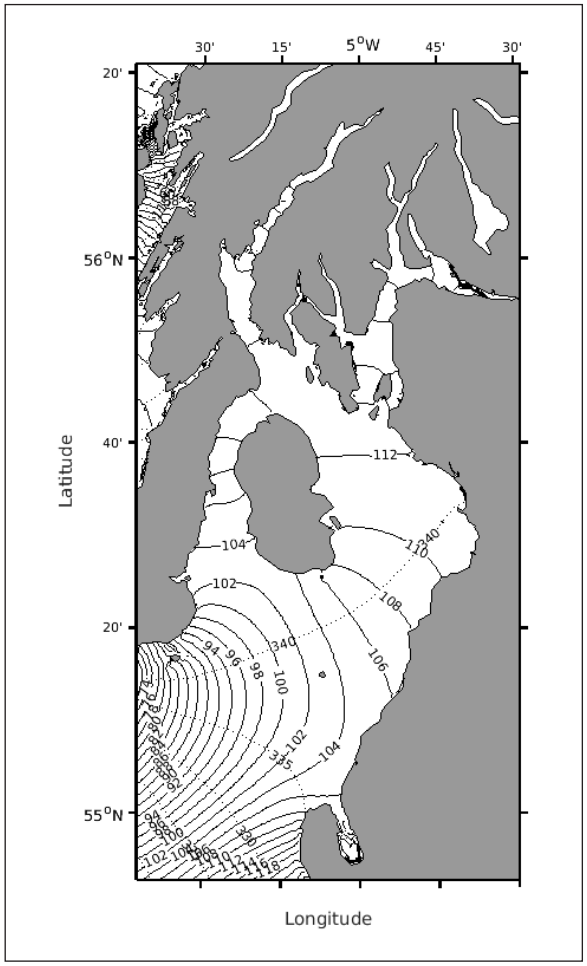
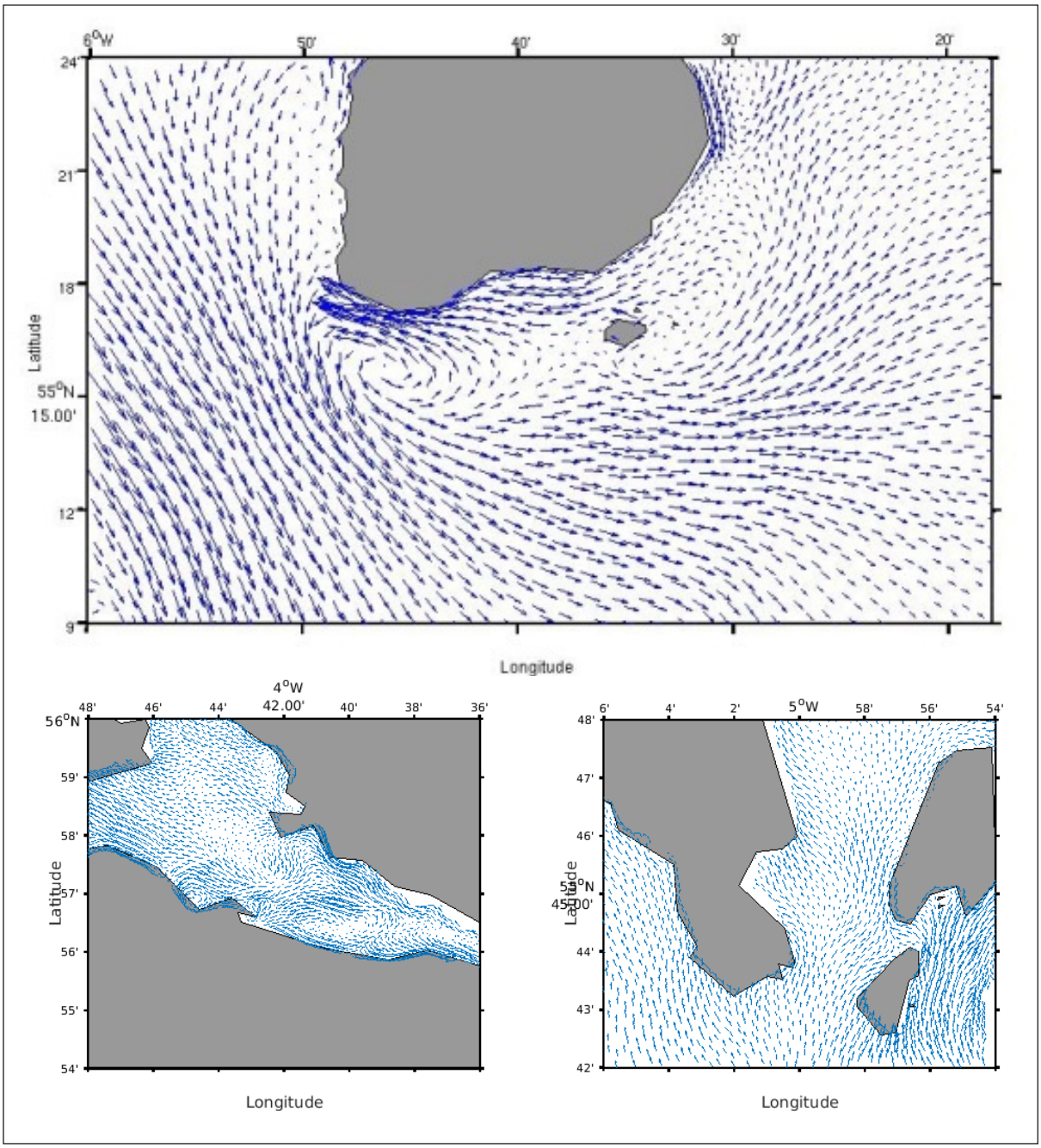


Figure 3.6. Eddies and currents around Mull of Kintyre, the Clyde estuary (Ardmore point) and the Cumbraes in spring tides 2 hours before high tide in Millport.



ECOSYSTEM SERVICES		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Supporting services underpin the provision of other services		Water circulation contributes to nutrient cycling and mixing and facilitates the transport of propagules (plant seeds or spores) and distribution of plankton and larvae.

3.6 Landscape–Seascape

This is a purely descriptive chapter so no concern or confidence levels have been assessed.

Introduction

Whilst the term 'landscape' may be well understood, the term 'seascape' refers to 'an area as perceived by people, from land, sea, or air, where the sea is a key element of the physical environment.' The term is increasing in usage and is included within the definition of landscape contained within the European Landscape Convention.[54]

Landscape/Seascape Assessment of the Clyde

The Firth of Clyde Forum commissioned a Landscape/Seascape assessment in 2012.[55] This report provides a strategic assessment of the coastal landscape and seascape of the Clyde Marine Region (CMR) which goes beyond individual authority boundaries and places the seascape at the centre of the assessment. The assessment identifies what is important about the existing landscapes of the coast and sea by analysing physical and experiential qualities. It identifies key coastal characteristics and key sensitivities to development/change, while also providing guidance which could be used to assist in the management of the coastal seascape/landscape. The guidance is on a wide range of opportunities to promote change and enhance the landscape. This includes simple tasks which could be undertaken at community level, such as repairing and painting railings, to more strategic advice, for example, on the most appropriate locations for conserving isolated coast, and where there are areas of

Figure 3.7. View of the Clyde Estuary, Dumbarton



© SNH, P&A MACDONALD

54. European Landscape Convention, Florence, 20.X.2000
55. Grant *et al*., 2013

derelict or neglected land which could be used as development sites. This document is intended for use where applicable by Planning Authorities and applicants when preparing and determining applications that have a visual impact on the coast.

Clyde Marine Region overview

The diversity of seascape

The CMR is unique in the Scottish coast in terms of the amount and expanse of sea broadly contained by the mainland, which curves from Ayrshire to the Mull of Kintyre. The overall complexity and variety of seascapes can be seen when travelling northwards through the Firth from open sea, through sounds to straits and lochs that make up the inner channels. There is therefore a huge variance in the experience of the scale of the sea when travelling through the area. This is experienced both as constant changes in scale and enclosure, and in the way views are constantly revealed, unfolding in sequence.

The character assessments often refer to 'transition areas', 'thresholds' or 'gateways' between different coastal character areas. These areas are particularly sensitive to poorly sited development which would distract from this important experience, or be difficult to accommodate due to the abrupt change of scale. A further attribute is those areas where there is a conjunction of seascape areas where the sea seems to radiate outwards from an intersection, e.g. the Inner Firth of Clyde or the mouth of Loch Long or where the Kyles of Bute open into the Sound of Bute. The sea, extending suddenly away in all directions can be disorientating especially when encountered after the relatively intimate scale of a narrow sea channel. From the land, limited access by road fragments the experience of some stretches of water while, from the sea, each seascape area is experienced much more readily in its entirety.

Figure 3.8. Portavadie, Loch Fyne Argyll



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The diversity of coastal topography and geological features

The complexity of the seascape is complemented by the variety of coastal geomorphological features, hinterland topography, land management and settlement pattern. The hinterland topography ranges from relatively low-lying inland valleys of Ayrshire to the steep enclosure of the heads of the Argyll lochs. There is a great diversity of features along the coast. Islands are a key characteristic of the Clyde with even the smaller islands, e.g. Sanda Island, creating key focal points. Coastal skylines are sensitive to development which might impact on views from the sea/coast (see figure 3.9).

Figure 3.9. Agricultural landscape, Great Cumbrae



© LORNE GILL, SNH

Settlement pattern

Long stretches of the coast are well settled (see figure 3.10), especially on the Inner Firth and along the Ayrshire coast and larger towns and villages merge, or almost merge, to form a continuous settled coastline. In such areas, the shore (as opposed to the coast) is often the most undeveloped stretch of available open space. The shore may even be backed by dunes or a high sea wall which blocks views inland to the settlement and focuses views out to sea, or to opposite, sometimes distant coasts. More often on the Argyll coast long stretches are continuously settled, but with only a single line or narrow band of settlement.

Inter-visibility and views

The inter-visibility across the Firth of the coasts ensures that numerous landmark features are visible far beyond their own coastal character area, including built structures, such as the cranes at Port Glasgow and Hunterston and lighthouses, for example at Toward Point and Skipness Point. One of the most widely recurring features across the southern extent of the Clyde is Ailsa Craig. The sweep of mainland also curves round major islands, such as Arran and the Isle of Bute, which further increases inter-visibility from the sea. The changing play of light influences visibility and the clarity of light across the

Figure 3.10. Views of settlements in the CMR. From top left clockwise: Gourock seafront, Aerial view east over the River Clyde and the Erskine Bridge towards Glasgow, Rothesay and Largs.



© CMPP



© P&A MACDONALD, SNH



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wider reaches of the Firth appear to highlight fine detail of land masses.

Views are influenced by the broad south west/ north east alignment of many of the sea channels; there is also a prevalence of long views 'framed' by land masses, either through enclosed sea lochs or along the wider channels of the more open reaches of the CMR. Looking north, the views tend to focus on high hills, while looking south; the views are often channelled to the mouths of lochs, and to wider stretches of sea, even to very distant land masses (figure 3.11), such as the Northern Ireland coast. In this context, it is important to highlight the importance of Arran, which is central to the CMR, and to which much of the surrounding seascape provides a setting. While the whole island is widely visible, the iconic, serrated silhouette of the northern peaks crops up continuously in views from as wide afield as the southern coast of Ayr, Kilcreggan on the Inner Firth and from the middle reaches of Loch Fyne.

Figure 3.11. Ailsa Craig



© LORNE GILL

Lighting and Dark skies

The coast can be a place to experience dark skies; however, due to the inter-visibility of the CMR, in many places there are nearly always views of the pale orange glare of street and road lights, even if on distant horizons. The most accessible areas where dark skies are likely to be experienced are:

Loch Striven and Loch Long (although the Ministry of Defence site does impinge) and parts of Loch Fyne, the Sound of Bute, the Outer Firth of Clyde West, the stretch of coast between Ballantrae and Loch Ryan where lighting is apparent only from small settlements on very distant shores.

Industry

In the Clyde estuary and the Inner Firth (east), towns have grown up where there is access to deep waters or sheltered harbours close to the coast (figure 3.8). There are several locations where the access to deep water has encouraged development in more rural areas such as the Finnart oil terminal on Loch Long. The most negative seascape impacts of industrial development are the restriction of

access to the coast, thereby limiting opportunities to experience the coast and sea, and the presence of large areas of abandoned and neglected works. In the estuary and Inner Firth, it would appear that sites do not stay abandoned for long, as there is constant redevelopment whereas in more rural areas redevelopment takes longer.

Archaeology

Since the days of early settlement in Scotland, the coast has provided food, fuel and access to the sea as a (relatively) accessible 'highway', therefore in past times it was likely to have been much more central to life and activities than it may appear today. As a result there are a wide range of archaeological sites around the CMR, from Neolithic standing stones, iron-age duns and forts, to more recent castles and even more recent industrial history. These often have a consistent relationship with topography and make an important contribution to the character of the area (figure 3.12).

Figure 3.12. Arran standing stones



© CMPP

Woodland and forestry

A key feature of the major towns around the CMR is the mature garden trees which feature extensively in many of the settlements, especially those which have a legacy of large gardens associated with villas. Another key characteristic of the area is the presence of woodland; large commercial conifer forests extend across steep slopes, predominantly, but not exclusively, in Argyll, and are very visible from the sea. The short-term impact of logging activity on seascapes can be negative for coastal communities and infrastructure supporting the industry should be carefully sited.

Detailed design of hard coast

In the settled areas there are long stretches of hard sea defences. These are sea walls, in the past built of dressed stone and more recently in-situ or pre-formed concrete. There are also sections of loose stone riprap. These are almost invariably topped with railings and form the frontage of pavements, promenades, esplanades, or, where space is very tight, roads. For many people, these pavements and promenades are the key viewing point for the coast, and the context from which the coast and sea is appreciated from the land. The sea wall, railings, and other associated 'street furniture', such as the paving materials, seats, bins, grass swards and, occasionally, pavilions or shelters, occupy a narrow strip along the coast. The condition of repair and the tidiness of these structures create a considerable impression on the appreciation of the coast from urban areas.

In many towns, Scottish Water has built water treatment works along the coast. These have been necessary to improve water quality, and many are tucked below street level and low key in their location. However, the detail of the hard landscape works is largely ubiquitous, with riprap defences and wooden spar railings. This is an example of how poor quality of design and lack of reference to existing coastal infrastructure results in piecemeal loss of quality and fragmentation of the unity of design which is such an attractive quality along these much-visited stretches of coast.

Maritime activity

Maritime activity varies considerably over the whole stretch of the CMR (figure 3.13). The busiest seas are the junctions of major shipping lanes, whilst the Inner Firth area is probably the busiest stretch of them all. Whilst historical activity was far higher, around 14,000 commercial shipping movements are recorded each month including lifeline ferry crossings. These 'navigational junctions'

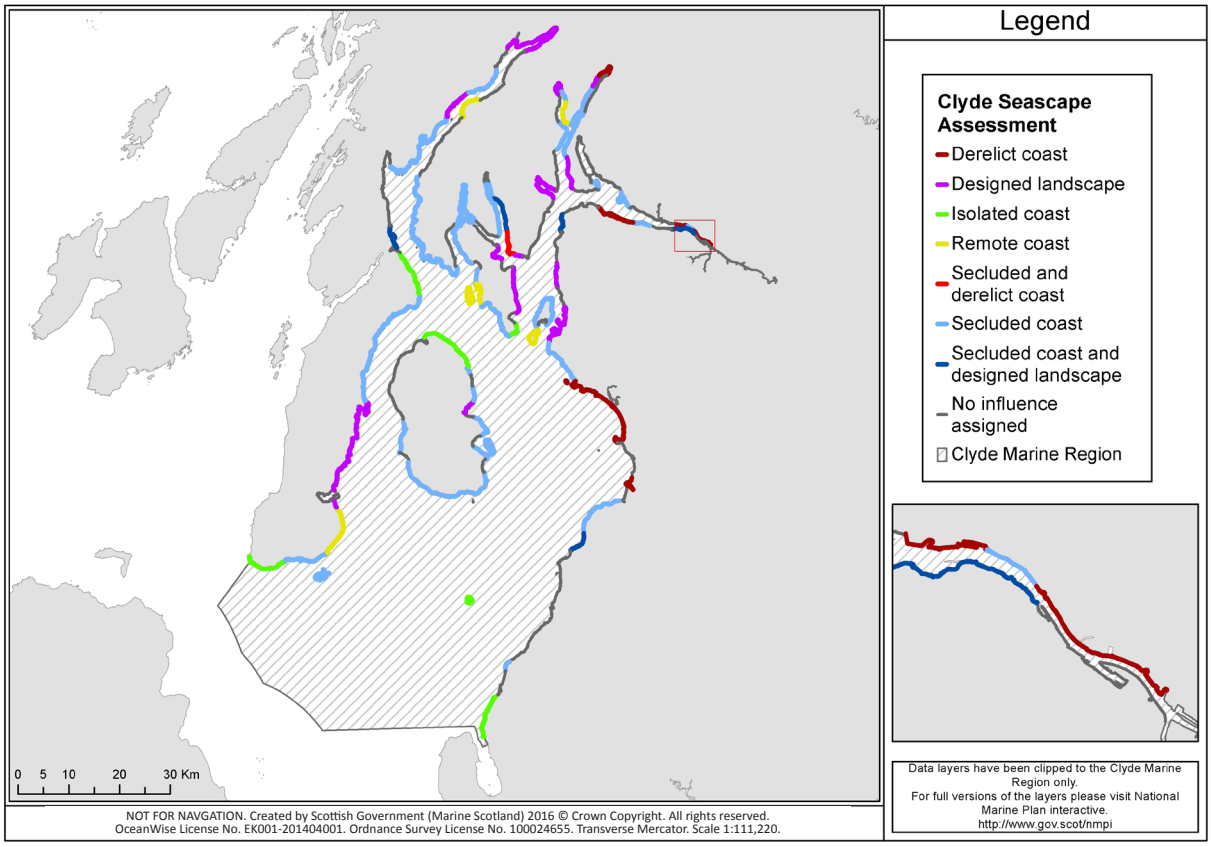
Figure 3.13. Greenock and Loch Striven



© PETER SANDGROUND

Map 9. Seascape areas identified in the Seascape assessment of the Clyde Marine Region

N.B. Culzean designed landscape in Ayrshire is not included on the map.



are characterised by almost constant activity, with sailing boats tacking through the channels, ferries crossing regularly, container ships working their way slowly through the main sea lanes and motor boats moving fast across the water from one settlement to another.

The study provides the following:

- A baseline of the key characteristics of coastal character at the strategic and local level
- Assessment of the sensitivity of the coastal character to different development and/or activities
- Identification of coastal areas with isolated/ remote qualities
- Identification of coastal areas with visual sensitivities

The map above (map 9) identifies areas of designed, derelict, secluded, isolated and remote coastline. For detailed guidance by seascape area, refer to the full report at www.clydemarineplan.scot/marine-planning/marine-planning-projects/#seascape.

- Derelict Coast – coastline that has previously been developed but is now no longer in use.
- Designed landscape – coastline that has been modified by man for aesthetic effect.
- Secluded coast – stretches of coast of any length, and which may be close to centres of population and /or human activity where there are few signs of built development. On the coast the dominant experience is likely to be of the natural processes of the sea and lack of built development. These may be areas dominated by agriculture, policy of other woodland. They will not be areas immediately overlooked by significant built development.
- Isolated coast – stretches of coast distant from centres of population and lacking obvious signs of development and of very significant environmental, cultural and economic value. By their nature these areas also tend to be relatively long, more than 1.5km in length, as well as being difficult to access other than by sea or, on land, by foot, bicycle or other non-vehicular mode of transport. They are also likely to be subject to designation or some other measure of significant environmental value.
- Remote coast – stretches of coast which lack obvious signs of development and have semi-natural qualities in terms of vegetation pattern. The dominant experience is of the natural processes of the sea and lack of built development. These stretches of coast are likely to be relatively long, more than 1.5km in length, as well as being difficult to access other than by sea or, on land, by foot, bicycle or other non-vehicular mode of transport.

ECOSYSTEM SERVICES[56]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Cultural	Health & Wellbeing. Tourism Aesthetics Heritage	Spending time by the sea has long been recognised for its benefits to health and wellbeing. The seascape has aesthetic properties that have inspired a wealth of literature and art.[57] Residents of west coast urban areas, in particular Glasgow, along with visitors from further afield take great pleasure in a visit to enjoy the views 'Doon the Watter'.

56. Marine Climate Change Impacts Partnership, 2015a
57. UK National Ecosystem Assessment, 2011

4. Condition of the Region
CLEAN AND SAFE

4.1 Water Framework Directive – Classification of transitional and coastal waters

Monitor Inner Firth, Loch Long, Loch Goil and south Bute to east of Arran 'corridor' for continued Good status



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SEPA first (2009) and second (2015) River Basin Management Plans

SEPA Water Environment Hub www.sepa.org.uk/data-visualisation/water-environment-hub/

SEPA Water body information sheets http://apps.sepa.org.uk/waterbodydatasheets/

Scotland's Marine Atlas Clyde: no score included

Introduction

The European Union (EU) Water Framework Directive (WFD) was adopted in 2000, for the protection, improvement and sustainable use of rivers, lochs, ground, transitional[58] and coastal waters across Europe. The WFD was transposed into Scottish law as the Water Environment and Water Services (Scotland) Act 2003 (WEWS Act),[59] the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) and their amendments.[60] CAR applies regulatory controls over activities which may affect Scotland's water environment such as discharges, diffuse pollution, abstractions, impoundments and engineering works on inland waters and they also protect groundwater.

The Scottish Environment Protection Agency (SEPA) is the lead national authority responsible for implementing the WEWS Act, in partnership with other responsible organisations such as Scottish Natural Heritage (SNH), Scottish Water, Forestry Commission Scotland, Scottish Canals, Local Authorities, District Salmon fisheries board and National park authorities. SEPA is also responsible for the enforcements of CAR.[61]

River Basin Management

Water management in the UK is carried out based on the geographical and hydrological unit of river basins. The WFD requires the production of the Scotland river Basin District (all of the CMR's water bodies are within the Scotland River Basin District) and Solway Tweed river basin district River Basin Management Plans (RBMPs). They will identify the current condition of water bodies, where activities are reducing the quality of water bodies, and will describe and carry out actions required to ensure waters meet the necessary standards. The RBMPs set out statutory objectives needed to deliver environmental improvements over a six yearly cycle up until 2027.[62, 63]

Within the Scotland River Basin District, river basin catchment areas are organised into nine Area Advisory Groups (AAGs) which contribute to the development and the delivery of the River Basin Management Plan. These groups provide a platform for disseminating information on the river basin management process and help identify opportunities for joint working. In addition, active engagement and partnership working will be targeted at the appropriate scale; this may involve small delivery groups at a single water body level or at a catchment level. There are two AAGs in the Clyde Marine Region (CMR) – Argyll and Lochaber, and Clyde.[64] The River Basin Management Plan for the Scotland River Basin District identifies priorities for environmental improvements and protection and set objectives for water bodies in these two areas.

The Clyde AAG area includes all of the land that drains into the Rivers Clyde, Ayr, Irvine, Leven, White and Black Cart Waters and Kelvin. The area covers

58. Areas of water found at river mouths and estuaries which are partly saline, but are also affected by freshwater flows from upstream
59. Water Environment and Water Services (Scotland) Act 2003
60. Scottish Environment Protection Agency, g
61. Scottish Environment Protection Agency, d
62. Natural Scotland, 2015
63. Scottish Natural Heritage, 2016b
64. Scottish Environment Protection Agency, a

11,139km^2 and is made up of 28 catchment areas, 17 of which include transitional or coastal water bodies. The south east of the Mull of Kintyre, Loch Fyne, Campbeltown loch and the Kilbrannan Sound water bodies make up the small area of the Argyll and Lochaber advisory area that is part of the CMR. Taking forward lessons learned in the first RBMP phase, SEPA intend to work flexibly with AAGs and other partners during the second RBMP. This means not necessarily implementing the objectives of the plan through the AAGs but working adaptably in each area depending on issues faced and local involvement.

Classification of water body status

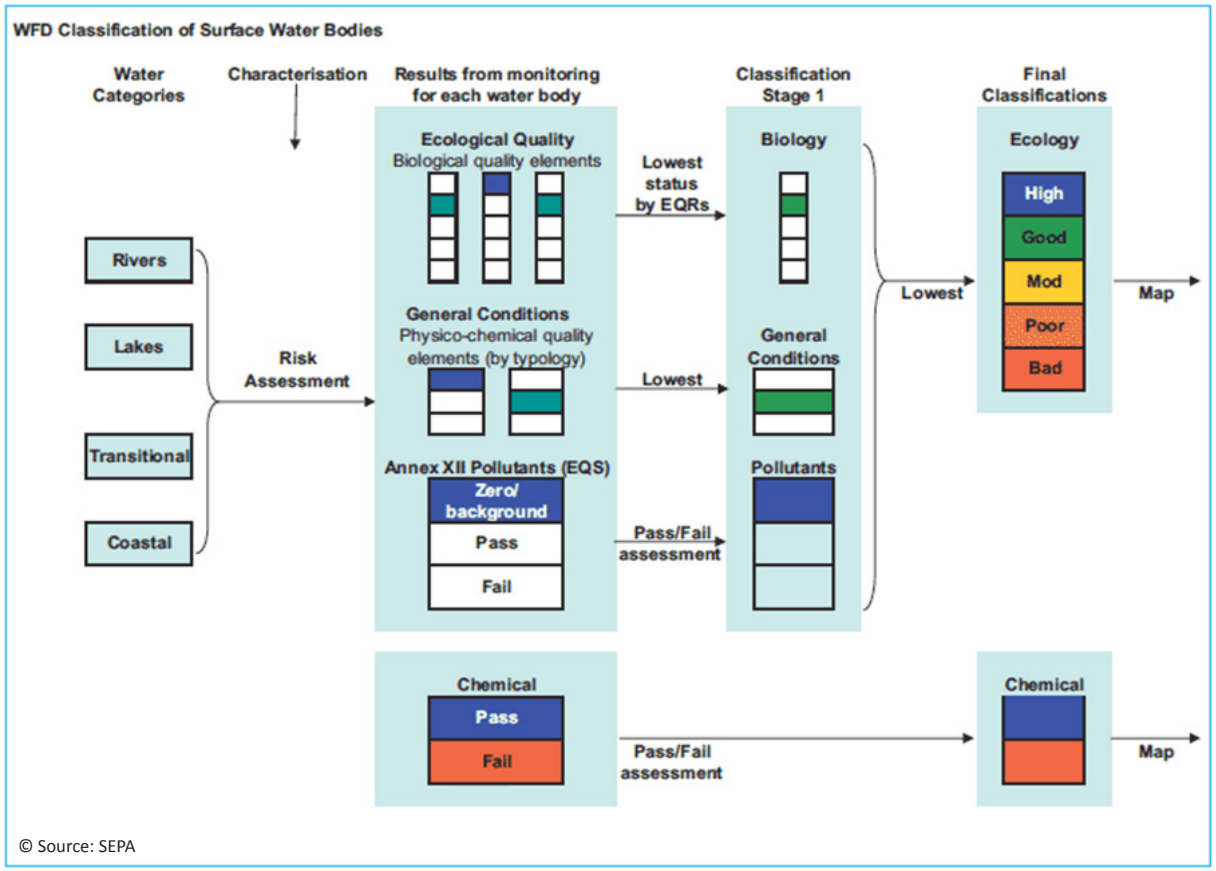
Each water body is classified according to its ecological condition from *Bad* to *High*. The status of a water body is determined by the lowest-classed quality element. Water bodies achieving less than *Moderate* status require action to be taken on the pressures affecting the water body; SEPA's aim is for water bodies to be at *Good* or higher status.

Some of the surface water bodies have been substantially modified over time for social and economic purposes including flood protection, hydropower generation, navigation, drainage and water storage for drinking water supply. Others may be totally man-made such as canals. The former are referred to as Heavily Modified Water Bodies (HMWB); canals are an example of artificial water bodies (AWB). Such water bodies may not be able to achieve *Good* status and are not subject to the conventional classification system. The principal objective in these cases is to achieve *Good Ecological Potential* (GEcP).[65] GEcP can be achieved when all efforts are made to mitigate man-made physical conditions, so they impact as little as possible on ecological or chemical conditions. It is called a 'potential' status as Good Ecological Status cannot be achieved under the conditions created by man–made features.

Water bodies of the Clyde Marine Region and their classification status

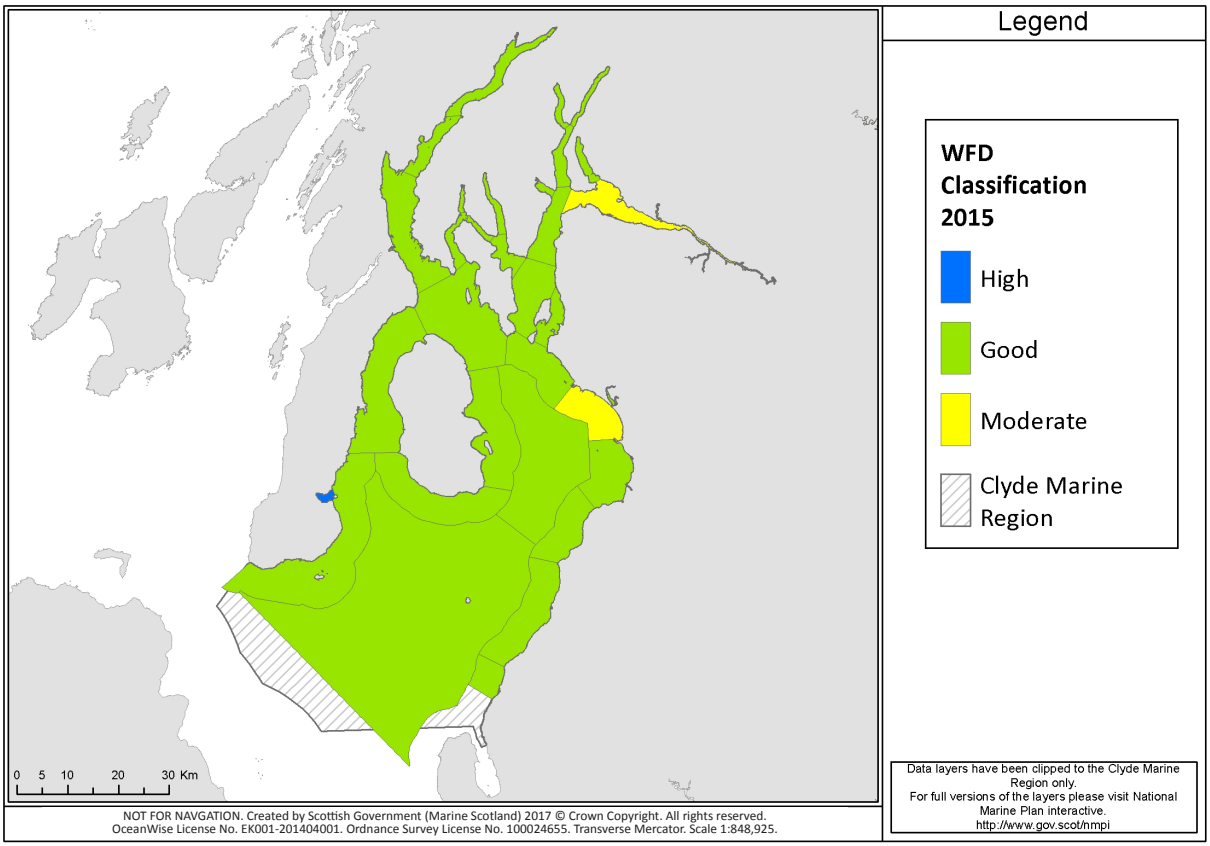
There are nine transitional and 26 coastal water bodies in the CMR. Table 4.1 lists all 37 water bodies, and shows their current and historical classifications. Table 4.2 outlines the pressures affecting water bodies classified as *Moderate* based on the 2014 classification results (at the time of writing, pressures related to the 2015 classification are not available).

Figure 4.1 WFD Decision tree for classification of surface water bodies



65. The Scottish Government, 2014a.

Map 10. WFD classification of water bodies in the Clyde Marine Region, 2015



The information in table 4.1 is taken from SEPAs Water Classification Hub: www.sepa.org.uk/data-visualisation/water-classification-hub – SEPAs Water Environment Hub: www.sepa.org.uk/data-visualisation/water-environment-hub/. This site provides information on water body status. Please check this site for updated information.

From 2014 to 2015 eight water bodies improved condition overall; none deteriorated. Seven water bodies: East Arran, Firth of Clyde Middle (Offshore), Loch Goil, Seamill and Ardrossan, sound of Bute, Loch Long North and Loch Long South improved from *Moderate* to *Good* status. Campbeltown Loch improved from *Good* to *High* Status. Of the remaining three water bodies which are at Moderate status, two, the Clyde Estuary Inner and Outer are HMWBs and the third, Irvine Bay is affected by morphological pressures. SEPA will work with relevant partners to improve the condition of water bodies at less than good status and to maintain the *Good* or *High* condition of the remaining water bodies.

Two of the HMWBs in the Clyde area are those of the Clyde river estuary. The inner and outer Clyde estuary has been changed by dredging to create channelization to improve waterways for traffic and also by the building of weirs and dams. In addition to these physical changes, the inner Estuary is exposed to point source pollution from sewage and industrial waste disposal. The Clyde estuary water bodies have consistently received *Moderate Ecological Potential*.[67] The other two HMWBs are Ayr estuary and Girvan estuary; both of these water bodies have *Good Ecological Potential*.

66. Scottish Environment Protection Agency, F
67. Scottish Environment Protection Agency, F

Table 4.1 Classification status of transitional and coastal water bodies in the Clyde Marine Region, from 2008-2014 and the pressures (2014) affecting these water bodies.[68,69]

WATER BODY TYPE	SUB BASIN	WATER BODY	2008	2009	2010	2011	2012	2013	2014	2015
TRANSITIONAL	CLYDE	Ayr Estuary	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP
		Ballantrae Lagoon North	High	High	High	High	High	High	High	High
		Ballantrae Lagoon South	High	High	High	High	High	High	High	High
		Clyde Estuary – Inner (incl. Cart)	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP
		Clyde Estuary – Outer	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP	Moderate EcP
		Gare Loch	Good	Good	Good	Good	Good	Good	Good	Good
		Girvan Estuary	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP	Good EcP
		Garnock/Irvine Estuary	Good	Good	Good	Good	Good	Good	Good	Good
		Stinchar Estuary	High	High	High	High	High	Good	Good	Good
COASTAL	CLYDE	Ayr Bay	Good	Good	High	High	High	Good	Good	Good
		Ballantrae	Good	Good	High	High	High	Good	Good	Good
		Culzean	Good	Good	Good	Good	Good	Good	Good	Good
		East Arran	Moderate	Good	Moderate	Moderate	Moderate	Moderate	Moderate	Good
		Firth of Clyde inner-Dunoon and Wemyss Bay	Good	Good	Good	Good	Moderate	Moderate	Good	Good
		Firth of Clyde inner Cumbraes	Moderate	Moderate	Moderate	Good	Good	Good	Good	Good
		Firth of Clyde Middle (offshore)	Moderate	Good	Moderate	Moderate	Moderate	Moderate	Moderate	Good
		Firth of Clyde Outer (offshore)	Moderate	Moderate	Moderate	Moderate	Good	Good	Good	Good
		Girvan	Good	Good	High	High	High	Good	Good	Good
		Holy Loch	Good	Good	Good	Good	Good	Good	Good	Good
		Irvine Bay	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
		Kyles of Bute	Moderate	Moderate	Good	Good	Good	Good	Good	Good
		Largs Channel (Fairlie Roads)	Good	Good	Good	Good	Good	Good	Good	Good
		Loch Goil	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Good
		Loch Striven	Good	Good	Good	Good	Good	Good	Good	Good
		Rothesay	Good	Good	Good	Good	Good	Good	Good	Good
		Seamill and Ardrossan	Moderate	Good	Moderate	Moderate	Moderate	Moderate	Moderate	Good
		Sound of Bute	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Good
		South Arran	Moderate	Moderate	Moderate	Moderate	Good	Good	Good	Good
		Loch Long North	Good	Good	Good	Good	Good	Moderate	Moderate	Good
		Loch Long South	Good	Good	Good	Good	Good	Moderate	Moderate	Good
		Loch Riddon	Good	Good	Good	Good	Good	Good	Good	Good
	ARGYLL AND LOCHABER	Campbeltown Loch	Moderate	Moderate	Moderate	Moderate	Moderate	Good	Good	High
		Kilbrannan Sound	Moderate	Moderate	Moderate	Moderate	Good	Good	Good	Good
		Loch Fyne Middle	Good	Good	Good	Good	Good	Good	Good	Good
		Loch Fyne Outer	Good	Good	Good	Good	Good	Good	Good	Good
		Loch Fyne Upper	Good	Good	Good	Good	Good	Good	Good	Good
		Mull of Kintyre – South East	Moderate	Moderate	Moderate	Moderate	Good	Good	Good	Good

68. Scottish Environment Protection Agency, F

69. Due to improvements in data collection and reviews of classification methods, standards for measuring the status of a water body change from year to year. As a result the table may indicate that water bodies have degraded in classification. This may not necessarily be due to failure to prevent deterioration in such water bodies, but as a result of classification standards becoming stricter; this is indicated where it is the case. Pressures also change from year to year based on updated information.

Table 4.2 Pressures on water bodies classified at less than Good status

N.B. Pressures related to the 2014 classification are noted here as the pressures related to the 2015 classifications were not available at time of writing.

WATER BODY	STATUS	PRESSURES (2014)[70]
Clyde Estuary-Inner (incl. Cart)	Moderate EcP	• Point source discharges from waste water (sewage) disposal to be dealt with 2021-2027. • Unknown pressure on water quality to be dealt with 2015-2021
Clyde Estuary-Outer	Moderate EcP	• Modifications to bed, banks and shores as a result of land uses and navigation. This will be addressed from 2021-27 through partnership work by SEPA, other public bodies, voluntary organisations and land managers
Irvine Bay	Moderate	• Modifications to bed, banks and shores as a result of land uses and navigation. SEPA have phased completion of the work to improve the physical condition of the water body for 2021-2027

When a water body shows a downgrade in classification, this could be due to the review of the methodology used in classification, rather than any actual environmental change. This is the case for Stinchar Estuary, when the status of the water body went from *High* in 2012 to Good in 2013 and this was due to the fact that in 2013 the classification assessment started to consider fish in transitional waters. For the classification to achieve *High* status fish fauna has to have ecological elements (such as: species composition, abundance, presence of indicator species, number of taxa and number of estuarine resident taxa) consistent with undisturbed conditions. The tool used to access the fish element (and also other elements) in water bodies shows when there are pressures affecting an element, but it is not known at this time what those pressures may be.

One of the objectives of the WFD is for water bodies to attain GEcS and GEcP. SEPA is responsible for working with partners to set out measures to deal with the pressures affecting water bodies. This is a collaborative process as sometimes improving measures are the responsibility of external authorities, such as Scottish Water, or can only be achieved through partnership work with various stakeholders. Overall, SEPA seeks to make sustainable improvements where possible.

ECOSYSTEM SERVICES[71]		
SERVICE TYPE	BENEFITS PROVIDED	COMMENTARY
Provisioning	Food	Poor water quality could impact on the system's ability to provide food that is safe to eat. Healthy habitats support a functioning ecosystem and stocks of commercially important species through provision of spawning and nursery areas.
Regulating	Waste processing and assimilation	Enhancing the capacity for the ecosystem to provide waste processing and water purification services will ensure that provisioning and cultural services can be provided. Some parts of the CMR are impacted by waste water and pollution. Local contamination can exceed the capacity, in particular of an estuarine ecosystem, to remediate or assimilate it.
Cultural	Recreational activities and sense of place	Clean and safe water is essential for recreational activities such as immersion watersports. Improvement in the condition of water bodies can potentially lead to increased biodiversity and productivity, resulting in a greater sense of place and increasing a place's educational and inspirational capacity.
Supporting services underpin the provision of other services		Supporting services underpin the provision of other services Coastal and transitional water bodies in the CMR support primary production, nutrient cycling and photosynthesis. Nutrient processing in sediments depends on invertebrates disturbing and irrigating the sediment and is fundamental to the survival of other marine organisms. Where supporting ecosystem services are functioning fully, they support stocks of commercially important species. Improving the ecological and chemical classification of these water bodies (including sediments) will optimise these supporting services and help improve overall ecosystem resilience.

70. Scottish Environment Protection Agency, i
71. UK National Ecosystem Assessment, 2011

4.2 Hazardous substances and their biological effects

Clyde estuary and inner Firth



Other Lochs and Outer Firth



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Clean Safe Seas Environmental Monitoring Programme (CSEMP) data www.bodc.ac.uk/projects/data_management/uk/merman/assessments_and_data_access/csemp/

Marine Scotland Science Regional Assessment of Hazardous Substances in Coastal and Offshore Marine Environments: 1999-2009 marinedata.scotland.gov.uk/dataset/regional-assessment-hazardous-substances-coastal-and-offshore-marine-environments-1999-2009

Scotland's Marine Atlas Clyde score: 'Generally some concerns but improving, with many local concerns'. Regional scoring is consistent with this.

Introduction

Hazardous substances are toxic substances; metals and chemicals which accumulate in the environment and in organisms and have a negative impact on them. Hazardous substances can bioaccumulate (gradual build-up of substances in an organism over time) and are biomagnified (pollutants become concentrated in organisms as they move up food chains and webs).[72] Specific biological effects are discussed further on in this chapter.

Types of hazardous substances

Polycyclic aromatic hydrocarbons (PAHs) are widespread pollutants which enter the marine environment through atmospheric deposition, road run-off and industrial discharges. Car emissions contribute more than 50% of PAH inputs to the atmosphere and 28% are from residential and industrial fuel combustion. PAHs are known to be mutagenic and carcinogenic.

Polychlorinated biphenyl hydrocarbons (PCBs) were widely used in transformers, capacitors, hydraulic fluids and as plasticisers in paints, plastics and sealants and can cause endocrine disruption, immunosuppression and Vitamin A deficiency. Production in Western Europe ceased in the 1970s, but continued in closed systems in the UK until 1986.

Polybrominated diphenyl ethers (PBDEs) are an organobromine compound and were used in the production of flame retardants. These were historically released into the environment during manufacturing and through atmospheric transportation. They continue to leak from treated materials through everyday use of household products. While effects on humans are not known, animal studies show that they are endocrine disruptors and can affect the central nervous system and the brain.[73] Although heavy metals can be found naturally in the environment at low levels, at elevated levels cadmium, for example, has long term effects on health and mercury is highly toxic.[74]

Tri-Butyl-Tin (TBT) was extensively used in the past to protect hulls from fouling but caused damage to many species in the marine environment; its use was phased out for boats under 25m from 1988 and then for all boats and ships by 2008.

Historic legacy of hazardous substances in the Clyde Marine Region

Hazardous substances are found in high concentrations in the Clyde Marine Region (CMR) due to the Clyde's industrial history and large population. Higher concentrations of contaminants are usually found in estuaries rather than on the open coast. Furthermore, Clyde sites have a greater potential to accumulate contaminants due to the hydrophobic nature of PCBs and PAHs. This means they accumulate in sediment and accumulate more readily in sediment types which have a high organic content and smaller particle size (larger surface: volume ratio), so higher levels can be found in muddy, rather than sandy sediments[75] (See Chapter 5.3 Shallow and Shelf Subtidal Sediments, for a map of sediment types in the CMR).

In terms of historic inputs, there are three areas in the CMR which are known point sources; the sewage sludge dump site at Garroch Head, the dredge spoil dump site at Cloch point and the former naval base at Holy Loch. All are located in the inner Firth. Annually, 1,500,000 tonnes of sewage sludge (industrial and domestic waste) from the greater Glasgow area was dumped at Garroch head from 1904-1998, resulting in a highly concentrated area of contamination. This was stopped as part of the UK's obligation under the EC Urban Waste Water Treatment Directive (see Chapter 6.10 Waste Water Treatment and industrial outfalls).

72. Webster *et al*., 2010
73. Webster *et al*., 2010
74. Webster *et al*., 2010
75. Webster et al., 2005



Creel boat © PETER SANDGROUND

Organic enrichment of the sediment from the sludge has caused levels of heavy metals, PCBs and PAHs to become elevated (due to sediment types with higher organic content having a greater potential to accumulate these pollutants). Concentrations of organic compounds remain high in these areas in both biota and sediment following the cessation of dumping. A study published in 2005, found that PCB concentrations were not found to have decreased significantly since dumping ceased in 1998. However, they were less persistent in plaice liver sampled from Garroch Head after dumping had ceased.[76]

Holy Loch was used as a United States Navy Submarine base from 1961,[77] until closure of this base in 1992.[78] Video surveys of the site following closure showed a large amount of debris on the sea bed – mainly scrap metal, furniture, electrical equipment and small vessels. The Ministry of Defence led a working group and SEPA carried out a study to analyse contaminants in the sediment and in mussels, to examine the potential for bioaccumulation in the loch. Samples of sediment were taken from several sites around the loch and elevated levels of heavy metals and PCBs were found at depths of 5-10cm, suggesting that contamination had been higher in the past. The contamination of PCBs and some some metals was described as 'severe but localised'. Body burdens in mussels for PCBs and heavy metals examined before and after debris were removed (which may have caused the release of sediment-bound contaminants) showed no significant changes in concentrations.[79]

Natural and anthropogenic activities carried out in the marine environment have the potential to remobilise contaminated sediments and release contaminants from sediments into the water column. Desorption rates and times depend on the type of contaminant, size of sediment particles and environmental factors, such as exposure to oxygen.[80]

76. Webster *et al*., 2005
77. Baxter, 2011
78. Miller *et al*., 2000
79. Miller *et al*., 2000
80. Eggleton and Thomas, 2004

Regulating and monitoring hazardous substances

Some contaminants cannot be physically removed once they have entered a system; some can only reduce by degrading or becoming more dispersed over time.[81] Regular monitoring ensures that concentrations do not pose a risk to human health, and where they do, action can be taken. There is potential to use shellfish, macroalgae, seagrass and saltmarsh to bio-remediate environments with excess chemicals.[82]

Most effects felt today are due to historic inputs and the persistent and semi-volatile character of some contaminants, meaning that they are still present in the environment. In the marine environment, many are considered ubiquitous partly due to their wide usage, ability to travel long-ranges through atmospheric transportation and run off from land. It is acknowledged that the marine environment acts as a sink for contaminants. Increasing knowledge and awareness of the harmful effect of such chemicals over time has led to their production being stopped and their use banned.[83]

The Stockholm Convention entered into force in 2004 and is a global treaty designed to protect human health by eliminating 12 of the most harmful persistent organic pollutants (POPs – organic chemicals) from the environment. It also works towards supporting the transition to safer alternatives, targeting additional POPs for action and cleaning up stockpiles.[84]

Descriptors eight and nine of the Marine Strategy Framework Directive (MSFD) seek to ensure that concentrations of contaminants cause no effect and contaminants in seafood are below safe levels in order to achieve Good Environmental Status (GEnvS). OSPAR (the mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic, named for the Oslo and Paris conventions) monitors substances which may be of possible concern and has developed a strategy to prevent further pollution of the OSPAR Commission maritime area. This strategy aims to reduce discharges of hazardous substances, with the overall objective of ensuring concentrations are near background values for naturally occurring substances and close to zero for man-made synthetic substances in the marine environment.

The Water Framework Directive (2000) (see Chapter 4.1 for more information on the WFD classification of water bodies in the CMR) sets out strategies against pollution in water, outlining steps to be taken and producing a first list of priority substances which pose a threat to the aquatic environment. This was updated with the WFD daughter directive – the Directive on Environmental Quality Standards (2008), also known as the Priority Substances Directive. This sets environmental quality standards for substances in river, lakes, coastal and transitional waters.

The main monitoring programme in the UK is the UK Clean Seas Environment Monitoring Programme (CSEMP). This programme fulfils the monitoring requirements set by OSPAR and EU directives across the UK, and has been established under advice from the International Council for the Exploration of the Sea (ICES).[85] Monitoring for this programme in Scotland is carried out in cooperation between Marine Scotland and Scottish Environment Protection Agency (SEPA). As the central programme examining contaminants, the CESMP provides spatial and some temporal data when available for monitoring conducted across the CMR.

UK Clean Seas Environment Monitoring Programme results

CSEMP assessment results discussed below are available to view from this website: www.bodc.ac.uk/projects/data_management/uk/merman/assessments_and_data_access/csemp/ where they are mapped and more details are available for specific contaminants across all sites. They are also available to view on NMPi: marinescotland.atkinsgeospatial.com/nmpi/.

Monitoring for hazardous substances is carried out across 34 sites in the Clyde Marine Region for sediments. Additionally, monitoring for hazardous substances and for biological effects (such as imposex) in biota is carried out across 32 sites and in 5 species– European plaice (*Pleuronectes platessa*), European flounder (*Platichthys flesus*), dog whelk (*Nucella lapillus*), blue mussel (*Mytilus edulis*) and common dab (*Limanda limanda*). Depending on how long a site has been monitored, trends can be determined. The following assessment criteria are used:

- Background Assessment Concentration (BAC). Mean concentrations significantly below the BAC are said to be near background concentrations of a contaminant at a pristine or remote sire to be considered of no concern.[86]
- Environmental Assessment Criteria (EAC). Concentrations above EAC can cause adverse effects on marine life.
- Effects Range Low (ERL). Concentrations below the ERL rarely cause adverse effects in marine organisms.
- In assessing hazardous substances in biota, European Commission food standard (EC) is

81. Webster *et al.*, 2010
82. Marine Maritime Organisation
83. Webster *et al.*, 2010
84. Secreteriat of the Stockhold Convention http://chm.pops.int/default.aspx
85. Webster *et al.*, 2010
86. Baxter *et al.*, 2011

also used, when EACs are not available. ECs are the maximum acceptable concentrations in food for the protection of public health.[87]

For alkylated PAHs and organobromines in sediment, and in organibromines in biota, no assessment criteria has been developed, so no indication of contamination levels is given, but where possible a trend is.[88]

Assessment of sediments

Overall the assessment for hazardous substances in sediments in the CMR showed that there is a high proportion of results which are above ERL (could cause adverse effects on marine organisms) at monitoring stations in the inner Firth compared to other sites in the CMR. However, across the CMR, the chlorobiphenys congener CB118 was shown to be above EAC at 23 out of 29 monitoring stations and one particular PAH, Benzo [g,h,i]perylene was above ERL at 33 out of 34 monitoring sites. More details of the assessment are provided below. Of all the monitoring sites, North of Ailsa Craig showed a consistent picture of concentrations decreasing over 10 years; across all hazardous substances measured, 29 of the 46 had a downward trend.[89]

Metals

- All monitoring sites in the CMR have levels of chromium which are above ERL, except for at Pladda (off the south of Arran), which was below ERL. There are no results for monitoring of metals at Garroch head.
- Lead was above ERL at 12 out of 17 monitoring sites.
- Zinc was above ERL at 9 out of 17 sites with an upward trend (concentrations going up in the last 10 years) indicated at 2 sites: off Cloch point and at Lunderston Bay.
- An upward trend (concentrations increasing) was also seen off Cloch point and at Lunderston Bay for arsenic; all sites in the inner Firth were above BAC for arsenic.
- Metals across all inner Firth sites were assessed at above ERL or BAC except for cadmium which was below BAC or ERL at all sites.

PCBs

- Majority of sites were below BAC or EAC for all PCBs, except for CB118 which was above EAC at 23 out of 29 sites.

PAH (parents)

- Results were mixed for PAH (parents) in the inner Firth; a number of monitoring sites across a range of contaminants in this group were above ERL.
- Benzo [g,h,i]perylene, was above ERL at 33 out of 34 monitoring sites.

Assessment of Biota

CSEMP monitoring in biota includes sites in the outer Clyde estuary whereas monitoring in sediment does not. In the outer estuary there are a high number of results above EAC (in PAHs and PCBs) or EC food limits (for metals) and BAC in biota compared to other sites across the CMR.[90]

Metals

- Lead was above the EC food limit in blue mussels at Woodhall and in Flounder at Bowling.
- Cadmium in flounder was above the EC food limit at Bowling. At Ardrossan cadmium was below BAC and decreasing in the last 10 years. At all other sites, cadmium was below the EC food limit.
- Zinc was above BAC in blue mussel at 13 out of 18 monitoring sites throughout the CMR.
- Copper was above BAC in blue mussel at 9 out of 18 monitoring sites, all of which were in the Clyde estuary, inner Firth and Lochs Goil, Riddon and Striven.

PCBs

- A high number of results for PCBs were above EAC or above BAC in the outer Clyde estuary and inner Firth compared to the rest of the CMR.
- CB105 was above BAC all 14 sites monitored across the CMR. All species except dog whelk were tested.
- CB118 was above EAC for all monitoring sites across the CMR (all species except dog whelk were tested across 24 sites), except in blue mussels at Strone Point which were below EAC.

PAH (parents)

- PAH (parents) were measured in blue mussels and were generally below EAC across the majority of sites.
- An exception to this is Chrysene and Ideno[123-cd]pyrene, which were above BAC at every site monitored.
- Benzo[a]anthracene and Pyrene were above EAC in all sites monitored in the inner Firth and outer estuary.
- Fluroanthene was also above EAC at all sites monitored in the outer estuary and inner Firth as well as at Seamill Boydston, Loch Striven, Loch Goil and at the Loch Ryan monitoring site (the latter is outwith the CMR).

For a visual representation of CSEMP monitoring results, please refer to the National Marine Plan interactive[91] or the CSEMP assessment results page https://www.bodc.ac.uk/projects/data_management/uk/merman/assessments_and_data_access/csemp/.

87. British Oceanographic Data Centre, 2014
88. British Oceanographic Data Centre, 2014
89. British Oceanographic Data Centre, 2014
90. British Oceanographic Data Centre, 2014
91. Marine Scotland, 2016a



Starfish © SUE SCOTT, SNH/MNCR

Concentrations of contaminants in the Clyde were described in a 2009 study as *'generally at levels such that there is an unacceptable risk of chronic effects occurring in marine species. This is mainly due to historic industrial inputs. However, downward trends were detected for Pb and PAHs in Clyde sediment indicating that the implementation of relevant regulations is beginning to have a positive environmental impact.'*[92] It is worth noting, that dredging and disposal are regulated activities within the CMR and that disposal in marine waters will only be licensed by Marine Scotland if it can be demonstrated that there is no unacceptable risk to aquatic life.

Biological effects of hazardous substances

Scotland's Marine Atlas highlights several examples of biological effects on living marine organisms. These include imposex (a disorder which causes females to develop male reproductive organs) in dog whelks, which is caused by exposure to the chemical TBT, an anti-fouling paint used on boats and ships since the 1970s. This has shown a significant downward trend, reducing to background levels in some areas since the ban on the use of TBT in paints used on both commercial and recreational vehicles.[93]

Imposex results

- Measurements were below EAC at all sites (15 were sampled). At Ballantrae, results were below BAC. Measurements at Loch Ryan were above EAC.

EROD results

The enzyme 7-Ethoxyresorufin-O-deethylase (EROD) is expressed in fish livers when certain contaminants are metabolised. Measuring this can show whether organisms are being exposed to contaminants through the food they eat.

- EROD was tested for in female flounder, dab and plaice at 6 monitoring sites. There is no assessment criteria available for some species; and for dab at Holy Loch concentrations were below BAC.
- Results in males, across the same species, were all above BAC at all sites; again except for dab at Holy Loch which was below BAC.

Genetic analysis of mussels has revealed the extent of adaptive stress response to contaminants.[94] Food Standards Scotland manages the Official Controls chemical contaminants monitoring programme, whereby shellfish from Classified Shellfish Harvesting Areas (CSHA) are analysed for hazardous substances to ensure they are safe for consumption.[95] For more information on CSHAs see Chapter 4.3 Microbiological contamination – Shellfish water protected areas.

92. Webster *et al.*, 2010
93. Baxter *et al.*, 2011
94. Baxter *et al.*, 2011
95. Food Standards Scotland, 2015b

ECOSYSTEM SERVICES[96]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food	The presence of hazardous substances in seabed sediment can cause chronic effects on living marine organisms. This can impact negatively on community structures and in turn, impact on food webs and chains. Hazardous substances can also have a genetic effect and disrupt hormones of organisms, affecting their capacity to reproduce. Many hazardous substances in biota are above the EC food limit in the outer Clyde estuary and inner Firth. Where levels of hazardous substances exceed set limits in the CMR, bivalve shellfish are not considered fit for human consumption.
Regulating	Waste processing and detoxification	Hazardous substances can affect the ecosystem's ability to provide water purification services, and can limit the capacity for provisioning and cultural services to be provided.
Supporting services underpin the provision of other services		Marine sediment can act as a sink for hazardous substances where these substances can then detoxify and degrade over time. There are concerns that certain parts of the Clyde estuary and inner Firth have been historically overloaded with contaminants and that this will impact the ability of the sediments to perform this essential ecosystem service.

96. UK National Ecosystem Assessment, 2011

4.3 Microbiological contamination – Shellfish water protected areas



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SEPA Water Environment Hub www.sepa.org.uk/data-visualisation/water-environment-hub/

Food Standards Scotland www.foodstandards.gov.scot/food-safety-standards/advice-business-and-industry/shellfish

Scotland's Marine Atlas Clyde score: 'Generally few concerns and no trend, but with some local concerns'. Regional assessment considers more recent SWPA designation and status.

Introduction

Harmful toxins and microorganisms can become concentrated in shellfish flesh and are harmful to humans once consumed. These include: *Escherichia coli* (bacteria related to faecal contamination); phytoplankton and toxins produced by phytoplankton including: paralytic shellfish poisoning toxins, amnesic shellfish poisoning toxins and lipophilic shellfish toxins and chemical contaminants.[97] There are two levels of protection to public health; Shellfish Water Protected Areas (SWPAs) and Classified Shellfish Harvesting Areas (CSHAs).

Shellfish Water Protected Areas

The designation order (The water Environment (Shellfish Water Protected Areas: Designation) (Scotland) Order 2013) identifies the 84 areas around Scotland as Shellfish Water Protected Areas. The shellfish growing water areas are protected and, where necessary improved by a package of measures integrated with the river basin management process.[98]

These areas have been designated by Scottish Government based on the existing Shellfish Growing Waters (which were created under the Shellfish Waters Directive which was managed by SEPA and repealed in 2013) and attempted to overlap with the existing CSHAs (which are managed by Food Standards Scotland, formerly Food Standards Agency Scotland), while also taking into consideration potential growth of the industry. These areas are reviewed every six years. There are six SWPAs within the Clyde Marine Region (CMR), accounting for 7% of all the SWPAs in Scotland, and they include: Fairlie, Kyles of Bute, Lamlash, Loch Long, Loch Striven and Loch Fyne.[99] These are shown in Map 11. This legislation does not prevent sites being developed in zones outside of the designated areas.

Figure 4.6 Oyster farming



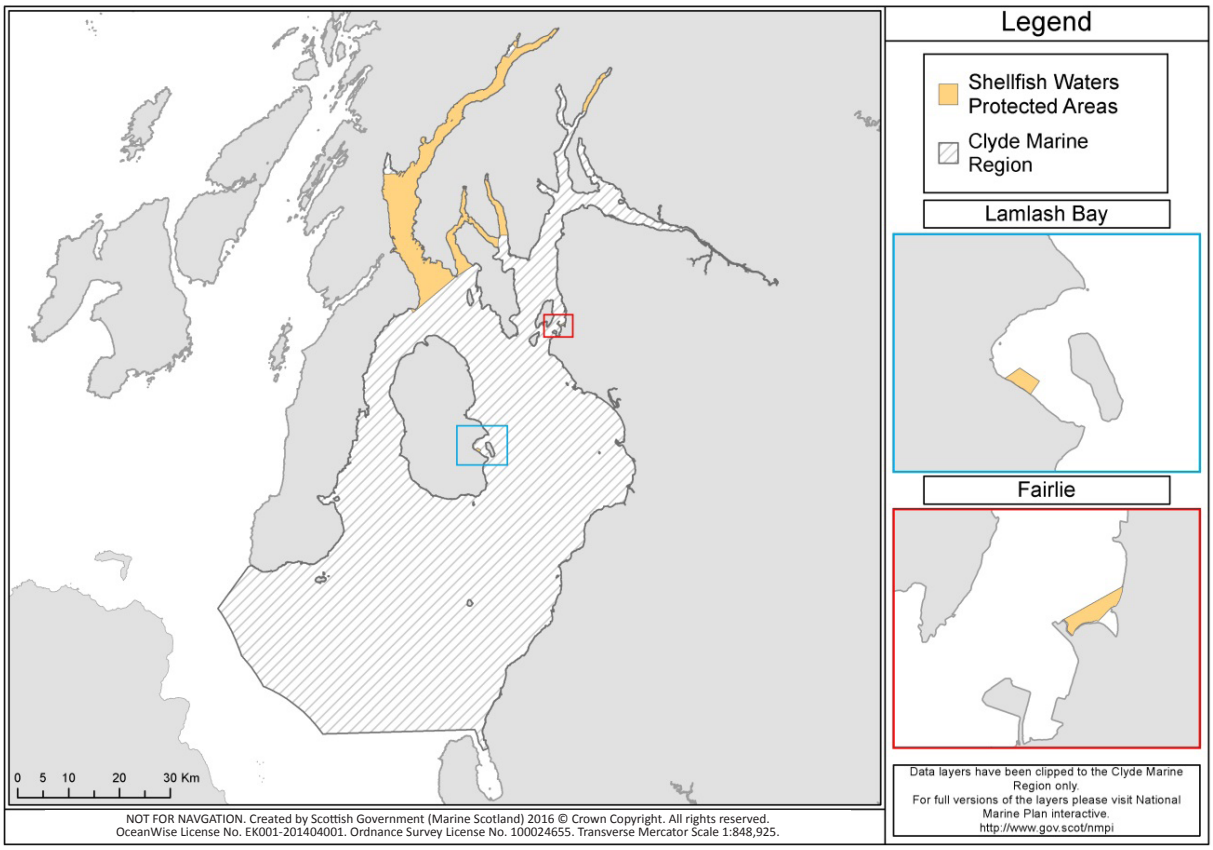
© JOHN CHARITY, SNH

SWPAs are classified as 'good', 'fair' or 'insufficient' according to the amount of *E. Coli* present in shellfish samples taken from SWPAs.[100] The objective under the SWPA Designation is for the SWPA's to reach 'good'; results highlighted on SEPAs Water Environment Hub show that none of the SWPAs in the CMR have reached target objective. All were classified as 'fair' from 2011-2014 except Loch Long which was classified as 'insufficient' for that period.

SEPA has set a timeline for the SWPAs to reach target objective or 'good' by 2027, except for Fairlie SWPA where the target is 2021. SEPA gives the reason for the failures to meet the objective as diffuse pollution from a rural source affecting water quality. The target objective at Fairlie SWPA will be met through priority catchment action. Loch Fyne, Loch Long, Lamlash and Loch Striven protected areas will be addressed by focussed area action by public bodies and land managers working together. It is still to be determined how to address the status of the protected area at Kyles of Bute.[101] As this information becomes known it will be added to SEPA's Water Environment Hub www.sepa.org.uk/data-visualisation/water-environment-hub/?riverbasindistrict=Scotland.

97. Food Standards Scotland, 2015b
98. The Scottish Government, 2016d
99. The Scottish Government, 2016e
100. The Scotland River Basin District (Quality of Shellfish Water Protected Areas) (Scotland) Directions 2015
101. Diffuse pollution priority catchments have been identified by SEPA as catchments failing to meet environmental standards. Fourteen priority catchments, containing some of Scotland's most important waters (for conservation, drinking water, bathing and fishing), have been selected using a risk based approach for action in the first basin planning cycle. Work will also include the mitigation of other water environment impacts, such as morphological change, abstractions, flooding and alien species, where these are also causing waterbody downgrades. The first RBMP identified the River Ayr, River Irvine, River Garnock and North Ayrshire Coast as catchments in or near the CMR for priority action.

Map 11. Shellfish Water Protected Areas in the Clyde Marine Region



Classified Shellfish Harvesting Areas

Food Standards Scotland (FSS) classifies and monitors Classified Shellfish Harvesting Areas (CSHAs) as a food hygiene control measure to protect public health. In this process, shellfish harvesters apply to their Local Authority to have a site classified for harvesting. However, CSHAs do not always lie within designated SWPAs. Samples from CSHAs are monitored for biotoxins and *E. coli*, presence of either would result in an intervention to ensure that a safe product reaches the consumer market. Depending on the amount of *E. coli* found, the FSS provides a number of different options to a harvester – either submitting shellfish product to purification or heat treatment/cooking of shellfish product by an approved method. When levels reach over 46,000 *E. coli*/100g of flesh, harvesting is not permitted.[102] Table 4.4 shows the action taken, depending on the level of *E. coli* found in samples. Discovery of biotoxins in harvesting areas is more reactive, and results in a temporary closure of sites until biotoxin levels return to normal.[103] More information on biotoxin monitoring is available in Scotland's Marine Atlas.[104]

The FSS classification for 2015-2016 identifies 20 shellfish harvesting areas within the CMR. All were given a classification rating of A, or B apart from the Campbeltown Loch production area which was given a classification rating of C for the period June-October. Two sites: Stevenson Sands Razors

Table 4.4: Shellfish Harvesting Area classification (Food Standards Scotland) categories and permitted levels of E.coli/100g flesh, and required treatments.

CATEGORY	RESULT	ACTION
A	Less than or equal to 230 E. coli/100g of the flesh	May go directly for human consumption if end product standard met
B	Not exceeding 4600 E. coli/100g of the flesh	Must be subject to purification, relaying in Class A area (to meet Category A requirements) or cooked by an approved method.
C	Not exceeding 46,000 E. coli/100g of the flesh	Must be subject to relaying for a period of at least 2 months or cooked by an approved method.
Above 46,000 E. coli/100g of the flesh		Harvesting not permitted.

102. Food Standards Scotland, 2015b
103. Food Standards Scotland, 2015b
104. Baxter *et al.*, 2011

North and South were declassified in 2015.[105] Sites can become declassified due to failure to produce samples of analysis, or cessation of harvesting from a site and so trends in declassification are not a reflection in the trend of the environment. Two areas were declassified in 2014-15, to be later reclassified in 2015-16. These were Arran: Pirnmill and Carradale Bay.[106] FSS works with Local Authorities and harvesters to maintain closely monitored standards. These partners also have an effective communication network with information of sudden or emergency closures, indicating that this is a well regulated sector, with little or no concerns for public health.[107]

Active aquaculture production sites in the Clyde Marine Region

There are over 70 active aquaculture production sites in the CMR, details of these including their locations and production is discussed in Chapter 6.3 Aquaculture.

ECOSYSTEM SERVICES[108]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food	Some shellfish harvesting areas in the CMR are not in a suitable condition to carry out shellfish farming and harvesting without purification. Purification enables the supply of food, socio-economic activity and income generation despite the fact that the ecosystem service is not functioning.
Regulating	Clean water	Whilst *E. coli*, phytoplankton and biotoxins are naturally present in the marine environment, there is potential in some parts of the CMR that nutrient enrichment and insufficiently treated waste water exceeds the capacity of plants and micro-organisms to assimilate, buffer or process contaminants. This can prevent effective waste processing and water purification services, resulting in higher than safe levels of E. coli, phytoplankton and biotoxins.

105. Food Standards Scotland, 2015c
106. Food Standards Scotland, 2015a
107. Food Standards Scotland, 2015b
108. UK National Ecosystem Assessment, 2011

4.4 Microbiological contamination – Bathing waters



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SEPA bathing water profiles
http://apps.sepa.org.uk/bathingwaters/Profiles.aspx

SEPA Bathing waters report 2014/15 and 2016
http://apps.sepa.org.uk/bathingwaters/

Scotland's Marine Atlas Clyde score: 'Some concerns but improving'. Regional assessment is consistent with this.

Introduction

Bathing waters are monitored and protected to safeguard the public health of users. SEPA carries out regular monitoring of faecal indicator organisms, which can cause gastrointestinal illness and ear infections. These are: *Escherichia coli* and intestinal enterococci, cyanobacterial blooms, macroalgae and marine phytoplankton.[109] The monitoring results are published to ensure protection of public health for beach users.

Monitoring and results

Monitoring is carried out by analysing over 1,500 water samples taken throughout the bathing season (1 July – 15 September) from all 84 designated bathing waters around Scotland. Sampling results are published within a few days of being taken, online or via electronic boards at some sites. Daily water predictions are also available at some sites.[110] These sites are also important for recreational activities such as immersion water sports including: dinghy sailing, kayaking and windsurfing. To guide efficiency in monitoring and protecting, sites which are visited by, on average, 150 or more people in a single day (during summer) are designated bathing sites under the Bathing Waters Directive,[111] though of course there will be many other waters which are not monitored which are suitable for recreation and are safe to use as well as those which will be in poor or unsafe condition.

Of the 84 bathing water sites designated in Scotland, 14 are in the Clyde Marine Region (CMR). They are listed in table 4.5.[112] From 2005-2014 monitored bathing waters were classified against European Standards to give an overall rating of (from highest to lowest) 'guideline' pass, 'mandatory' pass or 'fail'.

In 2016 the revised 2006 Bathing Water Directive came into operation and a new assessment system based on updated science was implemented for the 2015 results. In this new system, bathing waters fall under one of four classification types, based on a dataset gathered over four years giving an indication of 'normal' water quality condition in each location. Bathing waters are classified as protected areas under Annex IV of the WFD and continue to be protected under the Bathing Waters Directive. Currently 80% of Scottish bathing waters meet sufficient or better classification and in the CMR 79% of bathing waters also meet this standard. SEPA aims to bring all waters up to at least sufficient by 2020, as any bathing water which has five successive poor classifications will have permanent advice against bathing to be displayed.[113] Water quality of each of the CMR bathing waters is shown in table 4.5.

The new classification is driven by developments in understanding health risks posed by microbial contaminants and is considerably more stringent, resulting in some water bodies falling in classification. The new classification gives a more consistent picture, as it will take into consideration short term deterioration, how often this occurs and how severe this is. There is quite a high risk associated with failure under the new assessment system; this is not only for local communities who might lose the amenity and security of safe bathing waters, but also the associated impact on tourism and recreational activities and financial penalties which can imposed if bathing water standards are not met and maintained.

Diffuse pollution, surface runoff from rain and sewage from combined sewer overflows are the biggest risks to the cleanliness of coastal bathing waters.[114] The condition of bathing waters is affected by the quality of nearby water bodies and their catchments which drain into the bathing waters. Quality of bathing waters depends on how land and pollution pathways are managed. SEPA notes that integrating land and water pollution control is essential for effective protection and improvement of bathing waters. SEPA work in partnership with Scottish Water, the agricultural community, local authorities, Keep Scotland Beautiful and the Marine Conservation Society to deliver integrated land and water pollution control, with the aim of achieving high quality bathing waters.[115]

109. Scottish Environment Protection Agency, 2016b
110. Scottish Environment Protection Agency, 2016e
111. The Scottish Government, 2012b
112. Scottish Environment Protection Agency, c
113. Scottish Environment Protection Agency, 2016b
114. Scotland's Environment, 2014
115. Scottish Environment Protection Agency, 2016b

Table 4.5 Protected bathing designated areas in the Clyde Marine Region and their historic and current classification[116]

2005–2014 classification: White – site not designated as a bathing site in the year show, blue – guideline pass, green – mandatory pass and red – fail.
2015 classification: blue – excellent, purple – good, green – sufficient and red – poor

BATHING WATER COMPLIANCE RESULTS											
BEACH	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ayr (South Beach)											
Culzean											
Ettrick Bay											
Girvan											
Heads of Ayr											
Irvine											
Largs (Pencil beach)											
Lunderston bay											
Maidens											
Millport bay											
Prestwick											
Saltcoats and Ardrossan											
Seamill											
Troon (South beach)											

SEPA, in partnership with other organisations uses a number of different methods to determine the source of pollutants entering bathing waters. This includes tools such as:

- Microbial source tracking analysis where analysing microbial DNA allows identification of the generic origin of pollution to determine if human, ruminant or other derived faecal indicator organisms are either present or present at a significant level.
- Scottish Water Quality and standards programme whereby Scottish Water identifies capital investment to be made in water and drainage infrastructure. The main bathing water focus in recent periods has been an investment programme to identify and reduce the effects of unsatisfactory intermittent discharges in Ayrshire and 41 other bathing water studies. Scottish Water estimates it will spend £35m during 2015-2021 on further water pollution improvement to the benefit of Scotland's currently impacted bathing waters.
- Working directly with rural land managers in the 14 priority catchment areas across Scotland to increase understanding of diffuse pollution sources in rural areas. This resulted in over 80% of non-compliant land managers changing their behaviour and becoming compliant with environmental regulations. Priority catchment areas in the CMR include: River Ayr, River Doon, River Irvine, River Garnock and the North Ayrshire Coast.[117] The lowest classified bathing waters in the CMR: Girvan, Heads of Aye, Prestwick are all drained into by at least one of these catchments.

Clyde Marine Region bathing waters classification

The failure to meet standards at Heads of Ayr in 2014 may be as a result of wet weather in this period which increased run-off from agricultural land and surface water urban drainage. The catchment draining into Heads of Ayr bathing water is 90% agricultural land used for dairy farming. Average summer rainfall for the region is 392mm compared to 331mm across Scotland. There is also a sewage effluent discharge south of the bathing area, which may affect results.[118] In 2015, the classification was as a result of diffuse pollution from rural sources and

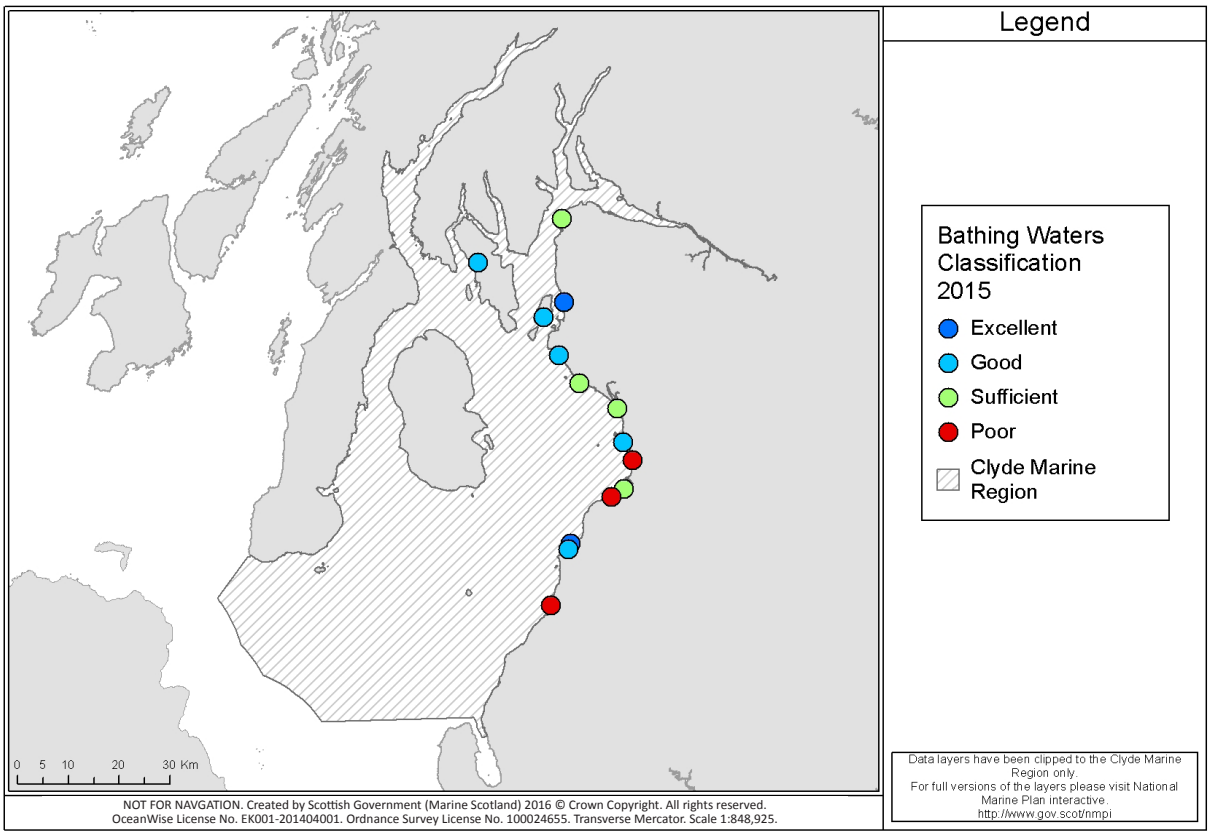
116. Scotland's Environment
117. Scottish Environment Protection Agency, 2016b
118. Scottish Environment Protection Agency, 2016a

point source discharges from waste water disposal. These issues will be addressed by priority catchment action[119] and partnership work between SEPA and Scottish Water from 2015-2021.[120]

Whilst Ettrick Bay is similarly surrounded by agricultural land and experiences higher than average rainfall, the bathing waters here experienced an improvement from guideline to mandatory from 2013 to 2014 and increased to 'good' under the new classification in 2015. This may be due to the fact that the population in the catchment is very low and that there are no sewage treatment works or sewerage overflows in the vicinity. Ongoing efforts by SEPA to reduce diffuse pollution and substantial investment in sewerage systems are also contributing to this improvement.[121]

In 2015 Prestwick has been classified as 'poor' as a result of diffuse pollution from rural sources; this will be addressed through priority catchment action. Additionally, the site is subject to point source pollution (work on this is underway, continuing to 2021) as a result of waste water disposal. This will be addressed through partnership work between SEPA and Scottish Water from 2015-2021. Also in 2015, Girvan's classification has been attributed to diffuse source pollution from rural sources. SEPA will address this through priority catchment action from 2015-2021.[122]

Map 12. 2015 classification of bathing waters in the Clyde Marine Region



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119. Diffuse pollution priority catchments have been identified by SEPA as catchments failing to meet environmental standards. Fourteen priority catchments, containing some of Scotland's most important waters (for conservation, drinking water, bathing and fishing), have been selected using a risk based approach for action in the first basin planning cycle. Work will also include the mitigation of other water environment impacts, such as morphological change, abstractions, flooding and alien species, where these are also causing waterbody downgrades. The first RBMP identified the River Ayr, River Irvine, River Garnock and North Ayrshire Coast as catchments in or near the CMR for priority action.
120. Scottish Environment Protection Agency, i
121. Scottish Environment Protection Agency, 2015a
122. Scottish Environment Protection Agency, i



Windsurfing © PETER SANDGROUND

ECOSYSTEM SERVICES		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Regulating	Waste processing and water purification	Diffuse pollution and combined sewer overflows at certain points in Ayrshire exceed the capacity of plants and micro-organisms to assimilate, buffer or process faecal contaminants, thereby preventing effective regulating services and leading to poor bathing water quality. Increasing sea temperatures will exacerbate this issue (see Chapter 3.1 Climate change – impacts on marine life and processes).
Cultural	Sense of place and cultural heritage	Maintaining clean and safe bathing waters contributes to people's sense of place and interaction with the marine environment and maintains the cultural heritage of seaside bathing sites.
	Health benefits	Having clean and safe bathing waters enables people to utilise the marine environment for exercise and sport.
	Recreation and tourism	The general improvement in the condition of bathing waters in the CMR over the last five years can support increased sport, tourism and recreation.
Supporting services underpin the provision of other services		Elevated levels of *E.Coli* in the marine environment can impact on effective storage, cycling and maintenance of nutrients essential for marine living organisms and for the support of all other marine ecosystem services.

4.5 Eutrophication



Monitor Loch Long and Loch Goil for continued Good status

Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SEPA bathing water profiles
apps.sepa.org.uk/bathingwaters/Profiles.aspx

SEPA Bathing waters report 2014/15 and 2016
apps.sepa.org.uk/bathingwaters/

Scotland's Marine Atlas Clyde score: 'Some concerns but improving'. Regional assessment is consistent with this.

Introduction

Nutrients in the correct amount are essential for supporting primary production in aquatic environments. Eutrophication is the addition of extra nutrients (nitrogen and phosphorus) to water bodies which results in the hypernutrification of the environment. Too much nitrogen and phosphorus can lead to excessive plant growth and plankton blooms. This can in turn cause oxygen depletion and have a damaging effect on marine organisms as well as making water unsafe for recreational or aquaculture purposes.[123]

Excess Nutrients

Excess nutrients enter the water system through agricultural run-off and diffuse pollution via river catchments and point source pollution from sewage treatment works and industrial discharges. Aquaculture activities can cause eutrophication when waste produced by farmed fish and any waste feed released fall to the seabed. However, all these activities are licensed and controlled by SEPA through the Controlled Activities Regulations (CAR), which minimises excess nutrients entering the system.

Treatment requirements for waste water are based on population size within the plant catchment and the state of the water receiving discharges (this topic is discussed in Chapter 6.10 Waste water treatment and industrial outfalls). In addition, SEPA works with the agricultural sector to prevent the amount of nitrates polluting water systems through promoting good farming practises. The Nitrates Directive (1991) is now a key part of the Water Framework Directive (WFD), and is focussed on reducing agricultural pressures including diffuse pollution on water quality. As well as establishing codes of good agricultural practise, the Nitrates Directive requires member states to report on eutrophication, nitrate concentrations and estimations of future trends in water quality.[124] Although there are no Nitrate Vulnerable Zones in the CMR, suggesting that agriculture is not a major emitter of nitrate, it may still contribute to eutrophication of aquatic environments in some areas.



Agriculture in the Clyde © LORNE GILL, SNH

123. Baxter et al., 2011
124. European Commission, 2016c

Monitoring and assessment of water bodies

SEPA collects data for the assessment of water bodies under the WFD. This process is fully explained in Chapter 4.1 Water Framework Directive and classification of water bodies. These data are also used for OSPAR monitoring for eutrophication, as discussed in Scotland's Marine Atlas.[125] The relevant biological and chemical parameters which give an indication as to whether or not a water body is at risk of eutrophication are: dissolved oxygen, dissolved inorganic nitrogen, macroalgae and phytoplankton.

Phytoplankton blooms have been known to cause loss of stock in fish farms at Loch Striven and Loch Fyne. Both these lochs have little freshwater input, a low rate of tidal exchange and undergo periods of deepwater stagnation.[126] A study published in 2001, indicated that historically phytoplankton chlorophyll in Loch Striven regularly exceeded 10mgm^{-3} during summer and this qualified it as eutrophic.[127] However, WFD classification from 2008-2015 now assesses this water body to be in Good condition.

Three *Moderate* water bodies (Loch Long North, Loch Long South and Loch Goil) which were subject to unknown pressures affecting phytoplankton in 2013 and 2014 have subsequently improved to *Good* status in the 2015 classification results. Water body classifications can be examined in more detail using SEPA's interactive tool 'Water Environment Hub' www.sepa.org.uk/data-visualisation/water-environment-hub/. The data on this site are also updated as water body assessments are carried out and more information becomes available and will reflect any changes in condition or when pressures and sources of pollution become known for Loch Long North, Loch Long South and Loch Goil.

ECOSYSTEM SERVICES[128]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food	Eutrophication can deplete the system of oxygen by facilitating excess plant growth. This can have a negative impact on other biodiversity, for example, resulting in a reduction in fish species. Harmful algal blooms can make shellfish unfit for human consumption although this has not been a major issue in the CMR.
Regulating	Clean and safe water	Overwhelming the marine environment with excess nutrients results in pollution and reduces the ecosystem's capacity to degrade and process nutrients in the water.
Cultural	Health benefits and recreation and tourism	Algal blooms, resulting from eutrophication can be harmful to humans and restrict recreational and cultural activities and enjoyment of the marine environment. They have not been an issue in the CMR in recent years; however warmer sea temperatures may lead to an increase in the tendency for stratification of the water column and could influence the developments of harmful algal blooms (see Chapter 3.1 Climate change – Impacts on marine life and processes).
Supporting services underpin the provision of other services		Effective storage, cycling and maintenance of nutrients are essential for marine living organisms and support all other marine ecosystem services. Nutrient cycling encourages productivity and makes nutrients available to all other levels of food chains and webs. Draining through soil on land can dilute pollutants to safe levels by processing or assimilating them. If the ability of this system is compromised, pollutants can be transferred from the land via river catchments to the sea. This can impact the ability of the system to carry out nutrient cycling. There were concerns over the condition of phytoplankton in Loch Long and Loch Goil in the 2013 & 2014 WFD classification results, but these improved in 2015 (see Chapter 4.1 Water Framework Directive – Classification of transitional and coastal waters).

125. Baxter *et al.*, 2011
126. Tett *et al.*, 1986
127. Tett *et al.*, 2001
128. UK National Ecosystem Assessment, 2011

4.6 Oil and chemical spills and accidents



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

ACOPS annual survey reports www.acops.org.uk/acops-reports/

Scotland's Marine Atlas Clyde score: : 'Few concerns and no discernible trend'. Regional assessment includes a detailed look at oil spills which shows an improving trend.

Introduction

It is important to monitor oil and chemical spills as these may result in contamination of the Clyde Marine Region (CMR) with resulting harm to birds or other marine animals. Marine accidents are also monitored to help improve safety at sea.

Oil and chemical spills

The Maritime and Coastguard Agency (MCA) has statutory responsibility for taking action when oil or hazardous and noxious substances emanating from any at-sea activity threatens the United Kingdom or its surrounding waters. As part of its commitment to provide cleaner seas around the United Kingdom, the MCA publishes, via the Advisory Committee on Protection of the Sea (ACOPS), an annual survey of reported discharges and releases attributed to vessels and offshore oil and gas installations operating in the United Kingdom Pollution Control Zone (UKPCZ). Survey results, in co-ordination with historical data and records, enable MCA's Counter Pollution and Response (CPR) team to monitor trends in the number of incidents, the amount of oil and chemicals spilled, the geographical distribution of spills, the sources of pollution and the nature of the pollution.[129]

Analysis of ACOPS annual surveys for incidents in the CMR reveals that the number of incidents and the total amount of litres of oil spilled can vary

Table 4.6 Coastal oil spills in the Clyde Marine Region 2002–2013

YEAR	NUMBER OF INCIDENTS	TOTAL LITRES
2013	1	0*
2012	3	30*
2011	3	102*
2010	1	0*
2009	2	980
2008	7	560*
2007	6	1539*
2006	2	159
2005	2	345
2004	5	122*
2003	8	821.5
2002	4	315*

*figure includes at least 1 incident where the quantity involved was not known.



Container shipping © PETER SANDGROUND

129. Dixon, 2014

substantially from one year to another (see table 4.6). Overall, however, there has been a decreasing trend for both of these indicators since 2010. There have been no chemical spills reported in the area since 2002; these are usually associated with offshore oil and gas installations and vessels which are not present in the CMR.

All of the above incidents involved crude, fuel, lubrication or hydraulic oil. Many oil spills are minor and can be dispersed by natural means; up to 50% may evaporate, a small amount may dissolve, microbes can degrade the oil and some can attach to particles and fall to the sea floor. The rate at which this occurs depends on the oil type and the sea state. In some cases a water-in-oil emulsion may form what is known as 'chocolate mousse'. In inshore waters, depending on the size and type of spill, there are a number of options should the oil need to be removed; the movement of oil can be restricted through the use of booms and barriers, the oil can then be recovered through the use of skimmers, oil mops or vacuum pumps, or a dispersant can be used if conditions are appropriate. If the oil has reached the shore, then a shoreline clean-up operation will be needed to reduce the pollution to a tolerable level and to restore the coastline with the least impact on the environment.[130] For more information on response to marine pollution incidents, see www.gov.uk/guidance/how-we-respond-to-marine-pollution-incidents. Consult National Marine Plan interactive to view shoreline types around the CMR as contained within the Oil Spill Contingency Planning.

It should be noted that oil can also enter the marine environment through terrestrial drainage systems. It is a requirement for new developments with surface water drainage discharging to the water environment that such discharges will pass through sustainable urban drainage systems (SUDS).[131] Regulatory controls on the storage of oil also exist.[132]

Accidents

The Maritime Coastguard Agency is responsible for responding to maritime emergencies. For further information on the Search and Rescue framework for the UK and Northern Ireland, see www.gov.uk/government/publications/search-and-rescue-framework-uksar. There is a potential for up to five strategic decision-making cells to be established for specific aspects of an incident. The Maritime & Coastguard Agency (MCA) leads the at sea response from a Maritime Rescue Co-ordination Centre (MRCC), Salvage Control Unit (SCU), and Marine Response Centre. The Secretary of State's

Table 4.7 MAIB investigated accidents in the Clyde Marine Region since 2000

OCCURRED	DESCCRIPTION	LOCATION	VESSEL TYPE
26 Nov 2011	Series of accidents including windlass damage, grounding and 1 person injured on RO-RO cargo ferry *Norcape*	Operating in and around Troon Harbour	Merchant >100 tonnes
5 Dec 2010	Fire in engine room on tug SD Dexterous	0.5nm north of Rhu Narrows, Gareloch	Merchant >100 tonnes
27 Jan 2010	Collision between general cargo vessel *Leeswig* and trawler *Spes Bona V*	3.5' north-east of Pladda lighthouse	Merchant > 100 tonnes
3 Nov 2009	Contact made by bulk carrier *Mornes* with concrete dolphin	Hunterston Jetty	Merchant >100 tonnes
2 Nov 2009	Capsize and sinking of twin-rig prawn trawler *Jubilee Star*	Near Cowal buoy off Dunoon	Fishing
23 May 2008	Grounding of prawn trawler *Bountiful*	Scart Rock off Lady Isle near Troon	Fishing
19 Dec 2007	Girting (when the line of a tug becomes taught and the tug is pulled over and capsized) of the tug Flying *Phantom* while towing bulk carrier Red *Jasmine* with 1 person injured and loss of 3 lives	River Clyde	Merchant >100 tonnes
1 Sep 2004	Grounding of general cargo vessel *Jackie Moon*	Off Dunoon Breakwater	Merchant >100 tonnes
27 Dec 2000	Collision between feeder container vessel Nordsee and passenger vessel *Poole Scene*	River Clyde	Merchant >100 tonnes

Source: Marine Accident Investigation Branch

130. Department of Transport, Marine Pollution Control Unit, 1994
131. Scottish Environment Protections Agency, k
132. Scottish Environment Protections Agency, l

Representative has overall responsibility for salvage and will determine if a SCU is required. Where there are significant onshore consequences, a Strategic Co-ordinating Group and/or a Shoreline Response Centre may be required, with the lead being provided by the police or the local authority. For further details see www.gov.uk/government/publications/emergency-response-and-recovery. The Port Marine Safety Code applies to all harbour authorities in the UK that have statutory powers and duties. It is also strongly recommended that facilities outside of harbour areas such as berths, terminals and marinas should seek to have safety management systems in place which comply with the Code. See www.gov.uk/government/publications/port-marine-safety-code.

There are no Emergency Towing Vehicles funded by central Government for the CMR. Ships in need of assistance meet the full cost of towage through the commercial market, but must notify the relevant port authority.

The Marine Accidents Investigation Branch (MAIB)[133] investigates marine accidents involving UK vessels worldwide and all vessels in UK territorial waters in order to prevent further avoidable accidents from occurring and reports directly to the Secretary of State for Transport.

The following table shows the accidents in the CMR that have been investigated by the MAIB since the year 2000. For further information about action taken and recommendations, visit MAIB reports.[134]

ECOSYSTEM SERVICES		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
General comment – whilst minor oil spills can be dispersed by natural means, a major incident could have severe implications for services provided by those habitats and species that are affected.		
Cultural	Recreation and tourism	Clean and safe seas are essential for marine sport, recreation and tourism activities.

133. Marine Accident Investigation Branch, a
134. Marine Accident Investigation Branch, b

4.7 Dissolved oxygen

Inner Clyde Estuary



Rest of CMR

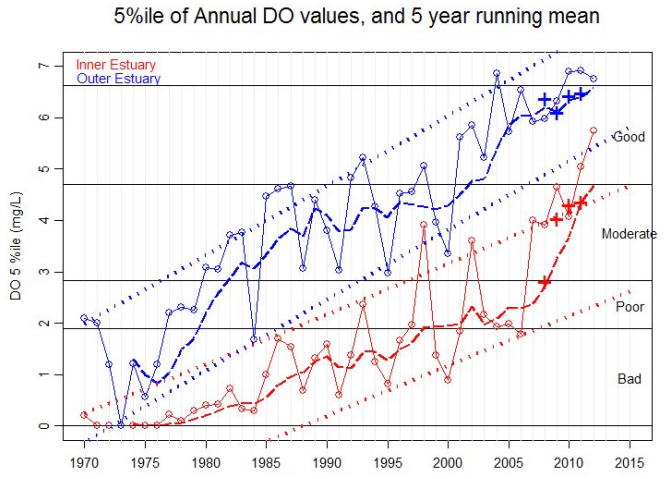


Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SEPA monitoring
River Clyde oxygenation project www.georgeleslie.co.uk/what-we-do/case-study/river-clyde-oxygenation-project/
Scotland's Marine Atlas Clyde score: no score included

Figure 4.3 Annual Dissolved Oxygen values with 5 year running average



This SEPA graph shows:
a. 5%ile DO concentrations in individual years (circles connected by solid lines);
b. 5 year running average of these values (dashed lines)
c. prediction intervals (dotted lines);
d. values used for WFD classification (+ signs).

SOURCE: SEPA

Introduction

Oxygen is supplied to the water of an estuary by rivers, through the surface of the water and by plant photosynthesis. The many organisms living within the estuary will, however, rapidly consume the oxygen. Where there is excessive organic enrichment, for example through input of untreated sewage, the sediments can become anoxic and microorganisms which degrade the sewage can consume all the oxygen within the water body itself.[135]

The situation in the Clyde Marine Region

In addition to organic enrichment, the narrowing and deepening of the River Clyde from Erskine upstream has resulted in the past in significant stratification, limited natural mixing between layers, and pockets of very low Dissolved Oxygen occurring at depth.[136] Studies indicate that an upper limit of 7mg/l of oxygen will support most ecological processes whilst a level below 2mg/l will stress the majority of fish species.[137]

Dissolved Oxygen levels have been routinely monitored in the Clyde Estuary since the 1970s. Results indicate that the Inner Clyde Estuary was completely devoid of oxygen when monitoring began and this had resulted in the lack of any migratory fish such as salmon and sea trout using the estuary. Since that time, there have been steady improvements, such that the Outer Clyde Estuary is currently at 'Good' status in terms of Dissolved Oxygen. Migratory fish returned to the River Clyde during the 1980s

Oxygenation option

Under the Water Framework Directive, the Clyde Estuary is required to reach the status of 'Good Ecological Potential' by 2027. In 2011 oxygenation tests were carried out on the Inner Clyde Estuary. Two oxygenation units were suspended from an unpowered barge moored off the river bank at the Shieldhall waste water treatment works. The units drew water in, oxygenated it and discharged it back into the river. This test allowed Scottish Water and other project partners (SEPA, Glasgow City Council and Peel Ports Clydeport) to assess the feasibility and costs of oxygenation as part of a wider body of work looking to improve water quality, reduce flood risk, and support economic development objectives for the area.

In 2013 Scottish Water finalised their Glasgow Strategic Study Wastewater Strategy which concluded that whilst discharges from Shieldhall

135. McLusky and Elliott, 2004
136. Scottish Environment Protection Agency, 2013a
137. Ross *et al.*, 2009



The River Clyde in Glasgow © PETER SANDGROUND

and Dalmuir Waste water Treatment Works and intermittent discharges from the sewer network contribute to the problem, removal of these discharges will not, in themselves, achieve Good Ecological Potential as required under the Water Framework Directive by 2027. Target Dissolved Oxygen levels will only be achieved at this time through oxygenation. A Disproportionate Cost Assessment undertaken by SEPA under the Water Framework Directive has confirmed that whilst oxygenation is the most cost-effective solution, there is uncertainty about both the Dissolved Oxygen trend and the ecological impacts. This leads SEPA to conclude that it would be disproportionate to implement oxygenation at this stage; however, this will be reviewed in the future. In the meantime, Scottish Water are evaluating the option of making operational changes to the Shieldhall Waste water Treatment works so that the final effluent discharges into the upper layer of the estuary. This takes advantage of the seaward velocities that exist in both the ebb and flood tides.

Metropolitan Glasgow Strategic Drainage Partnership (MGSDP)

The MGSDP is a partnership formed by organisations involved with the operation of the sewerage and drainage network within the area -Scottish Water, Glasgow City Council, Scottish Canals, South Lanarkshire Council, Clyde Gateway, Scottish Enterprise, Renfrewshire Council, East Dunbartonshire Council and the Scottish Environment Protection Agency (SEPA).

The Partnership's objectives are:

1. Flood risk reduction
2. River water quality improvement
3. Enabling economic development
4. Habitat improvement.
5. Integrated investment planning

Various projects are being undertaken to deliver the above objectives. Details of these are available on the MGSDP website at www.mgsdp.org/.

ECOSYSTEM SERVICES		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Supporting services underpin the provision of other services		An adequate level of dissolved oxygen within marine waters is essential to support marine life. Levels of dissolved oxygen in the Clyde estuary are now returning to levels which will support most ecological processes.

4.8 Marine litter



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

MCS beach clean data
Marine Litter Strategy for Scotland
www.gov.scot/Publications/2014/09/4891

Scotland's Marine Atlas Clyde score:
beach litter – some concerns and no discernible trend. Regional assessment is for marine litter including a worsening situation in particular for microplastics and a general perceived deterioration in marine litter from groups around the Clyde.

Introduction

Marine litter is found in all seas and ocean regions of the world and represents the effects of the wider problem of inefficient waste management and people's attitudes and behaviours towards litter. Marine litter is defined as: '*any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment*'.[138] Marine Litter is a trans-boundary issue which affects a range of sectors across different scales, with no clear solution to resolve it and which requires policy reform across a range of areas and investment in long-term social change.[139]

Sources and types of marine litter

About 80% of marine litter in Scotland is identified as coming from land based sources.[140] This includes sewage related debris (SRD) such as cotton buds, nappies, wet wipes and sanitary products. Activities carried out at sea contribute the remaining 20% of marine litter. In UK waters around 70% of marine litter is plastic[141] which will persist in the environment for thousands of years. Additionally, all plastics progressively fragment into microplastics (any plastic which is <5mm) through mechanical action and photo-degradation. Microplastics are also used as industrial 'scrubbers' and in personal hygiene products, so they also enter the environment ready formed. The UK Government plans to introduce legislation to ban the use of microplastics in cosmetic products from the end of 2018.

Shallow coastal areas of depths less than 40m have a much greater abundance of marine litter

Figure 4.4 Marine Litter in Kintyre following a storm event



© CLAIRE PESCOD

138. United Nations Environment Programme, 2005
139. Hastings and Potts, 2013
140. McIntyre *et al.*, 2012
141. HM government, 2012

than deeper waters. Greater abundances have been found in bays, which are more sheltered. This is reflected in the Clyde Marine Region (CMR) where, due to the prevailing south westerly winds, litter congregation areas or 'sinks' are found in sheltered areas at the top of the Clyde sea lochs and also northern shores, especially at Helensburgh.[142]

Impact of marine litter on species, ecosystems and society

The negative impacts of marine litter are well documented and wide ranging. Marine wildlife can ingest or become entangled in marine litter, causing death or false satiation effects, leading to increased mortality. The OSPAR Ecological Quality Objectives project has found that in Scotland 91% of dead northern fulmars (*Fulmarus glacialis*) surveyed have plastics in their stomach.[143] In the CMR, there is evidence of *Nephrops* (*Nephrops norvegicus*) ingesting microplastics.[144]

SRD and other marine litter accumulating on beaches and any accessible coastline present a public health issue, as well as a deterrent to recreation and tourism on Scottish beaches. MCS beach cleans carried out in the CMR from 2010-2015, were carried out over a total of 2,695.98 volunteer hours. If calculated at an approximate council worker hourly rate,[145] the labour costs for voluntary beach cleans would total between £22,969.75- £26,258.85 (based on a 35 or 40 hour week), not including other expenses such as transport or equipment. This figure and the number of volunteer hours given above does not take into account other beach cleans organised outwith the MCS.

Marine litter presents a threat to the fishing industry, as gear can snag on large objects on the seabed, damaging gear and increasing the risk of capsizing. Objects caught in nets cost time to remove, resulting in fishing time lost and potentially damaged gear. The estimated cost to the Scottish fishing fleet is approximately £11.5m each year in damages to vessels, equating to approximately £10,000 per vessel and 41 hours of lost fishing time, a significant portion of their time allocated at sea.[146] Floating marine litter presents a significant hazard to recreational craft, both through collision and through entanglement of ropes and other floating debris in propellers.

The accumulation of seaweed and other organic debris at the high water mark is known as the strandline. The strandline is a habitat for invertebrates and is an important part of the coastal ecosystem. Marine litter often becomes entangled in the strandline, to the degree that manual litter picking presents an onerous task. This can lead to the use of tractors and mechanical methods of seaweed removal, resulting in the loss or degrading of this important feature on the shore.[147, 148]

Microplastics in the marine environment

Research from the University of Plymouth was the first to identify the widespread occurrence of microplastics in the marine environment which have been accumulating since the 1960s.[149] This research has shown that microplastics are present on the shore and in the water column throughout the North East Atlantic. Moreover, microplastics have been shown to have persistent organic pollutants (POPs) concentrations of up to a million times the ambient level of sea water.[150]

A positive correlation between the presence of toxins in the fat tissue of great shearwaters (*Puffinus gravis*) and the ingestion of plastic suggest that consuming plastic facilitates the assimilation of toxins and POPs in marine organisms (see Chapter 4.2 on Hazardous substances for more information on this).[151] The United Nations Environment Programme (UNEP) recommends a precautionary approach to microplastic use and an eventual ban on their production and use.[152] Marine litter can also be used as a vector for the transport of invasive and non-native species, most commonly by bryozoans, barnacles and polychaete worms.[153]

A study of microplastics in the West Coast of Scotland showed filaments were the most commonly recovered plastics, followed by fragments, recovered from 34.4% of samples. Analysis of the samples showed variation is not due to a single contamination source or re-dispersal event and the amount of plastics in the sediment was not significantly related to the amount of plastics in the water column.[154] Additionally, the study examined a sample of the CMR *Nephrops* population for the presence of plastics. In the CMR, 84.1% of *Nephrops* sampled were found to have plastic in their gut. Larger individuals have a larger gastric mill and larger gaps between teeth, making them more capable of digesting plastics. As the gut lining is shed during moulting, individuals which are newly moulted have a lower weight of plastic in their gut,

142. Ross *et al*., 2009
143. OSPAR Commission, 2009b
144. Murray and Cowie, 2011
145. This figure is estimated based on the Annual Survey of Hours and Earnings: 2015 Provisional Results median full-time gross weekly earnings by elementary occupations from the Office for National Statistics.
146. Fishing for Litter, 2004
147. Mills, 2012a
148. Dyson, 2011
149. University of Plymouth
150. European Commission, 2016d
151. Galgani, 2010
152. United National environment Programme, 2015
153. Potts and Hastings, 2011
154. Welden, 2015

suggesting that langoustines are capable of reducing their plastic load. The large amount of microplastic fibers in the CMR indicate that *Nephrops* are at increased risk of the biological impacts of plastic ingestion; this can include false satiation which may affect body condition.[155, 156]

National and local action on reducing marine litter and marine litter data in the Clyde Marine Region

No agency in Scotland has overall responsibility for coordinating efforts to reduce marine litter. Just as a range of regional and national policies create a framework to advise and guide activity on the reduction of marine litter, a network of local, regional and national statutory bodies, charities, NGOs and organisations have a role in litter reduction activities. Some of these bodies deal with litter where it enters water sources or when it ends up on coastal habitats. This includes Scottish Water, which has responsibility for maintaining sewerage systems. To support the implementation of the Marine Litter Strategy for Scotland, Marine Scotland has formed the Marine Litter Strategy Steering Group. There is a general perceived deterioration in marine litter, especially amongst communities directly affected by it, with growing concern over increasing microplastics.

SRD ends up in the marine and coastal environment when combined sewers overflow during heavy rain or flooding events, resulting in SRD being washed out to sea. Scottish Water undertakes education initiatives, such as the 'Bag it don't bin it' campaign. The Scottish Environmental Protection Agency (SEPA) has a role in regulating and maintaining rivers and waterways.

Duty bodies have responsibility for keeping public beaches clean. Data collated in 2011 in the Firth of Clyde Forum's *'Marine Litter Strategy for the Firth of Clyde Step 1: Defining the Status Quo'* report found that in terms of Local Authority activity, the frequency of beach cleans amongst the seven Local Authorities with a coastline in the CMR region varies between each authority and it is thought that effort in beach cleaning is higher during the summer season and is dependent on the economic importance of the beach to the area.[157]

Much work on cleaning up marine litter is carried out by volunteers, community groups and charities. In the CMR there are:

- the Group for Recycling in Argyll and Bute (GRAB) Trust runs the Beaches & Marine Litter Project across the Argyll and Bute area (excluding Helensburgh and Lomond) and manages the Argyll and Bute Beach Forum.
- The Helensburgh East Esplanade Protection Group (longest running beach clean in the UK, operating since 1995).
- Arran Coastal Way.
- Community of Arran Seabed Trust (COAST).
- Field Studies Council, Millport, Isle of Cumbrae.
- Beachwatch Bute, removes 10 tonnes of litter from the island's beaches every year.[158]
- Loch Lomond and The Trossachs National Park at Arrochar and Lochgoilhead.
- Girvan, Alloway, Ayr, Prestwick and Troon Rotary Clubs.
- Clyde Muirshiel Regional Park rangers at Lunderston Bay.
- The MCS operates a national citizen science programme of beach cleans called 'Beachwatch'.[159, 160]
- The Great Nurdle Hunt – Clyde Nurdle Quest.

Whilst not all beach cleans in the CMR collect data for inclusion in the MCS figures, between 2010- 2015 a total of 90 MCS beach cleans were carried out over a total 2,695.98 hours.[161] The most time was spent and most litter collected was in Argyll and Bute. No beach cleaning through the MCS programme was carried out in West Dunbartonshire and so no data are available for any beach cleans that may have been carried out in this Local Authority. Table 7 provides a yearly breakdown of beach cleaning data by effort according to Local Authority areas.

The data from MCS beach cleans, 2010-2015 (figure 4.6), shows that overall plastic is the most prevalent type of litter collected throughout all Local Authorities (does not include the Local Authorities own beach cleaning activities). Following this, were levels of sanitary waste, in Argyll and Bute and Inverclyde and polystyrene in Renfrewshire and South Ayrshire. The data for North Ayrshire showed equal proportions of polystyrene and sanitary waste was collected. A high level of cotton buds were collected,

155. Welden, 2015
156. Welden and Cowie, 2016
157. Dyson, 2011
158. Bute Community Links
159. Marine conservation Society, 2014
160. MCS has been collecting data on marine litter through the citizen science program Beachwatch since 1994 and has thus amassed a large bank of data detailing both type and source of litter to be found in the UK. The protocols and methodology used are compatible with other systems on a European and worldwide basis. The data is analysed by MCS to identify the quantities, types and sources of litter affecting the UK coastline and the impacts of litter on marine life, human health and local economies, providing evidence that can be used to target specific polluters and pollutants at local, national and international levels. Beachwatch data is fed into the OSPAR project on Marine Litter. MCS also designed and hosts the current OSPAR marine litter database. Beachwatch data formed the evidence for the Government's two reports, Charting Progress 1 and Charting Progress 2 on the state of the UK seas Defra acknowledged that Beachwatch "provides the only long-term dataset" for beach litter in the UK. MCS were the lead author for the beach litter section in Charting Progress 2. MCS is a member of the EU Technical working group on Marine Litter which is devising guidelines for the monitoring of marine litter, to ensure consistency throughout the EU for the MSFD.
161. Data provided by MCS, 2015. It is not possible to calculate the number of volunteers involved, as it is likely that the same people carried out more than one beach clean per year in the MCS surveys.

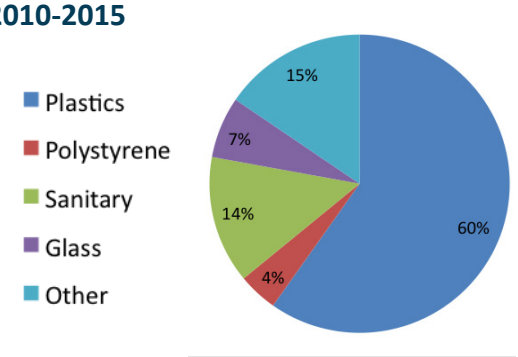
Table 4.8 Data from MCS Clyde beach clean 2010-2015 showing beach clean effort according to local authority area[162]

		LOCAL AUTHORITY				
		Argyll and Bute	North Ayrshire	South Ayrshire	Inverclyde	Renfrewshire
Total number of beach cleans 2010-2015		51	7	13	15	4
Average beach litter density per metre of beach (total no. of items/total length of beach cleaned)		2.52	3.05	1.79	7.75	2.30
Total weight collected (kg)		2042.15	250.25	456.5	393.6	58
Total no. of volunteer hours		1587.24	47.92	303	732.42	25.4
2010	No. of beaches cleaned	13	4	3	1	1
	Ave. beach litter density	1.76	2.91	1.57	7.28	4.58
	Total weight collected	414	208.25	171	25	No data
	Total no. volunteer hours	288.3	21.25	90	26	18
2011	No. of beaches cleaned	6	1	4	2	No data
	Ave. beach litter density	1.6	0.35	5.92	8.05	
	Total weight collected	200.5	2	99	58.5	
	Total no. volunteer hours	229.25	4	115.5	52.75	
2012	No. of beaches cleaned	10	1	2	5	No data
	Ave. beach litter density	1.35	0.94	10.63	10.08	
	Total weight collected	195	20	131	109.5	
	Total no. volunteer hours	219.3	6.67	50.5	499.17	
2013	No. of beaches cleaned	5	No data	2	3	No data
	Ave. beach litter density	3.14		0.25	6.87	
	Total weight collected	87.3		55.5	39.4	
	Total no. volunteer hours	221.5		29.5	25.5	
2014	No. of beaches cleaned	8	No data	1	4	1
	Ave. beach litter density	7.58		0.14	6.52	0.38
	Total weight collected	9.35		No data	161.2	22.4
	Total no. volunteer hours	416.42		17.5	129	6
2015	No. of beaches cleaned	9	1	No data	No data	2
	Ave. beach litter density	3.24	0.18			1.31
	Total weight collected	1136	20			3
	Total no. volunteer hours	212.47	16			34

which overall account for 77% of all sanitary items collected. It is also interesting to note that high proportions of cotton buds and other sanitary items were collected repeatedly in Lunderston bay in Inverclyde and Helensburgh in Argyll and Bute, supporting information that these areas are known litter sinks.

The results above are largely typical for each Local Authority; however, Renfrewshire recorded the highest amount polystyrene collected in the CMR, recording 18%, North Ayrshire had the highest percentage of plastics, recording 67%, and Inverclyde reported that sanitary products made up 20% of all litter collected; also the highest amount

Figure 4.6 Proportions by weight of types of marine litter collected as part of MCS beach cleans in the Clyde Marine Region 2010-2015



162. Data provided by MCS, 2015

for litter of this type. As part of their requirements under the Marine Strategy Framework Directive, DEFRA has contracted the MCS to supply data four times a year on beach litter levels at 19 beaches across the UK, four of which are in Scotland. One of these beaches is Lunderston Bay due to the long and robust data set available for the beach here. The Fishing for Litter (FFL) initiative is a UK-wide project and has been in action since 2005. FFL works with fishermen and harbour staff, providing collection facilities for fishermen to dispose of any marine litter they catch while at sea. The scheme currently operates in four harbours in the CMR: Tarbert, Campbeltown, Rothesay and Troon, and there is potential for the project to expand into other harbours within the CMR. The scheme has recently begun in Troon. Tarbert has five vessels registered, Campbeltown also has five and Rothesay currently has two registered vessels. From 2008-2011, four tonnes were collected at Rothesay and from 2008-2014 approximately 60 tonnes of litter have been collected from Tarbert. This equates to one 11yd^3 skip filled every six weeks, or enough to fill 2.5 local swimming pools.[163]

Glasgow City Council operates a workboat 'water witch' called *St Mungo*, which scoops or dredges rubbish and debris out of the River Clyde. The water witch was employed as part of a major clean-up of the Clyde and it collects both naturally produced debris such as tree branches and weeds and man-made created litter, such as large items dumped in the river, including shopping trolleys and gas bottles.

It is probable that there are many more unpublicised community actions being carried out by numerous groups and individuals. The need for such groups signifies a major issue with marine litter; it often falls to people and authorities who are not responsible for its creation to deal with cleaning it up. A large part of reducing marine litter will fall to achieving long term social change in regard to people's behaviours and attitudes towards waste.

ECOSYSTEM SERVICES[164]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food	Plastic ingestion by fish and shellfish could have an effect on productivity and food chain dynamics, due to impacts such as false satiation effects, loss of body condition and death. Concerns exist over the impact of microplastics on *Nephrops* in the CMR (and other areas). Research into the implications for human health is at an early stage.
Regulating	Clean and safe water	Presence of SRD on beaches and in the sea from combined overflows may indicate contamination and poor water quality. This has been an issue noted in particular around Helensburgh and the heads of the sea lochs in the past.
	Protection against coastal erosion and storm defence	Mechanical removal of the strandline to remove litter can affect resilience of the beach to physical processes and extreme weather and making them more vulnerable to erosion.
	Life cycle maintenance and biological regulation	Plastic ingestion or entrapment by marine organisms can result in changes in life cycle maintenance and population dynamics.[165]
Cultural	Aesthetic benefits of the seascape/ landscape and sense of place	Marine litter in the environment inhibits people's sense of place, cultural heritage and appreciation of aesthetic and inspirational qualities of beaches. It can detrimentally impact tourism and recreational activities. This is particularly true of litter sinks in the CMR at the heads of lochs and the north side of the Clyde estuary.
Supporting services underpin the provision of other services		Marine litter can contribute to creating anoxic conditions on seabed sediments which can affect nutrient cycling occurring in this zone. Entanglement of litter in strandline seaweed can also prevent its effective degradation and therefore nutrient cycling, whilst removal of the strandline takes important nutrient supply and habitat away from the coastal ecosystem.[166, 167] Accumulations of litter in the strandline have been reported in particular at the heads of lochs in the CMR and in many locations following a storm event.

163. 20 mx8 m with 1.35 m average depth
164. Galgani *et al*., 2010
165. Dyson, 2011
166 Mills, 2012a
167. Dyson, 2011

4.9 Noise

Very little Clyde specific data exists



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Scotland's Marine Atlas Clyde score: not included.

Introduction

Underwater noise is increasingly being recognised as an important stressor to marine life. Prior to the mid-19th century Industrial Revolution, low-frequency noise in the ocean was due to spray and bubbles associated with breaking waves, sounds generated by marine life, seismic noise, and other natural sounds. The Industrial Revolution marked the beginning of the use of powered (rather than sailing) vessels to transport goods and provide services. Increases in commercial shipping since that time have caused low-frequency noise levels to increase in many oceanic locations and impulse noises assocated with acoustic deterrants or piling type activities have also increased.[168]

Current status of underwater noise in the Clyde Marine Region

It is unknown how underwater noise has changed in the Clyde since the industrial revolution, however, there is a correlation between increasing background underwater noise and the increase in the world fleet gross tonnage.[169] Also there has been a general increase in human activities in coastal areas around the Clyde (for example- harbour construction and recreational boating) but again the effect this may have on marine life is currently not well understood. In the Clyde significant underwater noise is likely to come from a variety of sources, including shipping but also development (e.g. piling and cable laying), fishing (dredge) and defence (submarine movements and other facility testing) – see table 4.9 for further analysis.

Legislation and regulation of underwater noise

UK regulations mean licensable activities must be licensed or notified and conducted under strict conditions. Marine licences are issued by a range of bodies including Marine Scotland. As part of the licensing process, details of noise-generating activities are recorded in the noise registry. Where noise-generating activities are not licensable, noise information will be collected via a voluntary reporting scheme, further information on this scheme is included later in this chapter. For example, military activity is not licensed but the Ministry of Defence (MoD) is voluntarily co-operating with the system and may submit data as operationally appropriate, during activities such as controlled explosions of historic ordnance and when using active sonar.[170]

A licence may include mitigation measures and may include: timing restrictions on noisy activities during periods when marine organisms are at their most vulnerable to disturbance (e.g. fish spawning seasons or marine mammal breeding seasons); use of noise dampening technologies to reduce source levels or the use of alternative designs.[171]

Issues related to underwater noise

Underwater noise can have significant negative effects on the marine life which inhabit the CMR. Highly susceptible species, such as porpoises and dolphins as well as other fish and even invertebrates, may be impacted by excessive noise. Although the extent of the impact is not well known, there is evidence of the detrimental effects of noise



© PETER SANDGROUND

168. Discovery of sound in the sea, 2016
169. Tyack *et al*., 2015
170. Frequency band 10 Hz to 10 kHz, exceeding the energy source level 186 dB re 1 $\mu Pa^2 m^2 s$; or the zero to peak source level of 224 dB re 1 $\mu Pa^2 m^2$
171. Marine licensing, as introduced by part 4 of the Marine and Coastal Access Act 2009 (MCAA) and part 4 of the Marine (Scotland) Act 2010

on cetaceans (whales, dolphins and porpoises) and pinnipeds (seals). There is also some evidence available for fish but very little for invertebrates. Cetaceans are particularly sensitive to disturbance and injury due to exposure to excessive noise. Short term changes in behaviour can lead to isolation of animals through fragmentation of groups, reduced feeding and breeding success and changes to swimming, diving and communication behaviours. Longer term effects are less well understood but can include abandonment of preferred feeding and breeding areas, abandonment of calves and increased mortality and injury, including from strandings.[172, 173] This has the potential to affect the biological fitness of these animals, but how this then extrapolates to population effects is not well understood.

Many studies have shown that cetaceans, like humans, are very individual in their behaviour – thresholds for one individual may not be the same for the rest of the species and signs of disturbance can vary.[174]

Sound tends to be the primary sensory modality underwater because of the excellent transmission of sound through water. In comparison, the transmission of light is very limited. The various animal species that live underwater, like fish and marine mammals, each have their own specific hearing sensitivity and frequency range. The difference in hearing abilities will mean that the same sound source may not have the same effect over all exposed species.

What is generally accepted, is that marine life is now inhabiting a world that is increasingly more noisy than that for which it is naturally adapted to. There is increasing evidence that animals are responding to and behaviourally compensating for influences from anthropogenic sounds.

Underwater noise is categorised as 'impulsive' or 'continuous'. Impulsive noise is characterised

Table 4.9 Sources of noise in the underwater environment

Aspects which may be of particular relevance to the CMR are highlighted in **bold**

NATURAL NOISE SOURCES	ANTHROPOGENIC NOISE SOURCES
IMPULSIVE NOISE	
• Lightening • Geological noise	• **Acoustic deterrent devices** • **Coastal industry including construction (e.g. pile driving etc.)** • Explosives: mine and bomb clearance • Offshore industry Platform construction (pile driving, alternative methods) • Ship shock trial • **Acoustic transponders** • **Doppler current profiler** • **Fish-finding sonar** • **Military search sonar** • **Minesweeping equipment** • **Multibeam echo sounder** • **Normal-incidence echo sounder** • **Obstacle avoidance sonar** • **Research sonar** • **Seismic explorations Sidescan sonar** • **Sub-bottom profiler**
CONTINUOUS NOISE	
• Biota other than mammals, fish and crustaceans • Breaking gravity (surf) waves • Crustaceans • Fish • Flow noise • Gravel noise • Mammals • Precipitation other than rain • Rain • Thermal noise* • Wave-wave interactions • Wind	• **Acoustic cameras** • **Acoustic communications equipment** • **Dredging, pipe laying, cable laying** • **Fishing vessels** • Flow noise (pipelines) • **Industrial/harbour noise** • Oil & gas platforms: pumping, drilling, associated supply and maintenance) • **Platform maintenance (supply, tugs)** • **Platform operation (e.g. tidal turbines)** • **Shipping: commercial vessels, leisure craft** • Wind farm decommissioning

*Thermal noise is not sound; it contributes to the background noise of any measurement system based on the detection of pressure fluctuations.

172. Weilgart, L. S., 2007
173. Marine Scotland, 2014a
174. Scottish Marine Wildlife Watching Code, 2017

as a sound with a short rise time (e.g. impulse piling) whereas engine noise, for example, would be classified as continuous. The differences in the characteristics of the noise source may have implications for marine life in either acute or chronic exposures and the effect of either type is likely to be different depending on the exposure.

Underwater noise in the UK

There are data available over the last 70 years or so relating to the underwater noise characteristics of ambient/ background noise. There is a relatively good understanding on the major underwater noise contributors in terms of their acoustic characteristics. Most of these studies are in deep water and historically connected to the military's use of sonar for submarine detections. However, there is an increasing amount of evidence relating to underwater noise in coastal regions including a recent study using 12 sites around the UK.[175] This stems from an increased awareness as to the potential impacts of noisy activities, such as marine construction. However shallow sea evidence is still relatively limited.

The UK initial assessment for the Marine Strategy Framework Directive (MSFD) indicated that it was not possible to provide an assessment of underwater noise and its impacts, or to provide a relevant baseline.[176] It concluded that there was currently insufficient evidence to provide a quantitative assessment of underwater noise.

One study of natural and anthropogenic sound sources and acoustic propagation in the North Sea concluded that there is insufficient information on the physiology and behaviour of the marine fauna of the North Sea to make reasonable predictions of impact and proposals for management. There is also a lack of knowledge on the effects of the various anthropogenic sources of sound on the ecosystem of the North Sea, both individually and cumulatively.[177]

This lack of data are reflected in the CMR, where no primary research has been published on underwater noise. The MOD, whilst having no relevant CMR specific data sets available, has expressed an interest in working in partnership with potential underwater noise researchers.

In areas outside of the CMR where sound records exist, anthropogenic noise in the ocean has been increasing across much of the frequency spectrum[178,179] and especially at lower frequencies (< 500 Hz).[180]

Filling the data gaps

Data on underwater noise in the CMR is extremely limited so any fresh sources of information would be a positive step. Under the MSFD, work towards establishing a marine noise registry to record, assess, and manage the distribution and timing of impulsive anthropogenic sound sources has begun but the data are limited.[181, 182, 183] The work is managed by the Joint Nature Conservation Committee and the registry was launched in the summer of 2016. These data will then be used in future research to assess levels and patterns of impulsive and low frequency continuous noise in order to determine whether or not these could potentially compromise the achievement of GEnvS.

The overarching aim stated by DEFRA in the Marine Strategy Framework Directive is that human activities potentially introducing loud, low and mid frequency impulsive sounds into the marine environment are managed to the extent that no significant long-term adverse effects are incurred at the population level or specifically to vulnerable/ threatened species and key functional groups.[184] We are not yet at the stage where we are able to define where the threshold may sit.

Good practice guidance has been published to try to ensure a standardised measuring and recording of underwater noise. Differing techniques and metrics currently and historically used for measuring underwater noise can lead to misunderstandings and misinterpretation of results.[185] The International Organiastion for Standardisation is also progressing work which will enable improved standardisation.

Research carrie dout in the Moray Firth has revealed that noise differs greatly between sites and throughout the day, effects which are likely to be magnified in the Clyde where the complex underwater profile coupled with the highly urbanised inner Clyde and industrial and transport uses will make for a complexity which will require detailed study to create a useful underwater noise profile for the plan area.[186]

Marine Scotland has produced guidance on European Protected Species legislation[187] and JNCC has produced statutory nature conservation agency guidelines for minimising the risk of injury to marine mammals from seismic activities, piling and explosive use. The application of these guidelines is frequently set as a licence condition. In addition the International Maritime Organization has produced non-mandatory technical 'Guidelines for the

175. Merchant *et al*., 2016
176. HM Government, 2012
177. Ainslie *et al*., 2009
178. Andrew *et al*., 2002
179. McDonald *et al*., 2008
180. Frisk, 2012
181. Joint Nature Conservation Committee, 2016c
182. International Council for the Exploration of the Sea
183. Joint Nature Conservation Committee, 2016c
184. Department for the Environment and Rural Affairs, 2015
185. Robinson, 2014
186. Merchant *et al*., 2012
187. Marine Scotland, 2014a

reduction of underwater noise from commercial shipping to address adverse impacts on marine life' which promote ship quietening technologies for both propellers and equipment.[188, 189, 190, 191, 192]

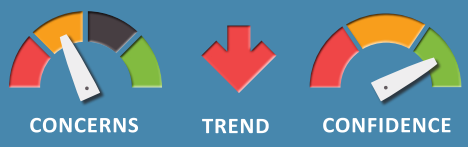
Our understanding of the effect on the marine environment from anthropogenic noise is still young and further targeted work is required to start filling the gaps in knowledge.

ECOSYSTEM SERVICES		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (fish and shellfish)	Excessive noise can limit the system's provisioning ability by negatively affecting breeding, hunting and feeding success in a wide range of species.
Cultural	Wellbeing Recreation	Many people reflect on the meditative quality of the marine and coastal environment; listening to the waves is an important part of a trip to the beach for many people. This is also true for diving enthusiasts. Marine noise pollution can negatively affect cultural services.
Supporting services underpin the provision of other services		The absence of noise is as important as noise itself. An absence of noise allows communication between individuals of a species, within groups and it facilitates hunting. Too much underwater noise will limit individual and group communication, potentially physically damaging or disturbing species and the ecosystem services they provide.

188. Joint Nature Conservation Committee, 2015
189. Joint Nature Conservation Committee, 2010b
190. Joint Nature Conservation Committee, 2010a
191. Joint Nature Conservation Committee, 2010a
192. International Maritime Organisation, 2014

5. Condition of the Region
HEALTHY AND BIOLOGICALLY DIVERSE

5.1 Intertidal rock and sediments



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SNH commissioned report 347 www.snh.org.uk/pdfs/publications/commissioned_reports/347.pdf

Scotlands Marine Atlas www.gov.scot/Resource/Doc/345830/0115114.pdf

MPA surveys www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-(mpa)/mpa-survey-research-reports/

Scotland's Marine Atlas Clyde score: 'Some concerns and deteriorating'. Regional assessment is consistent with this.

Figure 5.1 Intertidal zone at Hunterston



© CMPP

Figure 5.2 Saltmarsh at Bowling, Inner Clyde



© CMPP

Introduction

Intertidal rock includes habitats of bedrock, boulders and cobbles that lie between Mean High Water Springs and Mean Low Water Springs. Species in these habitats are affected by numerous physical variables including wave exposure, salinity, temperature and tides. On many rocky shores there is a distinct vertical zonation pattern brought about by a small number of dominant species inhabiting broad bands on the surface depending on their tolerance to the length of time they are exposed to the air at low tide and competition for space.

Intertidal sediments are mobile shingle and gravel, sand and mud or combinations of these, as well as saltmarsh soils. They support species that are tolerant of exposure to air and to variable temperature and salinity. The most notable areas for sediment are the mudflats and pockets of saltmarsh in the Clyde estuary, the heads of the lochs and the sandflats on the Ayrshire coast. The last of these have cultural and economic importance being frequented by many tourist visitors, in particular, during the summer months.

SENSITIVITY TO ACTIVITIES/PRESSURES[193]

Species found on rocky shores are likely to face increased pressures due to climate change with increasing sea temperatures and rainfall patterns. These pressures may be further exacerbated by the introduction of non-native species.[194]

Mudflats and sandflats are sensitive to physical disturbance, changes in wave regimes, sea-level rise and pollution. Development pressure can be significant in various parts of the Clyde, in particular in the Clyde estuary, but also on the Ayrshire coast. Beach litter levels remain high and have been increasing in almost all areas[195] and can be particularly problematic on the northern shore of the Clyde estuary in West Dunbartonshire where a combination of litter from recreational use, along with litter brought by wind and tide, leads to accumulations.[196] Sandflats can also be sensitive to any beach grooming. Sandflats are sensitive to fisheries and various damaging recreational activities although there is no direct evidence of this in the CMR.

193. Baxter *et al.*, 2011
194. Baxter *et al.*, 2011
195. UK National Ecosystem Assessment, 2011
196. Dyson, 2011

Table 5.1 Priority Marine Features found on intertidal sediments in the Clyde Marine Region and their sensitivity to activities/pressures

For further details on specific pressures in the region, see the Productive section

PMF	COMPONENT BIOTOPES/SPECIES	SENSITIVITY TO ACTIVITIES/PRESSURES[200]
Intertidal mudflats	Littoral mud	Physical disturbance, changes in wave regimes, sea-level rise and pollution.
Sea loch egg wrack beds	*Ascophyllum nodosum* ecad *mackayi* beds	Coastal development and any potential seaweed harvesting that may occur in future as this industry develops.
Seagrass beds	*Zostera noltii* beds in littoral muddy sand	Suction dredging and bait digging as well as a range of coastal developments.
Blue mussel beds	*Mytilus edulis* beds on littoral sediments	Physical damage, in particular demersal fishing, bait-digging, anchoring, coastal developments, chemical pollution and harvesting.
	Mytilus edulis and *Fabricia sabella* in littoral mixed sediment	
Native oyster	*Ostrea edulis* individuals and beds on shallow sublittoral muddy sediment	Over-fishing, pollution, disease and non-native species.

There are no PMFs currently mapped on intertidal rock in the CMR.

The main concern for intertidal rock and sediments in the Clyde Marine Region (CMR) is the introduction and increase in non-native species, in particular wireweed (*Sargassum muticum*).[197] Wireweed is a distinctive large olive-brown seaweed, often over 1m long which can dominate in rock pools, altering the habitat. It was first recorded in Scotland in Loch Ryan in 2004 and has since spread northwards throughout the Firth of Clyde and beyond. In 2010 Scottish Natural Heritage (SNH) commissioned research on the spread of wireweed on the west coast of Scotland. The report concluded that *'much of the eastern Firth of Clyde is colonised by established populations of* S. muticum*, with less dense colonisation in the west Firth of Clyde.* S. muticum *favoured bedrock and boulder substrates but dense populations were also recorded attached to small pebbles buried in sandy sediments, as well as on man-made coastal structures such as slipways and piers'. The species was recorded both in rock pools and subtidally*.[198]

The non-native common cord-grass (*Spartina anglica*) is also present in the CMR. It colonises the lower zones of estuarine salt marshes and intertidal mudflats, excluding native flora and fauna such as the dwarf eelgrass (*Zostera noltii*) and can lead to a loss of habitat for feeding and roosting, seriously affecting populations of migratory wildfowl and waders. It may compete with areas used for commercial oyster and mussel farming.[199] For further information on these and other non-native species see Chapter 5.10 – Marine Non-Native species.

Intertidal mudflats are found in sheltered areas within upper reaches of estuaries and sea lochs. They are a widespread feature of the CMR and not indicated on map 13.

Sea loch egg wrack beds are a detached form of eggwrack that only occur in very sheltered conditions, such as the upper reaches of sea lochs. They are known to exist at only one location in the CMR, at Tarbert.

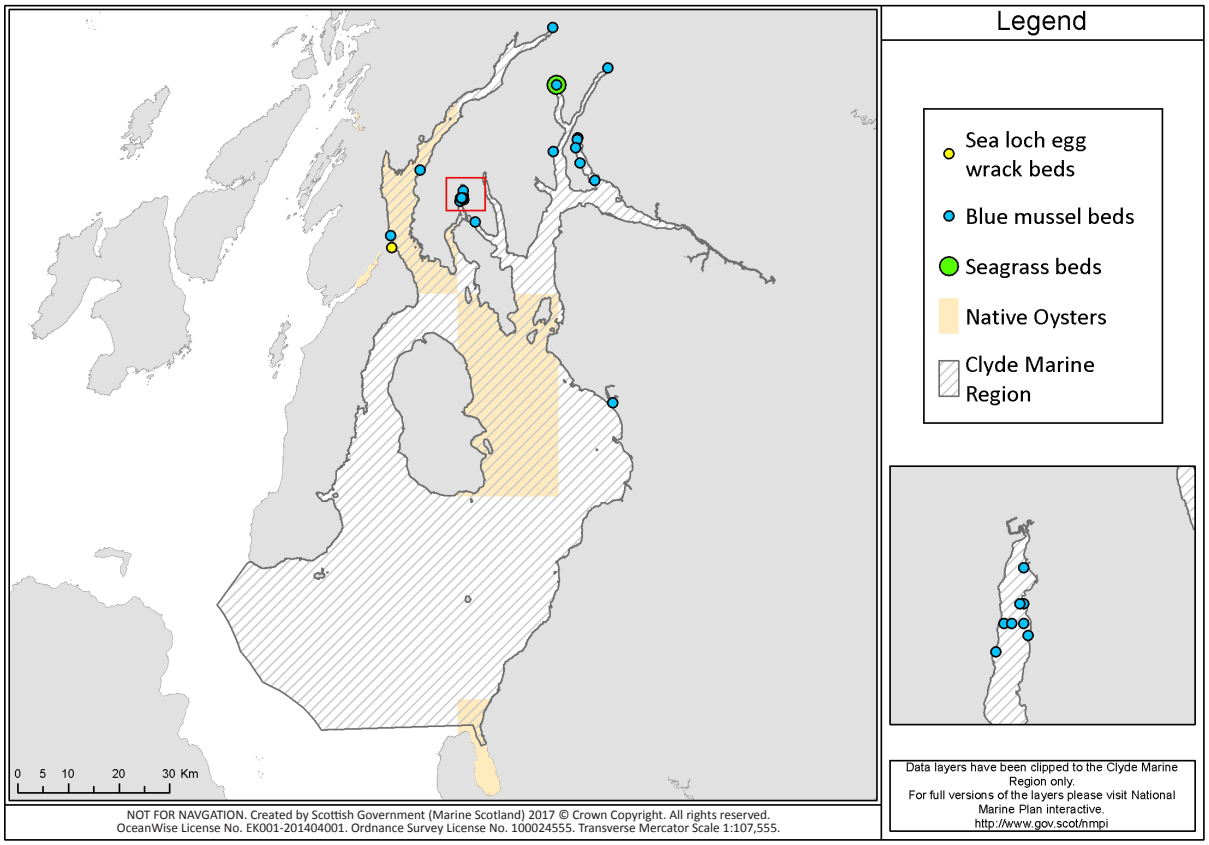
Figure 5.3 Blue Mussels



© CLAIRE PESCOD

197. Baxter *et al.*, 2011
198. Trendall *et al.*, 2010
199. Great Britain Non-native Species Secretariat, a
200. Baxter *et al.*, 2011

Map 13. Priority Marine Features found on intertidal rock and sediments in the Clyde Marine Region (note that these PMFs are likely to be more widely distributed than indicated on this map)



Intertidal seagrass beds have been documented at the head of Loch Goil, although the Upper Loch Fyne and Loch Goil MPA does not include this as a feature. They are also known to exist on the SSSI at Southannan Sands near Hunterston[201] although this is not currently indicated on NMPi. There have been significant declines in recent years in the UK and seagrass populations are currently considered as degraded.[202] However, the IUCN Red List of Threatened Species lists it as being of 'Least concern' at a global level.[203]

Blue mussels (figure 5.3 on previous page) can form dense beds or reefs in more sheltered firths and bays in the intertidal area. This PMF occurs in the sheltered lochs in the north of the CMR, but are not included as a feature within any MPAs.

Native oysters (figure 5.4) are typically found attached to rocks or other shells on mudflats in estuaries. They form beds that stabilise the underlying sediments and provide a hard substrate for other species. They were once widespread in Scotland and three records exist in the CMR (see Map 13 above).

For more information and a full list of Scotland's Priority Marine Features, visit www.snh.gov.uk/protecting-scotlands-nature/priority-marine-features/.

Figure 5.4 Native Oyster



© DAVID DONNAN, SNH

201. Scottish Natural Heritage, b
202. Baxter *et al.*, 2011
203. International Union for the Conservation of Nature

ECOSYSTEM SERVICES[204]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (incl. habitat provision for juvenile and spawning life stages)	Saltmarsh, seagrass beds and mudflats provide nursery grounds for fish species. Beds of cockles are found in several sandflats of the CMR, including the Isle of Bute, and the Ayrshire coast, but there are no commercial operations. Native oysters were once abundant and widespread in Scottish waters, but are now scarce.[205] Blue mussels and native oyster are not wild fisheries, but mussels and Pacific oysters are grown by the aquaculture sector of the CMR.
	Pharmaceuticals, fertiliser, biofuels	Seaweeds found on rocky shores, can be used for food, pharmaceuticals and in a range of other products. There is limited seaweed harvesting in the CMR.
Regulating	Sea defence	Loss of saltmarsh may reduce the provision of important natural sea defence services. Mudflats also provide a natural sea defence by absorbing wave energy and are an important sink for organic material.[206] Coastal sand dunes can protect the land behind them from wind and waves. Saltmarsh and mudflats are sensitive to sea-level rise (see Chapter 3.2 Climate change – Sea-level rise and coastal flooding).
	Clean and Safe waters	Loss of saltmarsh may reduce water purification services, i.e. breaking down waste and detoxifying water.
	Climate regulation (carbon capture and storage)	Saltmarsh is a carbon sink; sequestration rates are high, but the net benefit is small due to the low total area of these habitats in the CMR.
Cultural	Tourism and nature watching	Tourism, recreation and education are all provided by sandy beaches, saltmarsh and rock pools. The presence of marine litter or effects of eutrophication in the CMR may impact on the provision of these ecosystem services.
	Education and science	Intertidal rock and sediments provide an important education opportunity as an area accessible by students e.g. at FSC Millport.
Supporting services underpin the provision of other services		Seagrass provides substrate stabilisation by rhizomes, input of organic matter and habitat formation.[207] Mussel and oyster beds provide species habitat. Mudflats provide foraging areas for waterbirds. Rocky shores provide important resting and foraging places for many animals such as harbour and grey seals, otters and various wading birds, including oystercatchers, curlews and turnstones. Rocks provide hard substrate for seaweed and other organisms to attach to.

204. Marine Climate Change Impacts Partnership, 2015a
205. Mason and Fraser, 1986
206. Baxter *et al.*, 2011
207. Lancaster, 2014

5.2 Subtidal rock

Subtidal rock



Biogenic reefs only



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

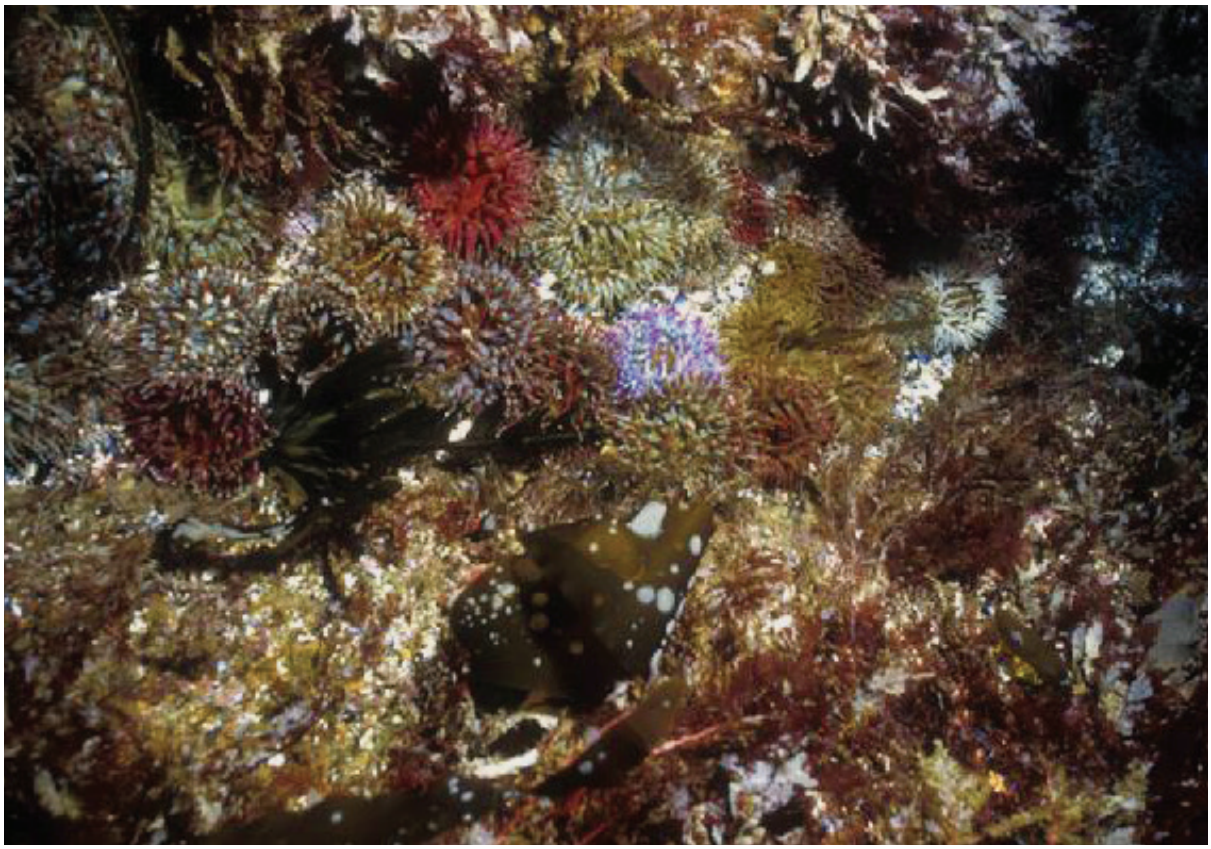
Scotland's Marine Atlas
www.gov.scot/Resource/Doc/345830/0115114.pdf

MPA surveys
www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-(mpa)/mpa-survey-research-reports/

Scotland's Marine Atlas Clyde score: 'Few or no concerns and stable'. Regional assessment is consistent with this except for biogenic reefs which have declined in extent in the CMR.

Introduction

Subtidal rock comprises bedrock, boulders and cobbles and occurs below the low water mark. Light plays an important role in the types of species found, with seaweeds inhabiting those areas with plenty of light nearer the surface and animals such as sponges and soft corals inhabiting deeper areas. Subtidal communities can also be influenced by wave and tidal action and salinity. There are limited areas of subtidal rock within the Clyde Marine Region (CMR) and these occur to the south of Arran, along the Ayrshire coastline and subtidal extensions of rocky shorelines or cliffs. This chapter also includes biogenic reefs where 'rocky' habitat is created by living organisms such as molluscs (see table 5.2).



Subtidal rock community, showing seaweeds and anemones © SUE HISCOCK

Table 5.2 Priority Marine Features found on subtidal rock in the Clyde Marine Region and their sensitivity to activities/pressures

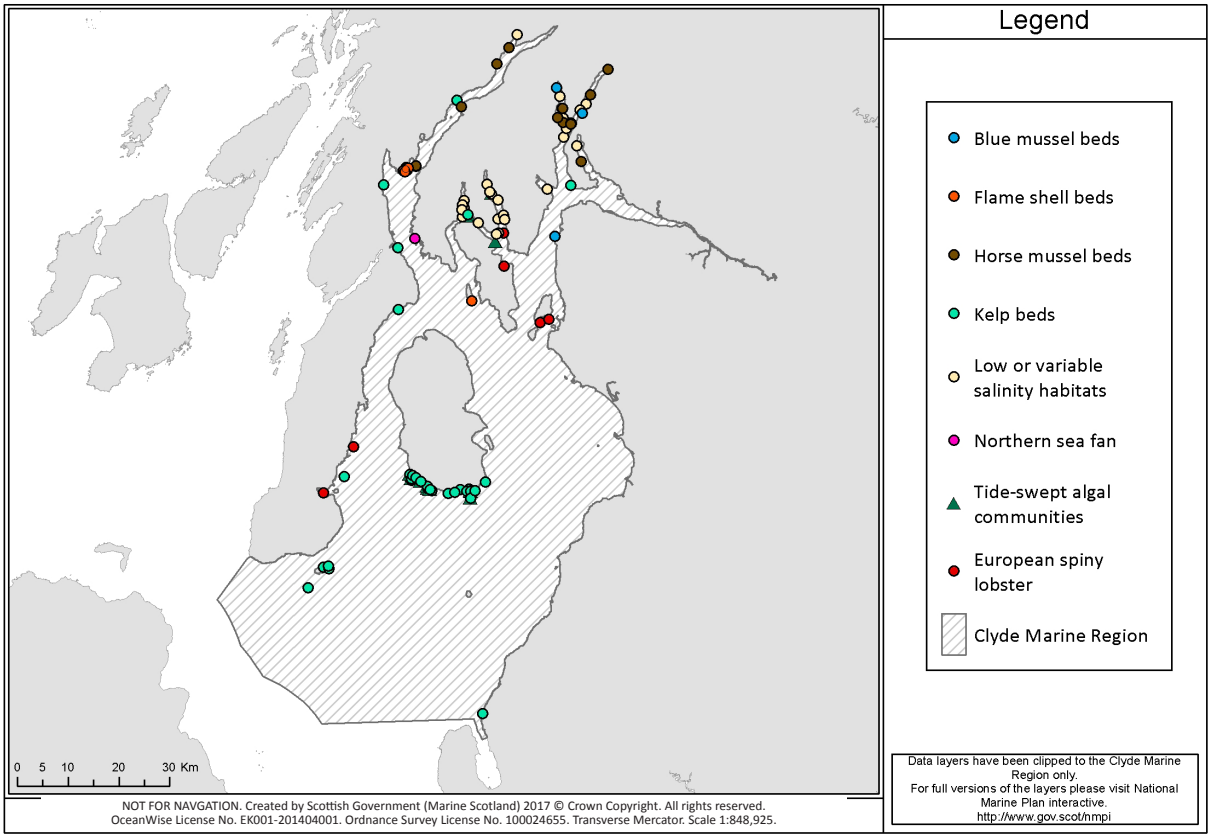
For further details on specific pressures in the region, see the Productive section

PMF	COMPONENT BIOTOPES/SPECIES	SENSITIVITY TO ACTIVITIES/PRESSURES[208]
Northern sea fan and sponge communities	*Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock	Physical damage from bottom fishing gear and siltation from fish farms. Increasing temperature (climate change) as sea fans are at the southern limit of their distribution in the CMR.
Pink sea fingers	*Alcyonium hibernicum*	Climate change and pollution
European spiny lobster	*Palinurus elephas*	Overfishing, although this species is not targeted in the CMR.
Kelp beds	*Laminaria hyperborea* on tide-swept, infralittoral rock	Any future seaweed harvesting.
	Laminaria hyperborea on tide-swept infralittoral mixed substrata	
	Laminaria hyperborea and foliose red seaweeds on moderately exposed infralittoral rock	
Tide-swept algal communities	Kelp and seaweed communities in tide-swept sheltered conditions	Seaweed harvesting, scallop dredging and any activity or development that reduces water flow.
Low or variable salinity habitats	Kelp in variable or reduced salinity	Saline lagoons are threatened by destruction of the habitat or change due to altering the water flow and salinity regime which could be due, for example, to coastal development, land claim, water abstraction. Sea level rise, storm events and pollution.
	Submerged fucoids, green or red seaweeds (low salinity infralittoral rock)	
BIOGENIC REEFS		
Blue mussel beds	*Mytilus edulis* beds on sublittoral sediment	Anchoring, demersal fishing operations, coastal developments and pollution.
Horse mussel beds	*Modiolus modiolus* beds with hydroids and red seaweeds on tide swept circalittoral	Physical damage to the seabed which may severely damage or even destroy beds.
	Modiolus modiolus beds with fine hydroids and large solitary ascidians	
	Modiolus modiolus beds with *Chlamys varia*, sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata	
Flame shell beds	*Limaria hians* beds in tide-swept sublittoral muddy mixed sediment	Physical damage to the seabed from mobile fishing gear, dredging and boats anchoring as well as coastal developments resulting in changes in water flow patterns.

208. Baxter *et al.*, 2011

Map 14. Priority Marine Features found on subtidal rock in the Clyde Marine Region

(note that these PMFs are likely to be more widespread than indicated on this map)



Pink sea fingers are found on shaded vertical rock surfaces and almost 50% of global records are from Scotland's west coast. Pink sea fingers have been recorded in 2006 by a Seasearch dive off Sanda Islands, although the record is currently being validated and does not appear on NMPi.[209]

The **European spiny lobster** is usually found at depths of between 5 and 70m but can go much deeper. It is now considered to be scarce in Scotland.

Three kelp bed biotopes of *Laminaria hyperborea* are found around the CMR but in particular to the south of Arran and around the Sanda islands.

Kelp and seaweed communities in tide-swept sheltered conditions are mainly found in sea lochs and are known to occur off the northern tip of the Isle of Bute.

Within the CMR there are records of **'Kelp in variable or reduced salinity'** at the heads of most of the Lochs; this feature tends to be found on very wave sheltered bedrock and boulders. 'Submerged fucoids and seaweeds on low salinity intralittoral rock' are characterised by dense seaweeds. This is a feature unique to Scotland and has been recorded at the head of Loch Shira.

Blue mussel beds are found on shallow mixed sediments. The bed stabilises the underlying sediment, providing a hard substrate for a diverse community of plants and animals. There are a small number of known sites in the Inner Firth and lochs of the CMR.

Horse mussels can form dense raised beds over sediments and thereby alter the habitat by providing a hard substrate and refuge for other species. Three different biotopes occur in the sheltered lochs of the CMR and is a feature of the Upper Loch Fyne and Loch Goil MPA.

Flame shell beds are formed where byssus threads of the flame shell intertwine with seaweed, maerl, shells and stones to provide a surface to which other species can attach. Large beds once existed in the Firth of Clyde, including at Skelmorlie Bank, Ayrshire, Stravanan Bay, Isle of Bute and Tan Buoy, Great Cumbrae.[210] Only one remaining extensive bed is now known to exist in Loch Fyne and its location has been confirmed during MPA survey work. It is a feature of the Upper Loch Fyne and Loch Goil MPA – see Chapter 5.9 Protected areas.

209. Seasearch, 2006
210. Hall-Spencer and Moore, 2000

Flame shell beds have declined considerably in the Clyde.[211] The beds are prone to damage from anthropogenic impacts and are especially susceptible to demersal fishing; recent evidence suggests they may take more than 100 years to re-establish following a single dredging event;[212] nests can be removed from the seabed and individuals are then consumed by fish, crabs and other scavengers. There is also evidence to suggest that historic use of TBT as an antifouling agent on salmon nets in the aquaculture industry may also have contributed to the decline of flameshell beds, due to a reduction in spat settlement.[213]

For more information and the full list of Scotland's Priority Marine Features, visit www.snh.gov.uk/protecting-scotlands-nature/priority-marine-features/

ECOSYSTEM SERVICES[214]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (incl. habitat provision for juvenile and spawning life stages)	Spiny lobsters are not currently targeted in the CMR but can provide a source of food. Subtidal rock supports the common lobster and crab species which are important to fisheries. There is concern over the decline in biogenic reefs in the CMR and the resultant lack in suitable habitat for certain species, especially nursery habitat. The lack of this type of complex substrate may hamper the recovery of fish stocks.
	Pharmaceuticals, fertiliser, biofuels	Seaweed can be cultivated/ harvested for food, chemicals, food additives and even health products.[215] Seaweed is not currently commercially cultivated in the CMR but is harvested on a small scale in some areas.
Regulating	Coastal protection Carbon storage	Biogenic reefs and seaweeds can capture and store carbon, and can provide coastal protection.
Cultural	Marine recreation	Interesting and attractive features such as rocky reefs and cliffs,[216] pink sea fingers and flame shell beds, can attract recreational divers.
Supporting services underpin the provision of other services		Biogenic reefs, such as horse mussel and flame shell beds along with rocky reefs, provide a hard substrate which other species can attach to or more complex substrate used for shelter and feeding.

211. Baxter *et al*., 2011
212. Tyler-Walters *et al*., 2016
213. Minchin *et al*., 1987
214. Marine Climate Change Impacts Partnership, 2015a
215. UK National Ecosystem Assessment, 2011
216. Clyde Diving

5.3 Shallow and shelf subtidal sediments



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Scotland's Marine Atlas www.gov.scot/Resource/Doc/345830/0115113.pdf

MPA surveys www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-(mpa)/mpa-survey-research-reports/

Clyde Ecosystem Review www.clydemarineplan.scot/wp-content/uploads/2016/06/Clyde-Ecosystem-Review.pdf

Tuck *et al.*, Kaiser *et al.* and Coggan *et al.*

Scotland's Marine Atlas Clyde score: 'Many concerns and stable'. Regional assessment is consistent with this.

Introduction

Subtidal sediments include shingle, gravel, sand and mud. Shallow subtidal sediments extend from the mean low water mark to around 70m; shelf sediments are those found from 70-200m depth. They cover the majority of the seabed in the Clyde Marine Region (CMR). For more information on substrates including a seabed sediments map, see the Chapter 3.3 Seabed and coastal geology and sediments.



Subtidal sediments © BEN JAMES, SNH

Table 5.3. Priority Marine Features found on shallow and shelf subtidal sediments in the Clyde Marine Region and their sensitivity to activities/pressures

For further details on specific pressures in the region, see the Productive section

PMF	COMPONENT BIOTOPES/SPECIES	SENSITIVITY TO ACTIVITIES/PRESSURES[217]
Northern feather star	*Leptometra celtica*	Dredging and demersal fishing
Fan mussel	*Atrina pectinata*	Scallop dredging and other mobile fishing gear.
Heart cockle	*Glossus humanus*	Dredging and demersal fishing activities
Ocean quahog	*Arctica islandica*	Mechanical damage particularly from bottom fishing gear.
Kelp and seaweed communities on sublittoral sediment	Kelp and seaweed communities on sublittoral sediment	Physical loss or removal
Burrowed mud	Seapens and burrowing megafauna in circalittoral fine mud	Fish farms (smothering, nutrient enrichment and chemical pollution), trawling for *Nephrops*.
	Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud	Bottom trawling and creeling, chemical pollution from fish farms.
	Tall seapen *Funiculina quadrangularis*	Mobile fishing gear and, to a lesser degree, creels.
	Fireworks anemone *Pachycerianthus multiplicatus*	Mobile fishing gear particularly trawling for *Nephrops* and, to a lesser degree, creels.
	Mud burrowing amphipod *Maera Loveni*	Unknown
Maerl beds		Physical disturbance and smothering due to scallop dredging, bottom trawling, aquaculture and extraction as a fertiliser.
Maerl or coarse shell gravel with burrowing sea cucumbers	*Neopentadactyla mixta* in circalittoral shell gravel or coarse sand	Scallop dredging or maerl extraction.
Inshore deep mud with burrowing heart urchins	*Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud	Benthic trawling for *Nephrops*.
Seagrass beds	*Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand	Anchors, nutrient enrichment and increasing turbidity that reduces available light.
	Ruppia maritima in reduced salinity infralittoral muddy sand	
Shallow tide-swept coarse sands with burrowing bivalves	*Moerella* spp. with venerid bivalves in infralittoral gravelly sand.	Can be targeted for scallop dredging – the slow growing bivalves are sensitive to overfishing and physical disturbance.
Low or variable salinity habitats	Sublittoral mud in low or reduced salinity (lagoons)	Saline lagoons are threatened by destruction of the habitat or change due to altering the water flow and salinity regime which could be due for example to coastal development, land claim, water abstraction. Sea level rise, storm events and pollution.

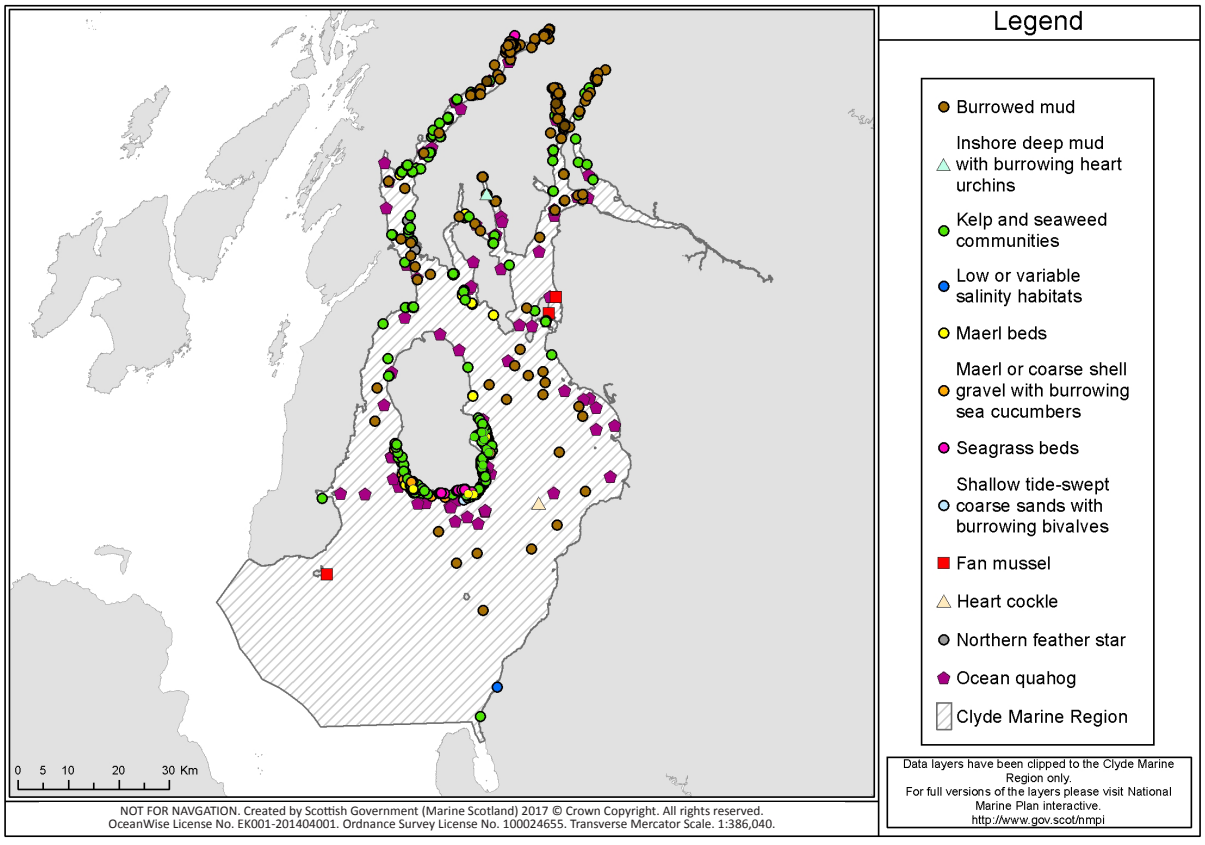
217. Baxter *et al.*, 2011

Many of the PMFs for subtidal sediments in the CMR (see table 5.3) are sensitive to physical damage, smothering or pollution from a range of activities including fishing activities such as demersal trawling and dredging and impacts from fish farms.[218]

In the past 50 years a commercially important fishery for burrowing *Nephrops* has developed in areas of the Clyde containing mud and muddy sediments. *Nephrops* are targeted by small demersal trawlers. Several studies from various parts of the world consider the impacts of trawling on habitats. It is generally recognised that trawling reduces the structural complexity of the seabed, by smoothing out mounds and filling in troughs,[219] although this type of structural change can also be caused by natural events. One study showed visible marks from trawling remaining for only 52 hours,[220] whilst trials in the deep-water mud of the Gare Loch suggested that after 16 months of trawling activity trawl marks were only faintly visible (although community effects extended beyond the life of the study) and this study concluded that scouring marks are likely to last longer in deep water and in sheltered areas with fine sediments.[221] The persistence of marks depends on their original depth, the sediment type, the current, wave action and biological activity.[222] Trawling also alters the benthic community but these changes can be difficult to predict. In the Clyde, studies have shown that different locations become more similar and that overall habitat and species diversity is reduced.[223] Some changes may be temporary but where the seabed is frequently disturbed, a new stable state may be reached.[224]

Scallops are the most important commercial mollusc species in the Clyde and again over the last 50 years, a dredge fishery has been active throughout the area, where there are sand or gravel sediments.[225] Dredging can change the granulometric properties of gravel,[226] can damage vulnerable soft animals such as sea sponges[227] and can negatively impact animals in previously stable mud, coarse gravel or biogenic habitats.[228] It can also break up maerl and cover adjacent beds with plumes of sediment.[229] Experiments conducted at two sites in

Map 15. Priority Marine Features found on shallow and shelf subtidal sediments in the Clyde Marine Region



218. Baxter *et al*., 2011
219. Coggan *et al*., 2001
220. Fonteyne 2000
221. Tuck *et al*., 1998
222 Tuck *et al*., 1998; Fonteyne, 2000; Smith *et al*., 2000; Humborstad *et al*., 2004
223. Coggan *et al*., 2001
224. Kaiser *et al*., 2000
225. McIntyre *et al*., 2012
226. Hauton *et al*., 2003
227. Boulcott and Howell, 2011
228. Collie *et al*., 2000
229. Hauton *et al*., 2002

the Clyde show that a single sweep with a Newhaven scallop trawl can kill up to 70% of living maerl in the dredge path with no signs of regrowth after 4 years.[230] ICES concluded that there is significant evidence to implicate the role of fishing activities, particularly dredging, in the widespread decline in maerl.[231] The potential for maerl recovery is extremely low, although studies do show a positive correlation between reduction or removal of fishing pressure and improvements in maerl growth.[232] The most important factor in hampering the recovery of maerl is the extremely slow rate of growth. Along with this, low reproduction capability and small populations reduce the recruitment, dispersal and settlement capability[233] of both the maerl and species which this habitat supports, including scallops and gadoids.

The **northern feather star** is normally a deep water species but western Scotland is unique in having shallow water examples in depths of around 20m in sea lochs. They are known to occur in Loch Fyne in the CMR.

The **fan mussel** is one of Britain's largest molluscs and is found partly embedded in the sediment. They are considered nationally scarce within the UK and are known to occur in the CMR around Cumbrae and the Sanda Islands.

The **heart cockle** is found in undisturbed muds, usually below 50m and it is thought to be under-recorded as there is currently only one record in the CMR, off South Ayrshire.

The **ocean quahog** is a mollusc that is thought to live for over 400 years. It is found in sandy and muddy sediments all around Scotland and throughout the CMR. Ocean quahog aggregations are a feature of the South Arran MPA and the Upper Loch Fyne and Loch Goil MPA – see Chapter 5.9 Protected areas – and are also found in areas outside of MPAs.

Kelp and seaweed communities on sublittoral sediment greatly increase the primary productivity of an area and create a more diverse habitat. The dominant species are sugar kelp (*Saccharina latissima*), bootlace weed (*Chorda filum*) and various red and brown seaweeds. The turfs of seaweed may support a diverse range of animals including burrowing polychaete worms, bivalve molluscs, and scavengers including hermit crabs and fish. This is a feature of the South Arran MPA, and is also found around the CMR.

Burrowed mud is a dominant feature of the CMR and is home to a number of burrowing species, including the commercially important *Nephrops*. Amongst the PMF species are seapens including the Tall sea pen, Fireworks anemone, a burrowing amphipod (*Maera Loveni*) and spoon worm (*Maxmuelleria lankasteri*). These are protected features in the South Arran MPA and the Upper Loch Fyne and Loch Goil MPA. It is also found in areas outside of these MPAs.

The **deep inshore muddy basins** of some sea lochs support a community dominated by the heart urchin (*Brissopsis lyrifera*) and the brittlestar (*Amphiura chiajei*). There is currently only one record in the CMR of this PMF at the head of Loch Striven.

Maerl beds are found throughout the west coast of Scotland and are of particular interest and concern in the CMR. Maerl is a calcareous red seaweed which forms an important biogenic habitat. Maerl is extremely slow growing and some beds may be over 1000 years old. They create a complex, open structure that supports many other species. Over five hundred faunal species and 150 microalgal species are recorded as living on or in maerl beds; additionally maerl is an important feeding ground for juvenile Atlantic cod and provides nursery areas for bivalves such as scallops.[234] Maerl is a protected feature of the South Arran MPA. In the CMR it is also found around the Isle of Bute.

Eelgrass (*Zostera marina*/*angustifolia*) and *Ruppia maritima* form seagrass beds in the sheltered areas throughout the west coast of Scotland with *Ruppia marina* favouring more brackish conditions. Seagrass beds provide shelter or substratum for a wide range of species, such as wrasse or goby species.[235] These beds occur in a small number of places on the CMR and they are a protected feature of the South Arran MPA, but also occur in other areas around the CMR.

Shallow tide-swept sands with burrowing bivalves particularly tellin bivalves, surf clams, polychaete worms, tanaids and sand hoppers have been found off the south coast of Arran and this is a feature of the MPA.

Saline lagoons are shallow coastal water bodies with varying salinity and contain specialised species that can tolerate the wide range of environmental conditions that can occur in these areas. **'Sublittoral mud in low or reduced salinity'** is a lagoon with short-lived species such as blow lugworms and mud shrimps. This PMF is present at Ballantrae.

For more information and the full list of Scotland's Priority Marine Features, visit www.snh.gov.uk/protecting-scotlands-nature/priority-marine-features/.

230. Hall-Spencer and Moore, 2000
231. International Council for the Exploration of the Sea, 2005
232. Howarth *et al*., 2013
233. Mazik *et al*., 2015
234. The Marine Life Information Network, 2007
235. The Marine Life Information Network, 2016

ECOSYSTEM SERVICES[236]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (incl. habitat provision for juvenile and spawning life stages)	Spiny lobsters are not currently targeted in the CMR but can provide a source of food. Subtidal rock supports the common lobster and crab species which are important to fisheries. There is concern over the decline in biogenic reefs in the CMR and the resultant lack in suitable habitat for certain species, especially nursery habitat. The lack of this type of complex substrate may hamper the recovery of fish stocks.
	Pharmaceuticals, fertiliser, biofuels	Seaweed can be cultivated/ harvested for food, chemicals, food additives and even health products. Seaweed is not currently commercially cultivated in the CMR but is harvested on a small scale in some areas.
Regulating	Coastal protection Carbon storage	Biogenic reefs and seaweeds can capture and store carbon, and can provide coastal protection.
Cultural	Marine recreation	Interesting and attractive features such as rocky reefs and cliffs, pink sea fingers and flame shell beds, can attract recreational divers.
Supporting services underpin the provision of other services		Biogenic reefs, such as horse mussel and flame shell beds along with rocky reefs, provide a hard substrate which other species can attach to or more complex substrate used for shelter and feeding.

236. Marine Climate Change Impacts Partnership, 2015a

5.4 Marine fish (demersal and pelagic) and shellfish



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Some fish species are identified as overexploited or in decline or are lacking in sufficient data to make an assessment.
Shellfish stocks are largely over exploited or lacking in data apart from *Nephrops* stocks which are considered abundant.

Marine Scotland Science – Clyde Ecosystem Review www.clydemarineplan.scot/wp-content/uploads/2016/06/Clyde-Ecosystem-Review.pdf and other reports.

ICES www.ices.dk/community/advisory-process/Pages/Latest-Advice.aspx

Scotland's Marine Atlas Clyde score: commercial fish and shellfish 'many concerns with No Area Assessment'. Regional assessment is consistent with this.

Introduction

Pelagic species are those that move throughout the water column such as mackerel (*Scomber scombrus*) and herring (*Clupea harengus*), while demersal species such as cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) spend most of their lives in close proximity to the seabed.

The condition of the pelagic and demersal fish stocks in the Clyde is a complex and potentially contentious area. Views regarding populations of pelagic and demersal species range from the 'ecological meltdown' and 'endpoint of fishing' of Thurstan and Roberts (2010) to the functioning but 'altered ecosystem' as shown by Heath and Speirs (2012). There is more certainty with regards some shellfish stocks; *Nephrops* (*Nephrops norvegicus*) in particular are better understood and appear to be more productive in recent years.[237] In terms of demersal and pelagic species the composition has undeniably been altered and large individuals are now rare, despite a recovery in biomass of some species which was observed following the end of a targeted fishery for demersal finfish.

Other marine fish such as wrasse (*Labridae*), gobies (*Gobiidae*) and blennies (*Blennioidei*) should also be considered but data are significantly lacking in the Clyde and so this Assessment will focus on commercial demersal and pelagic species. The benefits of a full stock assessment of target and non-target species are being discussed by the Clyde 2020 group.

Many peer reviewed scientific papers about the changes in the Clyde Marine Region (CMR) ecosystem have been published, and widely discussed. Under the European Fisheries Fund (EFF) Inshore Fisheries Management projects produced in 2015, work package 4 includes a summary of available published biological and environmental data relevant to inshore fisheries management for the CMR.[238, 239, 240, 241]

There is a lack of data on the number of vessels under 10m trawling in the CMR and on the number of creels placed annually. It is apparent, however, that a greater volume of catch is landed by the trawl fishery than by the creel fishery (See Chapter 6.2 Productive – Sea fisheries) and that spatial and temporal conflicts potentially remain between the two approaches.

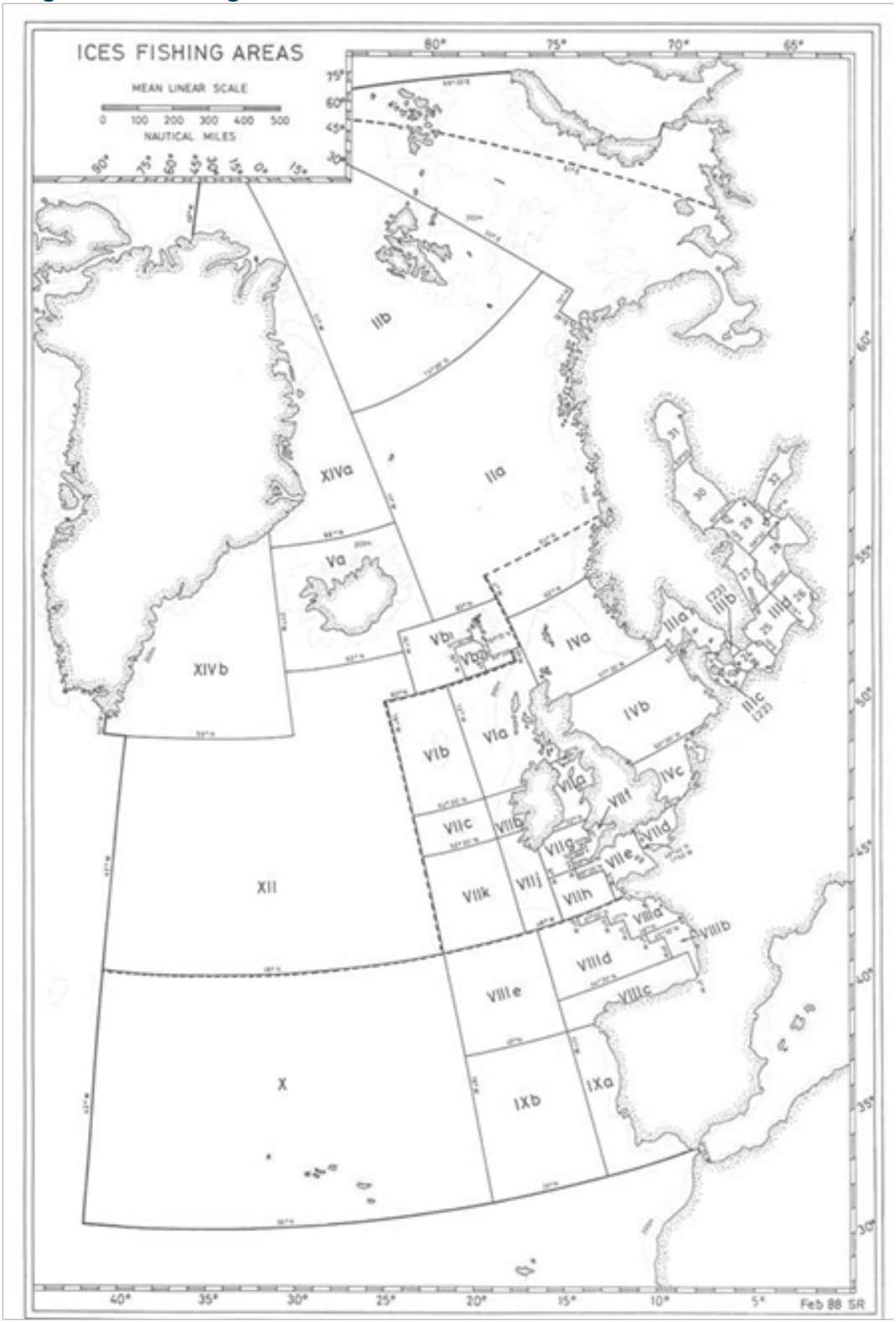
Whilst creel fishing is not as low impact as hand dived collection of target species, studies have shown that towed demersal fishing gear physically interacts with the seabed and water column (see Chapter 5.3 Shallow and shelf subtidal sediments).[242]

Stock assessment

Assessment of the state of commercially relevant stocks in the area is performed at a much larger scale than the Clyde; this is referred to as the VIa region. The International Council for the Exploration of the Sea (ICES), a meeting point for more than 4000 fisheries scientists from the 20 North Atlantic countries, makes the assessment within the VIa region (see figure 5.5). This area of sea is 236,928km^2 and includes the CMR, along with much of the West Coast of Scotland. A detailed assessment of the CMR itself is not currently available although ICES recently (2016) undertook a review of the Celtic Seas Region (the Malin shelf; the Celtic Sea and west of Ireland; the Irish Sea) and concluded that the five most important pressures in the Celtic Seas ecoregion are selective extraction of species, abrasion, smothering, substrate loss, and nutrient and organic enrichment.[243] A number of ICES statistical areas (the smaller accounting units which make up the ICES regions) do cover the CMR, including areas 39E4, 39E5, 40E5, 41E5, 41E4 and 40E4, and their advice (below) covers these units.

237. International Council for the Exploration of the Seas 2017e
238. Fox *et al.*, 2015
239. Thurstan and Roberts, 2010
240. Heath and Speirs, 2011
241. Hunter *et al.*, 2015
242. Ivanovic, 2015
243. Bailey and Barreto, 2015

Fig. 5.5 ICES Fishing Areas



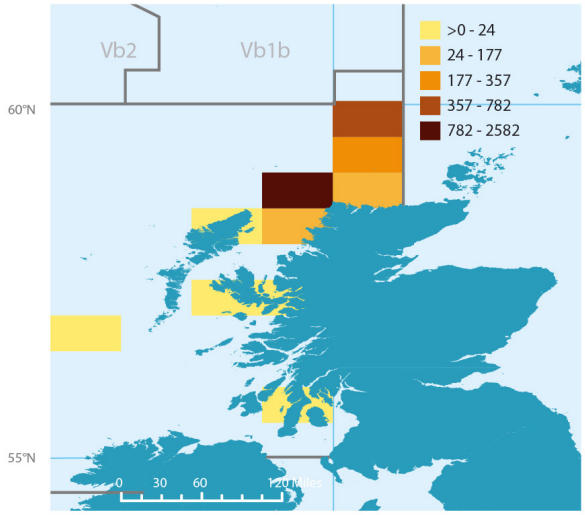
The ICES West of Scotland assessment of fin fish stocks includes information about spawning stock biomass (SSB), recruitment (the number of young fish entering the system) and the rate of mortality from fishing (F). A summary of their assessment is below.[244] No accurate stock assessment is currently available for species including, lobster (*Nephropidae*), or King scallop (*Pecten maximus*) in the Clyde Marine Region however Marine Scotland now state that they have sufficient evidence to undertake an assessment for brown crab (*Cancer pagurus*).[245]

244. Bailey and Barreto, 2015
245. Mesquita, 2017

West Coast of Scotland (ICES area VIa)[247]

- ICES now assess haddock on the basis of a Northern Shelf stock (North Sea, Skagerrak and West of Scotland).In 2017 ICES advised that Haddock stocks were fished at Maximum Sustainable Yield (MSY) (i.e. fished too heavily compared to fishing that produces maximum sustainable yield) although the spawning stock biomass was mostly above the ICES trigger level (Btrigger) since 2002.Recruitment of juvenile haddock is characterized by occasional large year classes but is currently low.[246]
- Cod stock remains in a very poor condition and ICES 2017 advice is "zero catches in each of the years 2018 and 2019."Cod was subject to the cod recovery plan for some time, although, there has been little response and stock biomass remains too low to be fished sustainably.[247]
- West coast herring, which is subject to a Long Term Management Plan,[248] is now subject to advice from ICES which concludes that there should be zero catch due to fishing mortality and the low level of the spawning stock biomass.

Fig 5.6 2015 Distribution of landings into Scotland by UK Vessels (tonnes) of herring *(Clupea harengus)*



Source: Marine Scotland Science Fish and Shellfish Stocks 2017 Edition

Table 5.4 Status of ICES target species of relevance to the Clyde Marine Region

SPECIES	SEA AREA	STATUS
Anglerfish *Lophius piscatorius*	Territorial waters and offshore	High risk species taking many years to reach maturity. North sea stock in decline, ICES continues to recommend a reduction in fishing effort and catch. West coast stock stable.
Atlantic herring	Territorial waters and offshore	An important food fish for many other species, ICES have set a Long Term Management Plan for west coast stocks.
Atlantic mackerel	Territorial waters and offshore	Western mackerel stocks considered of regional and possibly global importance. North Sea stock still to fully recover from decline in 1960s. Mackerel are one of the most widely distributed stocks on the West of Scotland. The fish migrate throughout the year and can be found from the Iberian Peninsula to the west of Norway and beyond. In 2010 the stock was considered to be in 'good' condition by ICES, but as the SSB is back-calculated based on egg production, there is some caution about the assessment. A long-term management plan for mackerel which includes fishing above FMSY has improved the biomass.
Cod	Territorial waters and offshore	Stocks severely declined. ICES consider stocks in the North Sea, western Scotland and Irish Sea below safe biological limits. Listed as vulnerable on IUCN Red List.
Ling *Molva molva*	Territorial waters and offshore	Scotland has a large proportion of the British population; numbers are maintaining a stable low level.
Norway pout *Trisopterus esmarkii*	Territorial waters and offshore	Recruitment is variable but fluctuations in North Sea stocks probably natural rather than due to fishing pressure.
Saithe	Territorial waters and offshore	Stocks recovering and thought to be fished sustainably.
Sandeel *Ammodytes* spp	Territorial waters and offshore	Stocks are in decline. Sandeels are an important source of food for many species including many species of seabird and cetaceans.
Whiting	Territorial waters and offshore	Stocks have been stable or declining for last 10 years, and North Sea distribution contracted.

246. International Council for the Exploration of the Sea,2017b
247. International council for the Exploration of the Sea, 2017a
248. Council Regulation (EC) No 1300/2008 of 18 December 2008 establishing a multi-annual plan for the stock of herring distributed to the west of Scotland and the fisheries exploiting that stock.

They state that the spawning stock biomass has been decreasing since 2004 and that 2016 was a record low year for F_{MSY}.[249]

- West coast whiting (*Merlangius merlangus*) SSB has been increasing since 2006 but remains very low compared to historical estimates ICES advises zero catch in each of the years 2017 and 2018.[250]
- Fishing mortality for North-east Atlantic Mackerel is below management trigger points and SSB is maintained at long term high levels. Incoming year classes appear to be around or above recent averages.[261]
- With regards to other demersal and pelagic species, there is quota for a range of species in the Vla region including for Saithe (*Pollachius virens*). There is no directed fishery for any other demersal or pelagic fish in the CMR.

Table 5.4 (left) summarises the species targeted within the ICES areas relevant to the CMR. Although these species are not subject to a targeted fishery within the CMR, their status in the wider area should be noted with regards to their likely role in the CMR ecosystem.

Historical context

The earliest records of herring as a commercial catch in Scotland date back to the early 12th Century. In 1674 up to 20,000 barrels of salted herring left the Clyde destined for France and by the late 1800s the catch per unit effort (CPUE[252]) for herring had increased while the CPUE for white fish had dropped. Salmon fishing records date back to the 12th century but overfishing, combined with significant pollution saw no salmon entering the Clyde system by 1900. However, this situation has since improved markedly and salmon have once again been recorded spawning in the Black Cart and Kelvin catchments.[253, 254, 255]

In the late 18th and 19th Centuries, fishing for herring, cod, haddock and turbot (*Scophthalmus maximus*) was common in the area. The herring fishery, in particular, continued to be significant due to the productive waters which attracted spawning shoals. The importance of the Clyde herring fishery to the Scottish fishing industry increased throughout the 1860s and 70s. To protect a crucial spawning ground located at Ballantrae Bank, the area was closed to fishing between January and May in 1860. This was repealed in 1867 and fishing restarted as before in 1868. By the early to mid-20th Century declines were observed in herring numbers.

In 1889, steam trawling was banned in the Firth of Clyde. However, in 1962, a byelaw was introduced allowing trawling except within 3 nautical miles (NM) of the low water mark. Further declines in demersal fish stocks resulted in a repeal of the 3 mile limit and trawling was opened up to this part of the Clyde in 1984. Landings in whiting, cod, saithe and flounder (*Platichthys flesus*) have all decreased through to the start of the 21st Century.

In 2014 the South Arran Marine Conservation Order[256] came into effect, prohibiting all types of fishing activities, both commercial and recreational and any removals from the seabed within areas of the South Arran MPA where maerl was known to be present.[257] Previously, in 2008 the Inshore Fisheries (Prohibition of Fishing)(Lamlash Bay) (Scotland) Order took effect, supported at the time by both Clyde fisheries interests and conservationists which established the Lamlash Bay No-Take Zone; This is now encompassed within the South Arran MPA.[258]

Clyde 2020

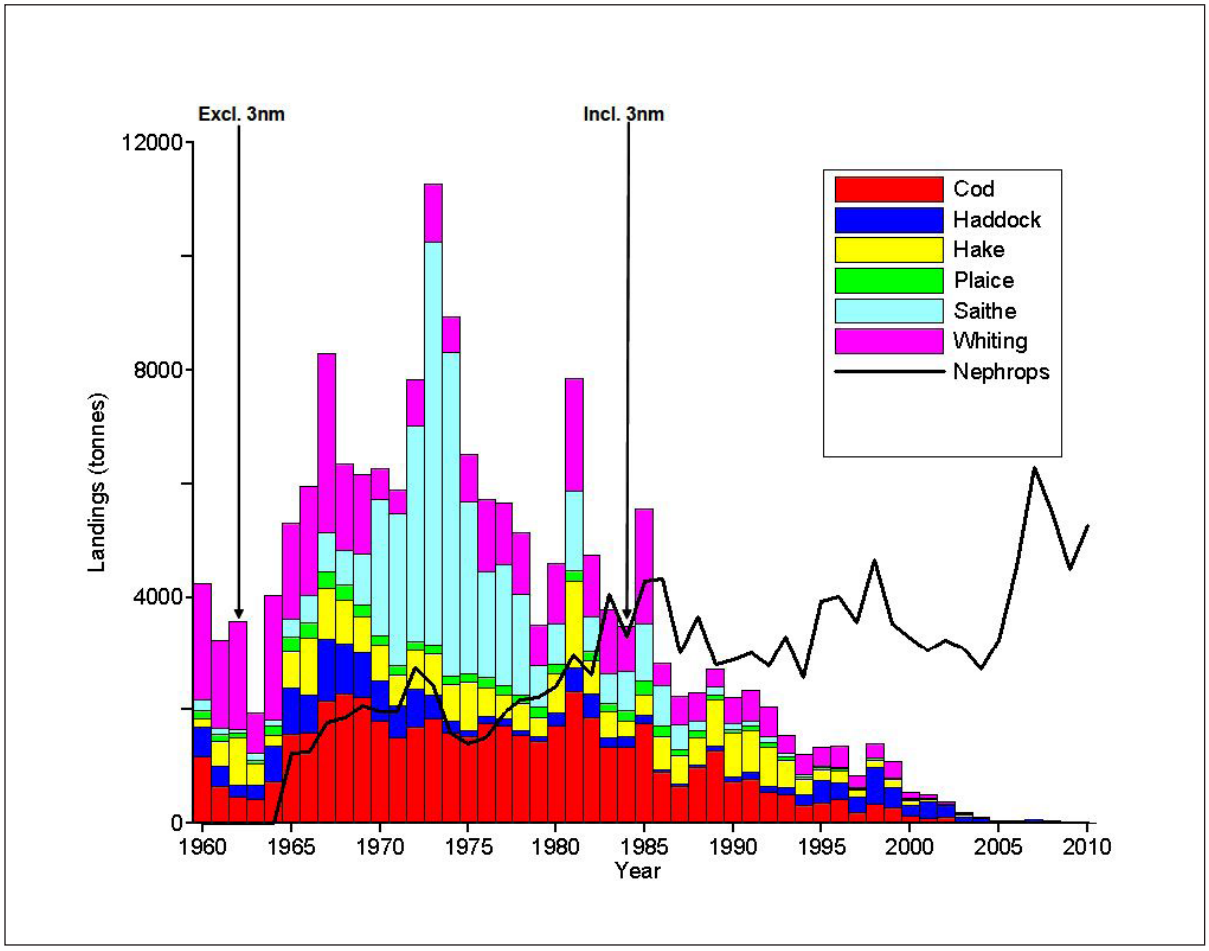
In 2014, the Clyde 2020 project held a summit where the latest Scottish Government (Marine Scotland Science) scientific evidence for demersal finfish populations in the Clyde was presented. This showed that the biomass in the Clyde is now greater (almost double) that of the 1930s and 1940s, however 90% of it is below minimum landing size and 72% of it is whiting. This indicates that the CMR demersal finfish biomass has recovered from very high exploitation rates in 1970s and 1980s (figure 5.7) and the area is still productive but it is in a new regime of small fish dominated by whiting.

Figure 5.8 also shows that there are some positive signs of change in the Clyde Sea demersal fish populations. The species evenness index is increasing; in the period 1995-2004 just four fish species made up 95% of the biomass of Clyde demersal fish, whereas in 2005-2009 this had increased to eight. In the earlier period 87% of the biomass was whiting, while in the later period this had decreased to 72%. The results also show a significant increase in overall biomass since 1990. As stated in the Clyde Ecosystem Review *'all of these indicators of improving conditions in the Clyde should be strong arguments supporting the prospect of a restored Clyde'*.[259]

In a comparison of stakeholder engagement systems, Clyde 2020 scored highly for dialogue and interaction with fishermen and the fishing sector.[260]

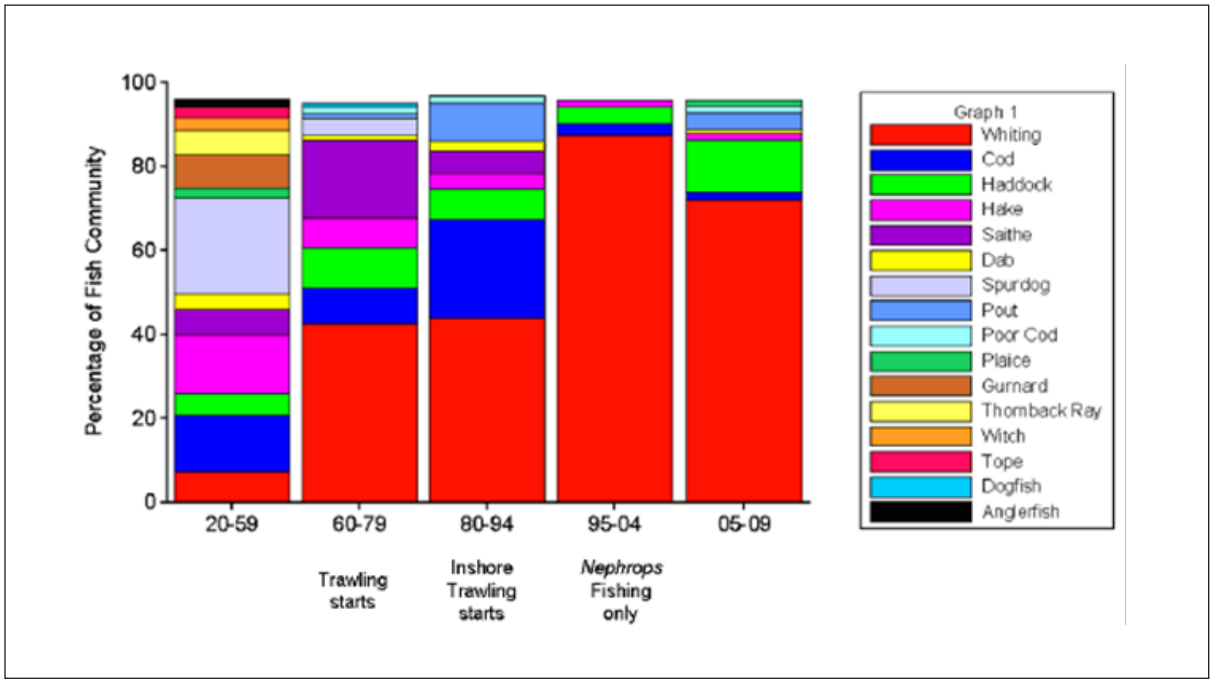
249. International Council for the Exploration of the Sea 2017c
250. International Council for the Exploration of the Sea , 2016
251. International Council for the Exploration of the Sea,2017d
252. Catch-Per-Unit-Effort (also called catch rate) is an index for fisheries monitoring. Declines in CPUE may mean that the fish population cannot support the level of harvesting. Increases in CPUE may mean that a fish stock is recovering and more fishing effort can be applied. CPUE can therefore be used as an index of stock abundance, where some relationship is assumed between that index and the stock size.
253. Wood, 1960
254. Buckland, 1871
255. Mackay and Doughty, 1986
256. Scottish Statutory Instruments, 2014 No 260
257. The Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 2014
258. The Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 2008
259. McIntyre *et al.*, 2012
260. Little *et al.*, 2015

Figure 5.7 Summary of landings (not stock) in tonnes of six demersal fish species in the Clyde Sea (ICES 39E4, 39E5, 40E4, 40E5). (Years when the Clyde opened to trawling, excluding 3nm from the coast and including 3nm are highlighted. Landings of *Nephrops* are shown as a black line.)



Source: Clyde Ecosystem Review

Figure 5.8 The species in the Clyde that make up 95% of the biomass of Clyde demersal fish (Figures along the X axis represent years)



Source: Clyde Ecosystem Review

Demersal species growth rates

In 2015 Hunter published results of research looking at trends in growth of five demersal species; cod, haddock, whiting, Norway pout and saithe. The conclusion was that large changes in growth (length/age ratios) of fish in the Clyde have been brought about independently of environmental influences. Due to the long-term nature of the declines in length, and regional differences in growth trends and the fisheries, the results suggest that the changes may have been largely due to over fishing with size selective nets. The declines in length were particularly severe in Clyde haddock and whiting and are suggestive of a long-term selective pressure favouring small sizes.[261]

Investigation of reports of semi-pelagic white fish in the Clyde Marine Region

In 2012 the Clyde Fisherman's Association (CFA) held a presentation at the Scottish Parliament, which documented changes in Clyde fisheries in more detail, and made many additional points concerning the findings of McIntyre *et al*. (2012).

One of the principal suggestions was that cod (and other white fish) in the CMR is no longer a demersal fish, but a semi-pelagic one. Hence it was also suggested that the standard demersal trawl surveys used by Marine Scotland Science (MSS) in the CMR, and which provided the data for the Heath and Speirs (2011) analysis, do not generate a correct picture of the abundance or distribution of cod (figure 5.9), or white fish in general, including whiting, in the CMR.

In response to extensive consultation with the Clyde fishing industry, MSS undertook a trial survey to investigate these reports of semi-pelagic white fish in the CMR. This was carried out in February 2014 and the results were published in 2016 showing that, on average, long-duration semi-pelagic fishing within the deep basins of the CMR catch white fish at a lower rate (i.e. numbers of fish caught per hour fishing) than standard demersal fishing in the same areas. However, such semi-pelagic fishing catches large fish at higher rates than in demersal fishing. It must be remembered that the results presented here are from an investigative survey and not a statistically designed survey.[262] In order to provide a more representative picture of the whitefish community of the CMR, a more comprehensive survey including semi-pelagic and bottom trawl sampling across the CMR and throughout the year is underway with the third research trial undertaken in 2017, results should be published shortly.

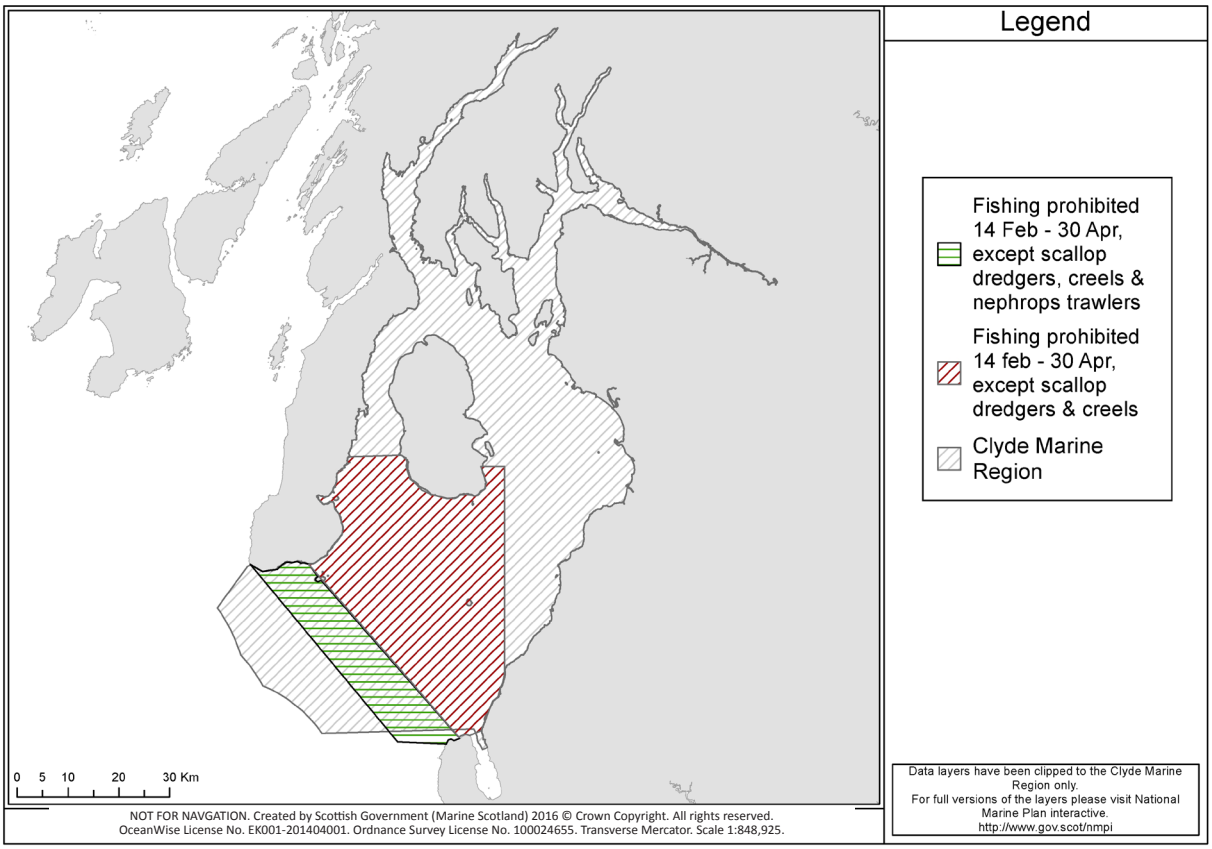
Figure 5.9 Juvenile Cod



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261. Hunter *et al*., 2015
262. Turrell *et al*., 2016

Map 16. Clyde Cod box



Connectivity of the Clyde Marine Region demersal and pelagic fish populations with other regions

Much work has been done to try to establish the distinctiveness of CMR fish populations – from genetics to otolith microchemistry. In herring this has drawn limited conclusions; the body of opinion is that fish sampled from the Clyde had otolith[263] chemistry consistent with fish originating from the Western Irish Sea.[264] Whilst demersal species research, focusing on cod, saithe and haddock, seems to conclude that the CMR fish are a largely separate, discrete residential stock with limited mixing with stock from outside the region.[265] This will be of particular relevance as the Clyde 2020 steering group considers options to improve the white fish stock status of the CMR.

Spawning grounds

The Ballantrae Bank, near the mouth of Loch Ryan, is accepted as being an important spawning ground for herring in particular[266] and further into the CMR, off the South end of Arran a further smaller herring spawning ground[267] has been identified and suggested as new protected areas, including during discussions regarding the network of MPAs in the Clyde.[268] Protective measures for spawning herring include a ban on herring fishing from 1st January to the 30th April,[269] a ban on all active fishing from 1st February to 1st April on the Ballantrae Bank spawning grounds,[270] and a ban on herring fishing between midnight on Saturday morning to midnight Sunday night.[271]

The 'Cod Box' area (shown in Map 16) is designated as an important area for cod, haddock and hake spawning. In order to protect spawning cod, no fishing is allowed in this area between 14th February and 30th April. In 2015 research published concluded that there was no evidence of local recovery in terms of abundance, biomass, or reduced mortality more than a decade after establishing the closure. Mortality may have

263. An otolith is a bony structure found in the middle ear of fish.
264. Geffen *et al.*, 2011
265. Galley *et al.*, 2006
266. Ewart, 1984
267. Parrish *et al.*, 1959
268. Marine Scotland, 2013b
269. Council Regulation (EC) No. 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.
270. The Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 2004
271. The Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 2004

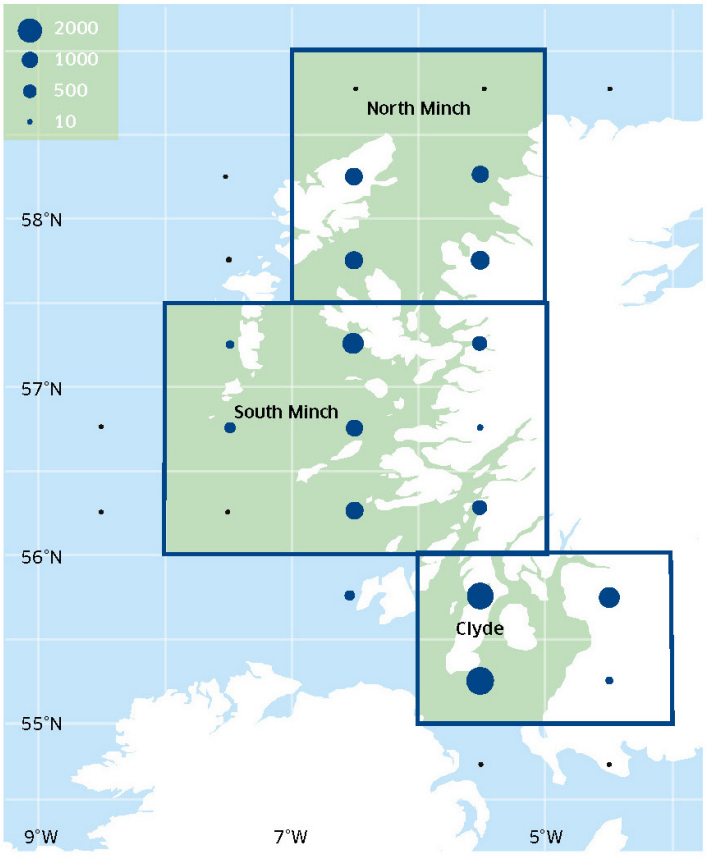
remained high because young cod are still caught as bycatch in the *Nephrops* fishery in the area (although by-catch of cod has reduced due to changes in mesh size and other measures[272]) and the predation rate may have increased due to an expanding whiting population.[273]

It has been more difficult to be precise about the areas most heavily used for spawning by other demersal species and so no specific areas are designated for this purpose.[274]

Shellfish

The development of the shellfish fishery was delayed in the Clyde by the Herring Fishery (Scotland) Act 1889, which prohibited otter and beam trawling until 1962 when otter trawling for *Nephrops* was permitted in the summer only. Shellfish, such as *Nephrops* (figure 5.10), king scallops, queen scallops (*Aequipecten opercularis*), lobster and edible or brown and velvet crab (*Necora puber*) are now the most important resource to the inshore fleet of the region. The majority of the inshore trawling fleet is dependent on *Nephrops* which are now landed all year.

Figure 5.11 Distribution of Scottish west coast *Nephrops* landings (tonnes) in 2015 (UK vessels into Scotland)



Source: Marine Scotland Science Fish and Shellfish Stocks 2017 Edition

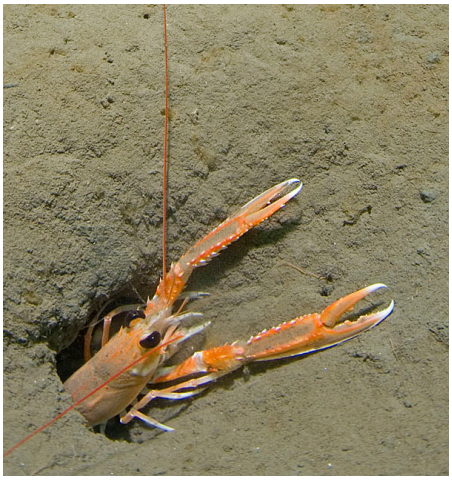
Nephrops

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of a particular sediment type; mud, sandy mud and muddy sand. In the CMR, burrow densities are higher in the south and the average size of *Nephrops* is smaller. This is particularly evident from the differences in discard composition between the north and the south of the CMR. Catches from the south have a higher proportion of small *Nephrops*, resulting in large proportions of undersized *Nephrops* and *Nephrops* heads. Trawls in the south also generate larger quantities of roundfish discards (35%), including the important commercial species whiting, cod and haddock.[275]

Survey assessments of the CMR *Nephrops* stock are carried out annually by an underwater TV survey (UWTV) which determines *Nephrops* burrow density on the seabed. The information gathered provides an index of stock abundance which is independent of the fishery and together provides information on the status and predicted stock level.

ICES describe the state of the *Nephrops* stock in the CMR as above the MSY trigger point and, with the recent high catches by trawlers, it is perceived to be a viable fishery although assessment still relies on an area covering the whole of the CMR and the Sound of Jura. In 2015, ICES altered its advice from a precautionary approach to one based on discard rates and survivability.[276] It should be noted that there is a predator/prey relationship between finfish and shellfish; it is possible that the change in fish species diversity in the CMR resulted in reduced pressure from predator species and may have led to a boost to the *Nephrops* population in the Clyde.

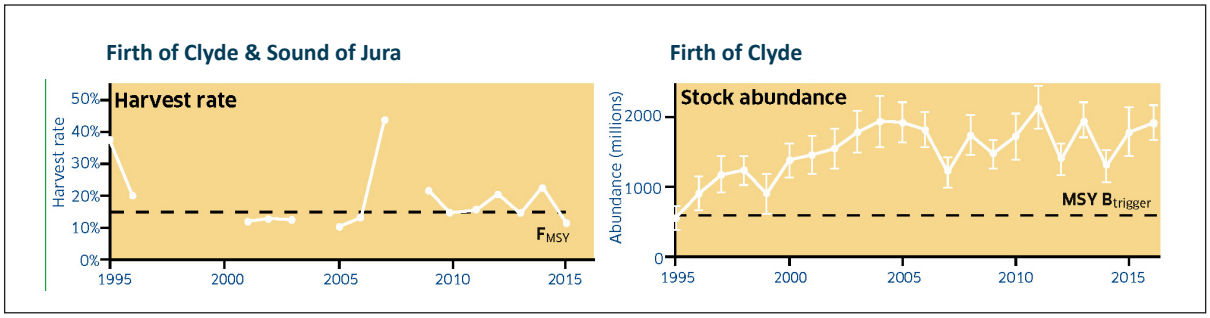
Figure 5.10 *Nephrops* emerging from its burrow



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272 . Stratoudakis *et al*., 2001
273. Clarke *et al*., 2015
274. Hislop, 1986
275. Bergmann, 2002
276. International council for the Exploration for the Sea, 2015a

Figure 5.12 Under Water TV surveys for *Nephrops* in the Firth of Clyde and Sound of Jura



Source: Marine Scotland Science Fish and Shellfish Stocks 2017 Edition

Nephrops Stocks

The latest ICES *Nephrops* stock assessment for the Clyde was released in May 2017and concluded that the CMR stock remained above **MSY $B_{trigger}$** and was being harvested above the proposed **F_{MSY} proxy**. On the basis of this assessment, ICES have recommended that the following CMR limits are set: Landings 6,185 tonnes, Catch 6,747 tonnes, an increase on their advice from the previous year of 6,206 and 6,568 respectively.

NB: MSY (Maximum Sustainable Yield) is, theoretically, the largest yield (catch) that can be taken from a specific fish stock over an indefinite period under constant environmental conditions. It is measured in tonnes. ***'B'*** refers to Biomass (so the MSY in this context is measured in total tonnes of *Nephrops* biomass regardless of age or sex). MSY ***trigger*** is the MSY point which triggers a cautious response in terms of management. ***F_{MSY}*** is the maximum rate of fish mortality (the proportion of fish removed by fishing) in this case a proxy is being used.

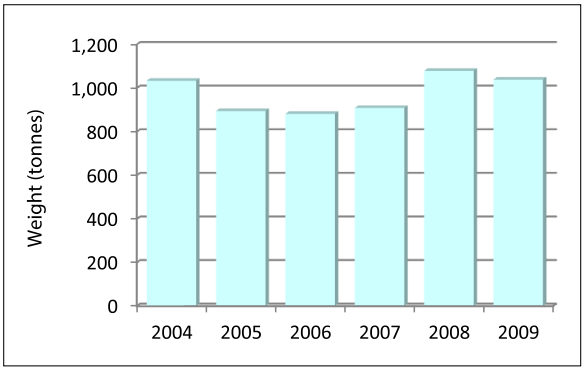
Scallops

The most important commercial molluscan species in the CMR are the king scallop and the related but smaller queen scallop. Landings from the Clyde king scallop stock unit have fluctuated markedly, declining to under 20 tonnes in 1990 and increasing since then to over 700 tonnes in 2012. Research does suggest that the size structure is heavily truncated in the CMR[277] however there is not enough data for reliable stock assessment (ICES, 2013, 2015).

Both species occur wherever the sea bed consists of sand, fine gravel or sandy gravel. The distribution of suitable sediments results in the species being found in a narrow strip of sea bed on each side of the CMR and around Arran in depths no greater than 40m. Anecdotally fishermen report changes in stock density in a variety of time scales and cycles which have yet to be fully investigated and understood.

In September 2003, The Prohibition of Fishing for Scallops (Scotland) Order 2003 was implemented. This put in place new measures for scallop conservation that limited the number of dredges a scallop vessel can tow to a maximum of eight per side for Scottish Inshore waters. Currently the Clyde 2020 group are discussing evidence from other models of management including the successful model in the Isle of Man.[278]

Figure 5.13 King Scallop landings (dredge) Clyde Inshore Fisheries Group Area 2004–2009 (tonnes)



Source: Clyde Inshore Fisheries Group, Fisheries Management Plan (2011)

Currently, there is no catch limit on UK scallop fisheries. They are mostly managed through minimum sizes, restriction on dredge numbers and seasonal closures in some areas. MSS conducts assessments of king scallop stocks around Scotland on a regional basis. In some areas, including the Clyde, insufficient data from sampling of landings means that analytical stock assessments have not been undertaken. There are also issues associated with apportioning catches, which are reported by statistical rectangle to the Clyde management area.

Scallop stocks are highly susceptible to overfishing, due to their limited mobility and confinement to a particular type of sea bed. Discussions are on-going within the Clyde 2020 group and the WCRIFG Clyde Sub-Group about the best way to undertake a king scallop stock assessment in the CMR.

277. Howarth *et al*, 2015
278. Howarth *et al*, 2014

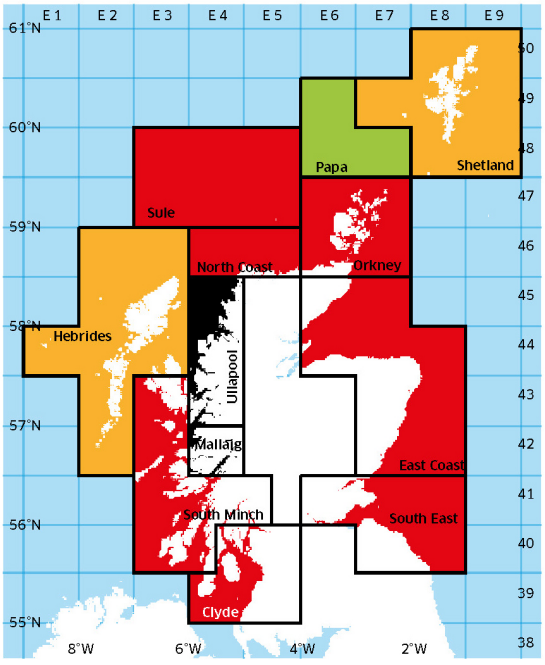
Other Shellfish

In the Clyde, there are creel fisheries for crabs, lobsters and shrimp some of which are on a part-time basis; these fisheries are regulated by minimum landing size only. Marine Scotland is currently consulting on minimum and maximum landing sizes for crab and lobster around the Scottish coast. Length Cohort Analysis (LCA) compares animals of the same length and is the method used for assessing crab stocks. Whilst data about brown and velvet crabs and lobsters in the Clyde could be improved, the ICES advice is updated annually and recommends a reduction in fishing mortality across all relevant species. see maps below for landings summaries for Scotland as a whole Gathering mussels has gone out of favour and now only a few are taken, mainly in the lochs. Beds of cockles are found in several parts of the Clyde, including the Isle of Bute, the Ayrshire coast and at Stranraer. Around the Arran coast and in other parts of the CMR electrofishing for razor fish is known to occur but remains illegal at time of writing.

Edible or brown Crab

Assessments based on LCA, done by ICES for their 2017 advice, show that brown crab are fished above F_{MSY} in the period 2013-2015 and that a reduction in fishing effort would give positive results in terms of yield and biomass in the longer term.

Brown Crab Assessment 2013–2015



Source: MSS Fish and Shellfish Stocks, 2017 Edition.

- Fishing mortality around or below F_{msy}
- Fishing mortality above F_{msy} for either males or females
- Fishing mortality above F_{msy} for both males or females

Figure 5.15 Brown crab stocks, relationship between F and F_{MSY} proxy

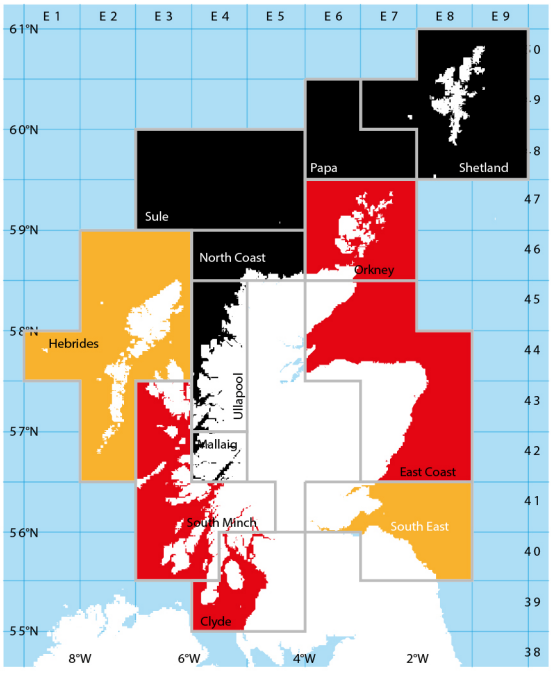
		F (Fishing Mortality)			
		2006-2008	2009 - 2012	2013- 2015	
Clyde	Males	✗	?	✗	Unknown
	Females	✗	?	✗	Unknown

See key on page 98. Source: MSS Fish and Shellfish Stocks, 2017 Edition.

Velvet Crab

Overall, assessments for the period 2013-2015 in areas with sufficient sampling data (including the Clyde) showed that most velvet crab assessment units in Scotland were being fished close to or above the F_{MSY} proxy. In some assessment units, a higher yield and biomass per recruit in the long term could potentially be obtained by reducing the level of fishing mortality (effort).

Velvet Crab Assessment 2013–2015



Source: MSS Fish and Shellfish Stocks, 2017 Edition.

- Fishing mortality around or below F_{msy}
- Fishing mortality above F_{msy} for either males or females
- Fishing mortality above F_{msy} for both males or females
- Not assessed for the period 2013–2015

Figure 5.16 Velvet Crab, relationship between F and F_{MSY} proxy

		F (Fishing Mortality)			
		2006-2008	2009-2012	2013 - 2015	
Clyde	Males	✗	✗	✗	Above F_{MSY}
	Females	✗	✗	✗	Above F_{MSY}

See key on page 98. Source: MSS Fish and Shellfish Stocks, 2017 Edition.

Lobster

Overall, assessments for the period 2009-2012 show that most lobster assessment units in Scotland, including the Clyde, were fished close to or above the F_{MSY} proxy. A higher yield and biomass per recruit in the long term could potentially be obtained by reducing the level of fishing mortality (effort).

Figure 5.17 Lobster, relationship between F and F_{MSY} proxy

		F (Fishing Mortality)		
		2006-2008	2009 - 2012	2009 - 2012
Clyde	Males	✗	✗	✗ Above F_{MSY}
	Females	✗	✗	✗ Above F_{MSY}

See key below. Sources: MSS Fish and Shellfish Stocks, 2017 Edition.

Figure 5.14 Key to Shellfish Stock Tables

		No overfishing	Overfishing	Unknown exploitation status
		✓	✗	↗ → ↘ ?
Decreasing stock trend	↘ or ✗	Reduce catch at rate of stock decrease.	Reduce catch at rate greater than the rate of stock decrease.	Reduce catch at rate greater than the rate of stock decrease.
Stable stock trend	→	Do not allow catches to increase.	Reduce catch.	Reduce catch.
Increasing stock trend	↗ or ✓	Increase catch at rate of stock increase.	Do not allow catches to increase.	Do not allow catches to increase.
No trend information	?	Do not allow catches to increase.	Reduce catch.	Reduce catch.

Source: MSS Fish and Shellfish Stocks, 2017 Edition

ECOSYSTEM SERVICES		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (fish and shellfish)	The Clyde is responsible for a significant percentage of the *Nephrops* catch for Scotland. There are smaller fisheries for other species such as scallops, crab and lobster (see Chapter 6.2 Sea fisheries). There are currently no commercially exploitable white fish stocks.
Regulating	Biological regulation	Different trophic levels are exploited by different species and at different stages within the lifetime of any one species; juvenile fish will consume planktonic stages of other fish whilst adults may graze on seaweeds or predate on crustaceans.
Cultural	Cultural heritage	Fish and fishing are an important part of the Clyde's cultural heritage. Many of the small towns around the Clyde have been, or still are, reliant on fishing as a core economic activity. The Clyde Fishermen's Association estimates the added value from the fishing sector to be in the region of £40m per annum (see Chapter 6.2). Many of the fishing harbours and surrounding areas in these towns are important parts of the cultural landscape and are supported by aspects of some local and regional development plans.
	Recreation	The Clyde was once recognised as a world class recreational fishing ground and supported not only significant numbers of angling businesses, but also encouraged mass participation by local people, although this activity has significantly declined over recent years due to a reduction in the numbers of large fish.
Supporting services underpin the provision of other services		Fish populations play a significant role in supporting the whole structure of the Clyde ecosystem; for example, the nutrients they process, excrete and generate from their decaying bodies form the basis of some of the muddy substrate food webs. Fish populations have a role to play in regulating nutrient, sediment and carbon cycles.

5.5 Sharks, skates and rays

Basking shark in the UK



All other elasmobranchs



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Scotland's Marine Atlas www.gov.scot/Resource/Doc/345830/0115138.pdf

SNH commissioned reports 339 www.snh.org.uk/pdfs/publications/commissioned_reports/339.pdf and 908 www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/publication-detail/?id=2403)

ICES Working group on Elasmobranchs report www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2015/WGEF/wgef_2015.pdf

OSPAR Commission Background commission on Basking Shark www.ospar.org/documents?v=7189

IUCN Red List www.iucnredlist.org/

Scotland's Marine Atlas Clyde score: 'many concerns and deteriorating'. Regional assessment consistent with this, except for basking shark where more recent data suggest an improving trend in Scottish waters.

Introduction

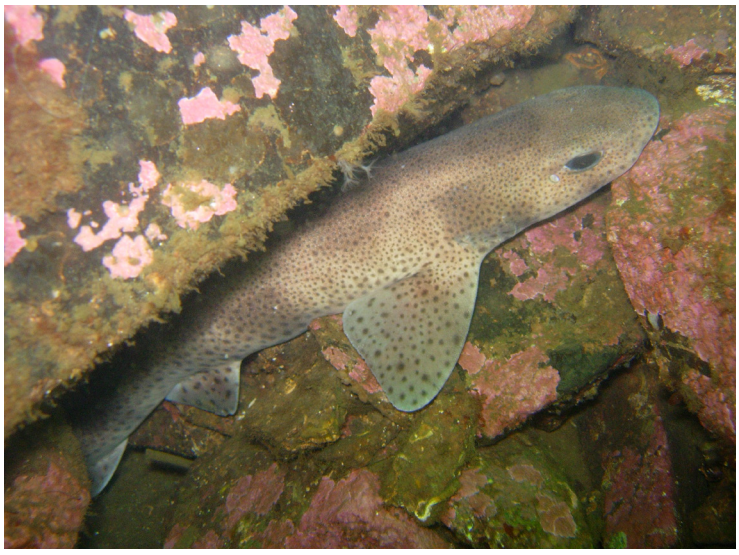
Sharks, skates and rays are a group of fish known as elasmobranchs. They are characterised by features including: a skeletal structure made out of cartilage instead of bone, five to seven pairs of gill clefts, and no swim bladder. Scotland has over 30 species of sharks, skates and rays recorded in its waters, 25 of which are found in coastal waters. Of these, eight in total are classified as Priority Marine Features (PMFs) and of these, six have been recorded within the Clyde Marine Region (CMR). Scotland's Marine Atlas provides more detail on the coastal species of skates, rays and sharks not listed as PMFs.[279]

Conservation status

All species of elasmobranchs found in Europe are on the OSPAR list of Threatened and Declining Species[280] due to their removal as target and non-target species by fisheries activity. They are also vulnerable to climate change impacts,[281] habitat disturbance and ship strikes or collision, particularly basking sharks (*Cetorhinus maximus*), as they spend time at the water surface[282] and lesser understood impacts such as the effect of electromagnetic frequencies.[283] Populations of elasmobranchs can take a long time to recover as they are typically slow growing and late to reach maturity, resulting in low fecundity.[284] Table 5.8 over page highlights the six PMFs known to be present in the CMR, any available information on their population trend, IUCN status and the main pressures which affect them. Of these six, all are migratory except the common skate which is considered to be possibly migratory.[285] Many species are subject to being caught as bycatch by several types of gear, including trawl nets.[286] Basking sharks are listed on Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) and are protected against intentional or reckless disturbance or harassment.

Catch per unit effort (CPUE) data from fisheries is available for the CMR for basking sharks (based on historic fisheries data) (0.05hr^{-1}) and for spurdog (*Squalus acanthias*) (0.67-503hr^{-1}).[287, 288] This may provide some indication of relative abundance, but should be considered with caution. For spurdog in particular, CPUE may be a misleading indicator of abundance. As the aggregating habitat of mature (often pregnant) females can result in enhanced vulnerability to capture and high CPUE figures even in depleted stocks.

Figure 5.18 Dogfish, a species of shark



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279. Baxter *et al*., 2011
280. OSPAR Commission, 2009a
281. Whitnich and Balanger, 2014
282. Baxter *et al*., 2011
283. Normandeau *et al*, 2011
284. Fecundity is the reproductive rate of an organism or a population

Table 5.8 Elasmobranch PMFs found in the Clyde Marine Region, their status and sensitivity to activities/pressures

(For further details on specific pressures in the region, see the Productive section)

SPECIES	IUCN STATUS[289]	POPULATION TREND[290]	SENSITIVITY TO ACTIVITIES/ PRESSURES[291. 292]
Basking shark (*Cetorhinus maximus*)	Endangered (for both the Northeast Atlantic and North Pacific subpopulations)	Declined by 50-90% in Scottish waters based on historic fisheries data. More recent sightings data suggest an overall long-term increasing trend, with a small but significant increase in the sightings of larger individuals.[293]	Ship strikes, potential disturbance and bycatch.
Spurdog (*Lamna nasus*)	Critically Endangered (Northeast Atlantic subpopulation)	Declining	Overfishing[294] and bycatch.
Porbeagle shark (*Lamna nasus*)	Critically endangered (Northeast Atlantic population)	Declining	Targeted fishery and is highly susceptible to overfishing.
Common skate (*Dipturus batis*)	Critically endangered (Northeast Atlantic subpopulation)	Declining	Bycatch
Blue Shark (*Prionace glauca*)	Near threatened	Unknown, but appears to be declining	Bycatch and targeted fishery
Sandy ray (*Leucoraja circularis*)	Endangered	Declining	Bycatch

Populations in the Clyde

There is very little stock information for elasmobranchs in the Celtic seas region (which includes the CMR);[295] however, biomass estimates based on research survey data have been made.[296] These are not stock assessments but do reflect trends and relative abundance of different species. These show that in the Clyde sea from 1920–1959, 13 taxa accounted for 95% of the average biomass, with spurdog accounting for greater than 20% (table 5.9). Additionally, species considered non-commercial by the study (such as spurdog) showed a strongly declining trend in biomass density over the period 1920–2004, with a slight recovery in 2005–2009. The study concludes that size structure of species has changed dramatically over time, with a deficiency in large (> 40cm) individuals after the period of peak harvesting rates in the 1980s and that it did not recover during the period of low harvesting rates after the late 1990s. Table 5.10 sets out the percentage biomass of species cumulatively accounting for 95% of demersal fish of greater than 40cm.

Table 5.9 Species cumulatively accounting for 95% of total demersal biomass averages over periods of years

SPECIES COMMON NAME	1920-1959	1960-1979
	% BIOMASS	
Spurdog	22.71	4.04
Thornback ray	5.91	
Tope	2.75	
Dogfish		0.99

285. Fowler, 2014
286. Food and Agriculture Organisation of the United Nations
287. CPUE is based on research surveys and data from fisheries before the 0 TAC was set in 2015.
288. Baxter *et al.*, 2011
289. International Union for the Conservation of Nature
290. Baxter *et al.*, 2011
291. Baxter *et al.*, 2011
292. International Council for the Exploration of the Sea, 2015b
293. OSPAR commission, 2015
294. Pre 2015 introduction of zero Total Allowable Catch in 2015 by the European Commission
295. International Council for the Exploration of the Sea, 2015b
296. Heath and Speirs, 2011

Table 5.10 Species cumulatively accounting for 95% of biomass of demersal fish > 40cm averaged over periods of years[297]

SPECIES COMMON NAME	1920-1959	1960-1979	1995-2004	2005-2009
	% BIOMASS			
Spurdog	32.44	13.69		5.81
Thornback ray	9.97	2.39		
Tope	3.94	2.90		
Dogfish			5.27	17.58
Cuckoo ray			6.01	
Spotted Ray			4.65	8.52
Nurse hound				19.58

Many species of elasmobranch have been exploited through commercial fisheries until relatively recently in Scotland, and this has been the main pressure on stocks. Prior to the landings ban in 2011, spurdog represented a sporadic, but valuable bycatch to the *Nephrops* (*Nephrops norvegicus*) trawl fishery.[298, 299] Numbers now caught as bycatch are considered to be small and this has been further reduced by the fishing industry implementing technical measures, such as modified nets, to reduce numbers of those caught. Despite this, they are a highly vulnerable species due to several life history characteristics; they tend to aggregate by age and sex, hence large groups are often caught at once; they reach sexual maturity between 9–11 years with low fecundity; they gestate their young for up to 24 months and live for up to 50–75 years.[300] In the years to come, as the Discard ban[301] is progressively applied, spurdog bycatch may present an additional challenge to the *Nephrops* fishery; as a species that has no quota, but is caught as bycatch, it may cause a vessel to stop fishing even if they still have quota for other species.

The International Council for the Exploration of the Sea (ICES) advises applying the precautionary approach and that a suite of measures, specific to species and fishery, be developed to manage the harvesting of commercial species or to achieve recovery of depleted species with zero total allowable catch, such as basking shark and spurdog.[302]

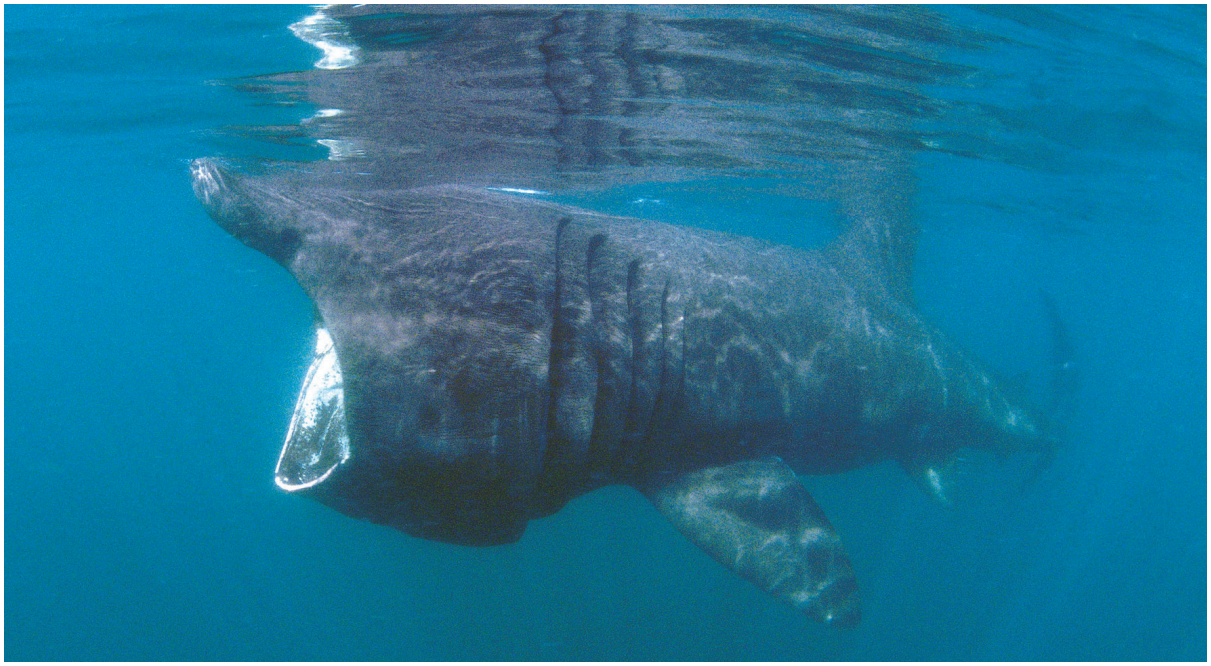
The Scottish Sea Angling Conservation Network (SSACN) created the Scottish Shark Tagging Programme (SSTP) to facilitate data collection on growth rates, maturation size and population ecology of sharks, skates and rays. Tagging is carried out in Scottish waters, including the CMR, by anglers. Both SSACN and the SSTP work in partnership with SNH, Marine Scotland and academic institutions to undertake further research on these animals in Scotland.[303]

Basking sharks in the Clyde Marine Region

Basking sharks (figure 5.19) are plankton feeding pelagic sharks that can grow up to 12m in length, making them the largest fish in UK waters and the second largest in the world.[304] These animals are highly migratory and can be seen in Scottish coastal waters from May to September. There is a strong relationship between the distribution of basking sharks and high levels of plankton; especially around areas with seasonally persistent tidal fronts (such as the CMR, Western Scotland and the central Irish Sea) where there is high plankton abundance.[305] Numbers of basking sharks sightings and planktonic copepod abundance have shown downward trends and were positively correlated.[306] A 2009 study based on sightings data identified The Sea of Hebrides as an important hotspot and area of high abundance for basking sharks and shows evidence of seasonal residence to coastal regions. Within the CMR, basking sharks were most commonly seen around north Arran, the Kyles of Bute and the mouth of Loch Fyne.[307]

297. Under descriptor 3 (commercial fish) of the Marine Strategy Framework Directive a target indicator of achievement of Good Environmental Status is over 30 % of finfish greater than 40cm in length.
298. Milligan *et al*., 2013
299. Fox, C., 2015
300. Milligan *et al*., 2013
301. Commission Delegated Regulation (EU) 2015/2440 of 22 October 2015 establishing a discard plan for certain demersal fisheries in the North Sea and in Union waters of ICES Division IIa
302. International Council for the Exploration of the Sea, 2015a
303. Scottish Sea Angling Conservation Network
304. OSPAR commission, 2009a
305. Lancaster *et al*., 2014
306. OSPAR commission, 2015
307. Speedie *et al*., 2009

Figure 5.19 Basking shark



© PAUL NAYLOR

Surveys carried out annually between 2002-2006 determined that the CMR had a below average Shark per Unit Effort value, compared to other areas of Western Scotland.[308] This is in contrast with historic records, which show the area supported a successful commercial basking shark fishery; so much so, that one of the most successful hunters of the twentieth century built his original factory on the Kintyre peninsula. This fishery began sometime around the Second World War until the 1960's when the animals were targeted for their liver oil products. Demand then declined due to increased supplies of mineral oil and began again in 1983-1995. This was due to a resurgence in industrial sales of liver oil and human consumption of fins and flesh).[309]

ECOSYSTEM SERVICES[310]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Cultural	Recreational opportunities and sense of place	All forms of wildlife-watching tourism in Scotland have been estimated to generate £63 m and support 1,704 jobs. Basking sharks are an important part of this; they have a role as a charismatic species which stimulates people's interest in the marine environment. People take part in various activities linked to their presence, such as diving and boat trips. The history of the basking shark fishery forms an important part in the heritage of the region.
	Knowledge systems	As fish populations in the Clyde have changed in structure over the years, and fishing for historically popular target species has declined, recreational angling groups have become involved in shark, skate and ray tagging programmes facilitating the continuation of their hobby in the local area and also contributing to our knowledge of elasmobranchs.[311]
Supporting services underpin the provision of other services		Sharks, skates and rays play an important role in regulating food webs as top predators. Spurdog for example, feed on a wide range of both bottom dwelling fish and fish which can be found mid-water. The historic abundances reported of elasmobranchs, particularly of spurdog, suggest that the ecosystem has changed from being able to support such numbers of a high-level predator and the role of these animals in ecosystem functioning have also become depleted or absent in this time. Different species of skates and rays may separate themselves within the same ecosystem by their different foraging behaviour (they are very selective and have different preferences) and patterns of activity; this allows a high diversity of species to share difference niches.[312] Rays in shallow waters feed by disturbing seabed sediment, creating a 'feeding pit' to uncover prey. This behaviour results in the immediate clearing of infaunal invertebrates followed by accumulation of organic material, resulting in food availability and nutrient cycling. Basking shark feed on primary food resources and can be considered to be health indicators for the marine environment and primary production. Having healthy and diverse populations of sharks, skates and rays enables supporting services which drive the provision of other services.

308. Speedie *et al*., 2009
309. Kunzelik, 1988
310. UK National Ecosystem Assessment, 2011
311. Scottish Sea Angling Conservation Network
312. Pierce, 2005

5.6 Whales, dolphins and porpoises



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Scotland's Marine Atlas
www.gov.scot/Publications/2011/03/16182005/93

IUCN Red List www.iucnredlist.org/

Clyde Marine Mammal Project
www.clydemarinemammalproject.org/

Scotland's Marine Atlas score: 'Some concerns and stable'. Regional assessment consistent with this.

Introduction

There have been 23 species of cetacean (the order of mammals which includes whales, dolphins and porpoises) recorded in Scottish waters in recent years.[313] Only two of these, the harbour porpoise (*Phocoena phocoena*) and minke whale (*Balaenoptera acutorostrata*), are regularly spotted in the Clyde Marine Region (CMR). Other species are more occasional visitors. Bottlenose dolphins (*Tursiops truncatus*) and a humpback whale (*Megaptera novaeangliae*) were spotted in the Clyde in 2015 and 2016 by the Hebridean Whale and Dolphin Trust (HWDT) community sightings network[314] and these species have also been recorded here in the 1990s and 2000s.[315] Other species that have infrequent sightings or strandings records in the CMR are northern bottlenose whale (*Hyperoodon ampullatus*), Risso's dolphin (*Grampus griseus*), killer whale or orca (*Orcinus orca*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), pygmy sperm whale (*Kogia breviceps*), Sowerby's beaked whale (*Mesoplodon bidens*) and striped dolphin (*Stenella coeruleoalba*).[316, 317]

Coastal waters around headlands and islands, narrow channels and fronts are important feeding areas for cetaceans. The front that occurs around the Clyde Sea Sill is considered to be a key attraction for cetaceans visiting the CMR from spring to autumn, due to the mixing of waters and the upwelling of nutrients along with associated food webs. The islands and narrow channels of the inner and outer Firth provide suitable feeding areas for resident harbour porpoise, the most abundant of cetacean species on the west coast of Scotland and in the CMR. A report by Whale and Dolphin Conservation highlighted that *'a very high density estimate of 1.071 animals/km^2 was reported for the Inner Hebrides, an area frequently reported to host concentrations of harbour porpoises* (Embling *et al.*, 2010; Marubini *et al.*, 2009; Evans and Wang, 2002; Pollock *et al.*, 2000) *and a high density of porpoises was also recorded for the Firth of Clyde, 0.823 animals/km^2. There are much less data available for the Firth of Clyde compared to the Inner Hebrides, but this high density estimate suggests it may also be an area of importance for harbour porpoises. High densities of harbour porpoises during the summer, the time of year when these animals breed and produce young, suggest these waters may be important for these behaviours'.*[318] For further background information on cetaceans in Scotland see this SNH publication www.snh.org.uk/pdfs/publications/naturallyscottish/whales.pdf.[319]

Conservation status

Populations of cetaceans are not managed at the scale of the CMR as they are so wide ranging.[320] All cetacean species are European Protected Species listed on Annex IV of the EC Habitats Directive defined as 'in need of strict protection' and bottlenose dolphin and harbour porpoise are also listed on Annex II 'whose conservation requires the designation of Special Areas of Conservation' (SACs). There are no SACs for these species in the CMR. The Habitats Directive also requires the UK to 'maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest' and 'establish a system to monitor the incidental capture and killing of the animal species listed in Annex IVa. In the light of the information gathered, Member states shall take further research of conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned.' In Scottish inshore waters, the Conservation (Natural Habitats) Regulations 1994 (as amended in Scotland) implement the species protection requirements of the Habitats Directive.

The precise population status of cetaceans occurring in the CMR is unknown as data are mainly restricted to sightings rather than effort-related surveys which can give information on absolute abundance. In addition, these species are highly mobile and at a global level their population range is far greater than the Clyde region. The Clyde Marine Mammal Project has recently been established to

313. Baxter *et al.*, 2011
314. Hebridean Whale and Dolphin Trust
315. Ross *et al.*, 2009
316. Clyde Marine Mammal Project
317. Scottish Marine Animals Stranding Scheme
318. Dolman *et al.*, 2013
319. Gillham and Baxter, 2009
320. For management units see this report http://jncc.defra.gov.uk/pdf/Report_547_webv2.pdf

improve our knowledge of cetaceans in the Clyde. Other sources of data include Seawatch Foundation and the Hebridean Whale and Dolphin trust (HWDT). The overall conservation status for those cetaceans that are Priority Marine Features (PMFs) in Scotland is presented in table 5.11. Population estimates undertaken at a wider scale have led the International Union for the Conservation of Nature (IUCN) to categorise these species as 'Least Concern' at a global level.[321]

For further information about marine mammals in the Clyde, visit the Clyde Marine Mammal Project website at www.clydemarinemammalproject.org/ or the HWDT at www.whaledolphintrust.co.uk/. When observing marine mammals always follow the Scottish Marine Wildlife Watching Code.[324]

Table 5.11 Cetacean PMFs occurring in the CMR and their status and sensitivity to activities/pressures

further details on specific pressures in the region, see the Productive section

SPECIES	IUCN STATUS[322]	STATUS (SCOTLAND)[323]	SENSITIVITY TO ACTIVITIES/ PRESSURES
Harbour porpoise	Least Concern	Favourable	Collision – the CMR is a very busy shipping area, particularly around the Inner Firth which may be used in particular by harbour porpoise. Noise disturbance from shipping and military activities are of particular relevance in the CMR Entanglement is a threat in particular to minke whales. Underwater noise from coastal developments, such as the construction of harbours, sea defences and other infrastructure, can cause disturbance to cetaceans. Piling operations, in particular, produce high levels of underwater noise. Wildlife watching operations, and marine recreational activities, have the potential to cause disturbance to cetaceans if carried out inappropriate ways. Relevant codes of best practice such as the Scottish Marine Wildlife Watching Code should always be followed to reduce the impacts. Pollution – although most contaminants are now in decline, they are still at high levels in some parts of the CMR (see Chapter 4.2 Hazardous substances). Management and mitigation measures for dealing with these pressures are in place through marine licensing, SEA, EIA, Habitats Directive (EPS).
Minke whale	Least Concern	Favourable	
Bottlenose dolphin	Least Concern	Favourable	
Short-beaked common dolphin (*Delphinus delphis)*	Least Concern	Favourable	

ECOSYSTEM SERVICES[325]		
SERVICE TYPE	BENEFITS PROVIDED	COMMENTARY
Cultural	Tourism	They are increasingly becoming a tourist attraction and the total gross income generated (directly and indirectly) by cetacean-related tourism in rural parts of the west of Scotland has been estimated in one paper at £7.8 m in the year 2000, with 242,000 tourists taking part.[326] A more recent report estimates that the West Coast and Islands, Loch Lomond & Trossachs is the second most important region for wildlife visitors (after Highlands & Islands), with 23% of trips and nights, and £65 m of wildlife visitor expenditure.[327] Note that this includes terrestrial wildlife. Generally there is evidence that the marine wildlife watching industry is growing.
	Spiritual and cultural well-being	Cetaceans have traditionally been part of Scottish marine heritage.
Supporting services underpin the provision of other services		Cetaceans generally play an important role as predators within the food web. Dolphins and porpoises have teeth and feed mainly on fish. Baleen whales, such as the minke whale, feed on small fish and krill by taking large volumes of water into their mouths and sieving the food out using baleen plates. Cetacean carcasses provide a source of food for many other marine species. The full role of cetaceans within the ecosystem is still not completely understood.

321. International Union for the Conservation of Nature
322. International Union for the Conservation of Nature
323. Baxter *et al.*, 2011
324. Scottish Marine Wildlife Watching Code, 2017
325. UK National Ecosystem Assessment, 2011
326. Parsons *et al.*, 2003
327. The Scottish Government, 2010b

5.7 Seals



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Scotland's Marine Atlas
www.gov.scot/Publications/2011/03/16182005/93

SNH Commissioned report No. 361 www.snh.org.uk/pdfs/publications/commissioned_reports/361.pdf and publication of South West count

IUCN Red List www.iucnredlist.org/

Scotland's Marine Atlas score: 'Some concerns and stable'. Regional assessment includes more recent data showing an improvement in numbers in the CMR.

Introduction

The Atlantic grey seal (*Halichoerus grypus*) and the harbour (common) seal (*Phoca vitulina*) are found throughout Scotland's waters and are both present in the Clyde Marine Region (CMR), although in lower numbers than elsewhere. They are both known as 'true seals' and are highly adapted to life in water, with the ability to dive deeper and remain underwater longer than eared seals, sea lions and walrus found in other parts of the world. They do, however, need to return to land at 'haul-out' sites to rest, moult and breed. Seals eat fish; dive records show that both species forage for fish on or close to the seabed.[328] For further background information on seals see the SNH Commissioned Report No. 361.[329]

The harbour seal is the more common of the two species in the CMR and can be found in particular at Sanda Island, at certain points on the Mull of Kintyre coastline, in the south of Arran, around the Isle of Bute and in Loch Fyne.[330] The grey seal is found in lower numbers, again at Sanda Island and the south of Arran, but also at Lady Isle off Troon on the Ayrshire coast.[331] Some of these areas have been designated as haul-out sites (see map 17). The total population estimate in Scotland in 2009 for grey seals was 105,072 and for harbour seals was 20,427.[332] The latest count for harbour seals in the CMR was 1,167 in 2015, up from 811 in 2007. This is in contrast to the general decline seen on the east coast of Scotland (>90% since 2000) and Orkney (>70% decline since 2000).[333] Grey seals were counted at 304 in 2015, up from 272 in 2007.[334]



Seal © PETER SANDGROUND

Conservation status

The EC Habitats Directive includes grey and harbour seals on Annex II *'whose conservation requires the designation of Special Areas of Conservation'* (SACs). Whilst there are SACs for seals in other parts of Scotland, there are none in the CMR. Additionally, in response to declines in harbour seal numbers, the Marine (Scotland) Act 2010 has introduced Seal Conservation Areas in parts of Scotland; there are no conservation areas for harbour seals in the CMR.

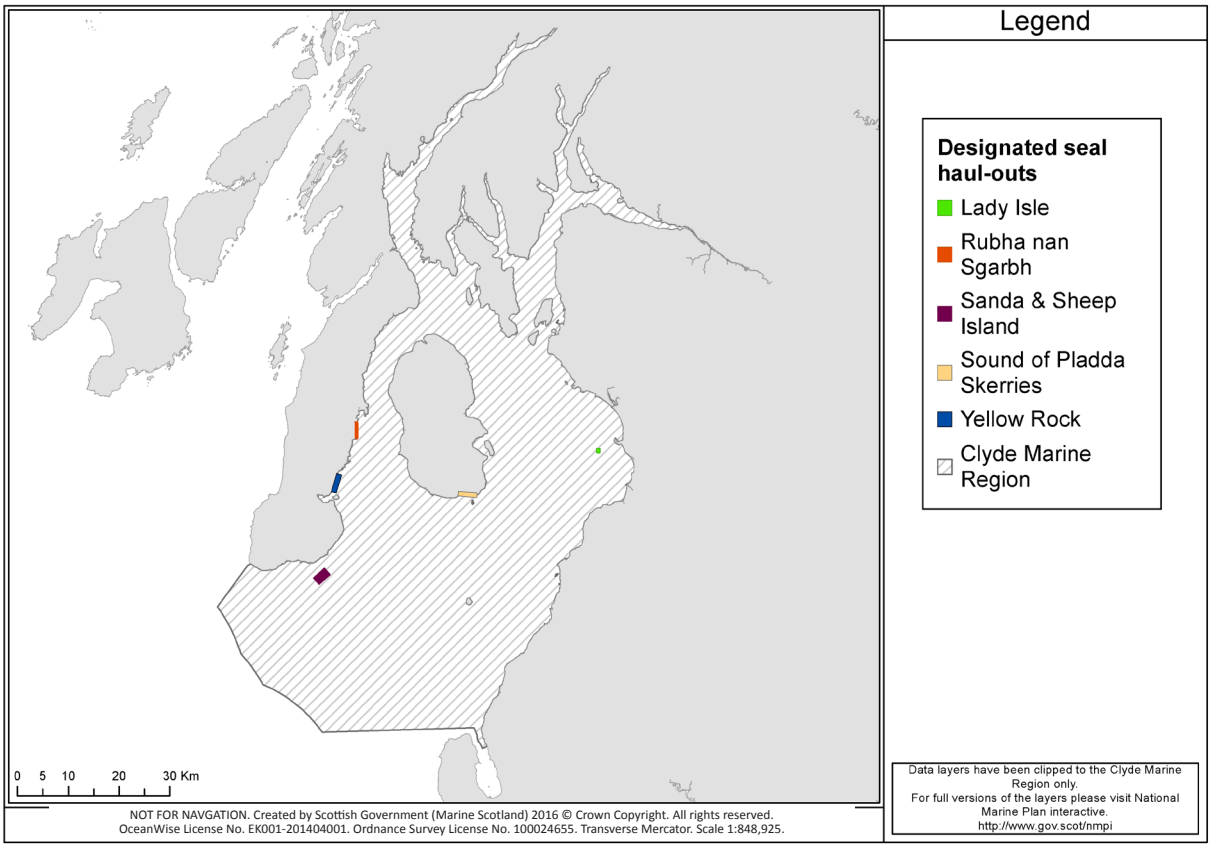
The Marine (Scotland) Act 2010 makes it an offence to shoot seals in Scotland, and since 2011 it has been an offence to kill, injure or take a seal at any time of year except to alleviate suffering or where a licence has been issued to do so. Licences may be issued for limited seal management if strict legal tests are met where it is necessary to avoid damage to fisheries or fish farms. For the purposes of considering licence applications to shoot seals, the coast has been divided into seven seal management areas: the CMR is in the South-West Scotland area. The number of seals licensed to be shot in any seal management area is determined on an annual basis, based on the most recent data on seal population size and the underlying trend in their numbers. For 2016, of the 43 licences granted across Scotland, four were issued in the South-West Scotland area, two for protection of health and welfare and two for prevention of serious damage. This equates to the potential loss of 15 grey seals and 17 common seals.[335] It should be noted that, in general, the number of seals shot is well below the potential loss figures.

The Protection of Seals (Designated Sea Haul-out Sites) (Scotland) Order 2014 introduced additional protection for seals at 194 designated haul-out sites, some of which are in the CMR (see map 17). It is an offence to intentionally or recklessly harass seals at these sites.

Both species are of 'least concern' on the IUCN Red List due to their large and either stable or increasing population at a global level. However, for the harbour seal, monitoring should be at a finer scale as some populations are small and declining.[336]

328. Duck, 2007
329. Duck, 2010
330. Duck, 2010
331. Duck, 2010
332. Baxter et al., 2011
333. NERC Special Committee on Seals, 2016
334. Duck and Morris, 2016
335. Marine Scotland 2016b
336. International Union for the Conservation of Nature

Map 17. Seal Haul-Out sites in the Clyde Marine Region



Pressures

There are a range of pressures that may generally affect seals, but the extent and magnitude of most have not been quantified and there have been no studies in the CMR. Potential pressures include exposure to hazardous substances, entanglement in marine litter, bycatch, a reduction in prey distribution and biomass due to habitat damage and climate change, collision with ships, shooting of seals under licence, the use of acoustic deterrent devices and disturbance from recreational activities at haul-out sites.

For further information about sightings of seals in the CMR, visit the Clyde Marine Mammal Project website at www.clydemarinemammalproject.org/. When observing marine mammals, always follow the Scottish Marine Wildlife Watching Code.[337]

ECOSYSTEM SERVICES[338]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Cultural	Tourism	They are increasingly becoming a tourist attraction as they are curious and easy to observe. Viewing seals on Arran is a popular tourist activity. A recent report estimates that the West Coast and Islands, Loch Lomond & Trossachs is the second most important region for wildlife visitors (after Highlands & Islands), with 23% of trips and nights, and £65m of wildlife visitor expenditure.[339] Note that this includes terrestrial wildlife. Generally there is evidence that the marine wildlife watching industry is growing.
	Spiritual and cultural well-being	Seals have traditionally been part of Scottish marine heritage and an inspiration to folklore and mythology.
Supporting services underpin the provision of other services		Seals are top predators and feed on fish, squid and crustaceans. They play an important role in maintaining an ecological balance. There has been much debate over the relationship between commercial fish stocks and seal numbers. Whilst over-fishing has depleted some commercial fish stocks and pollution has contributed to the decline in salmon in the Clyde, there is a question over whether increases in seal populations hinder the recovery of these other stocks. Science from other regions generally concludes that seals take less fish than predatory fish, humans, seabirds and probably cetaceans. However, it is also proposed that 'rogue' seals may predate heavily on salmon at fish farms and at the mouths of rivers.[340]

337. Scottish Marine Wildlife Watching Code, 2017
338. UK National Ecosystem Assessment, 2011
339. The Scottish Government, 2010b
340. Butler, 2011

5.8 Seabirds and waterbirds

Seabirds



Waterbirds



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

Scotland's Marine Atlas
gateway.snh.gov.uk/sitelink/index.jsp

Scotland's Marine Atlas
www.gov.scot/Publications/2011/03/16182005/93

Seabird Monitoring Programme jncc.defra.gov.uk/page-1550

Wetlands Bird Survey counts
www.bto.org/volunteer-surveys/webs

Birds of Conservation Concern
www.bto.org/science/monitoring/psob

Scotland's Marine Atlas score: seabirds 'Few or no concerns and improving', waterbirds 'some concerns and stable'. Regional assessment includes more detailed and more recent count trends showing declines in several species.

Seabirds

Introduction

Seabirds are bird species which have adapted to forage at sea, but are reliant on land to breed. They can be divided into those species which feed at the water's surface, such as terns and kittiwakes and those which are adapted to dive to much deeper depths and sometimes also swim to catch their prey, such as puffins and black guillemots.[341] Seabirds are considered a good indicator of the health of the marine environment for several reasons. They are at the top of the food chain and so any changes in lower trophic levels or in the physic-chemical environment are likely to manifest themselves within seabird populations. In addition, they have been monitored in the UK for over 20 years through consistent programmes which have produced reliable data.[342]

Twenty-one of the 24 species of seabird found in Scotland have bred or breed in the Clyde Marine Region (CMR).[343] Although the Clyde does not support a significant share of Scotland's seabirds (due to the low-lying coastline and the general ease of access of the coast to the surrounding human population), large populations are found in various sites around the Clyde, most notably the internationally important gannet (*Morus bassanus*) colony on Ailsa Craig. Other sites favoured by seabirds include the Ayrshire cliffs, Sanda island group, Horse Isle, Lady Isle, Little Cumbrae, Pladda, Holy Isle and Inchmarnock where gannet, black-legged kittiwake (*Rissa tridactyla*), Arctic tern (*Sterna paradisaea*) and sandwich tern (*Thalasseus sandvicensis*), lesser black-backed gull (*Larus fuscus*), herring gull (*Larus argentatus*), great black-backed gull (*Larus marinus*), black guillemot (*Cepphus grylle*), shag (*Phalacrocorax aristotelis*), cormorant (*P. carbo*), common guillemot (*Uria aalge*), razorbill (*Alca torda*), northern fulmar (*Fulmarus glacialis*) and Atlantic puffin (*Fratercula arctica*) are all found.[344]

Within Scotland, nine of the commonest seabirds have shown sustained declines over the past 20 years. These are: European shag, Arctic skua, herring gull, great black-backed gull, black-legged kittiwake, sandwich tern, common tern and common guillemot.[345] Across the whole of the UK seabird abundances have been declining since the early 1990s, with the lowest level recorded in 2004.[346]

Seabird populations in the Clyde Marine Region – Designated areas and the pressures affecting populations

Ailsa Craig

Ailsa Craig is home to one of the largest northern gannet colonies in the world, with over 33,000 pairs, and has been designated a Site of Special Scientific Interest (SSSI) under UK law for this reason. It is also designated a Special Protection Area (SPA) under EU law due to the gannet population and also on account of 1,800 breeding pairs of lesser black-backed gulls, which represents 1.5% of the Western European/Mediterranean/Western African population.[347, 348]

341. Monaghan and Zonfrillo, 1986
342. Parsons *et al*., 2008
343. Monaghan and Zonfrillo, 1986
344. Monaghan and Zonfrillo, 1986
345. Foster and Marrs, 2012
346. Baxter et al., 2011
347. Joint Nature Conservation Committee, 2001
348. European Council Directive 2009/79/409 on the Conservation of Wild Birds CITATION FOR SPECIAL PROTECTION AREA (SPA) AILSA CRAIG

Table 5.12. Seabird Monitoring Programme (SMP) colony count data for Ailsa Craig from 1995-2015[352]

		SPECIES									
		PUFFIN	FULMAR	GGB GULL	LBB GULL	HERRING GULL	GUILLEMOT	RAZORBILL	KITTIWAKE	SHAG	GANNET
POP. TREND		↑	↓	↓	↔	↓	NO TREND	↓	↓	NO TREND	↔
YEAR	1995	20									32,456
	1999										35,825
	2001		197	85	400	1,450	9,415	1,471	1,675	28	
	2004										27,130
	2005	84	50	50		500	9,000			100	
	2006	130									
	2008	120							200		
	2009			80		450	11,668	1,030	428	96	
	2010	61			183	131				72	
	2011	79	96								
	2012	37	106			82				49	
	2013		39	25	151	129	7,832	680	489		
	2014	149	58	10	172	60	4,681	769	228		33,226
	2015	183	49	11	166	129	5,404	446	299	66	

During the breeding season, the site regularly supports 65,000 individual seabirds, including guillemot, kittiwake, herring gull, lesser black-backed gull and gannets.[349] Ailsa Craig is managed by the Royal Society for the Protection of Birds (RSPB) who conduct annual surveys of the site. These data contribute to the Seabird Monitoring Programme (SMP). These results are reported in table 5.12 above, and show approximate population trends based on SMP counts on the island.

Numbers of seabirds, especially gannets, have shown a population increase since the eradication of rats in 1991.[350] A decline in numbers of gannets was seen in 2004 and this is thought to be due to a decline in breeding density throughout the colony. The next count in 2014 shows numbers had increased to levels similar to pre-2004 counts. The 2004 gannet count of adults on site represented 14.9% of gannets in Scotland and 10.4% in the UK and Ireland at that time.[351] The count information in the table shows declines for great black-backed gull, herring gull, razorbill and kittiwake. A similar trend is also reflected through site condition monitoring for the Ailsa Craig SPA.

Scottish Natural Heritage (SNH) assessments of the site have found the condition under the SSSI designation to be 'favourable maintained', meaning the population and distribution of the gannet population and the seabird assemblage including razorbills, guillemot, kittiwake and herring gull within the site have been maintained and where possible, the condition of the site has been enhanced for key seabird colonies.[353]

The conservation objectives for Ailsa Craig SPA are:

> To avoid deterioration of the habitats of the qualifying species (listed below) or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and
>
> To ensure for the qualifying species that the following are maintained in the long term:
> - Population of the species as a viable component of the site
> - Distribution of the species within site
> - Distribution and extent of habitats supporting the species
> - Structure, function and supporting processes of habitats supporting the species
> - No significant disturbance of the species

Qualifying species include gannets, guillemots, herring gull, kittiwakes, lesser black-backed gulls and the seabird assemblage. The site has been assessed under the SPA as 'favourable maintained' for breeding gannets, guillemots and the breeding seabird assemblage and 'unfavourable declining'[354]

349. Joint Nature Conservation Committee, 2001 342. Zonfrillo, 2001
350. Zonfrillo, 2001
351. Wanless *et al.*, 2015
352. Joint Nature Conservation Committee, 2016b
353. Scottish Natural Heritage, 2016d
354. One or more of the attribute targets have not been met and recovery is unlikely under the present management activity on the site

for breeding lesser black-backed gull, kittiwake and herring gull. The reason given for this is partly due to national declines in these species and may result in part from reduction in food availability.[355]
The reasons for some local declines may be complex and not related to wider changes; for example, reduced breeding space may well have been the cause of decline due to increased vegetation growth, which is now controlled. This may be an issue on Ailsa Craig, since the eradication of the rats has led to growth of vegetation and reduced breeding space.

The Joint Nature Conservation Committee (JNCC) provides guidance for monitoring designated sites such as SSSIs and SPAs. For more information on what targets are used to measure whether conservation objectives are being met for each feature on a site, see JNCC's Common Standards Monitoring Guidance for Birds.[356]

Sanda Islands

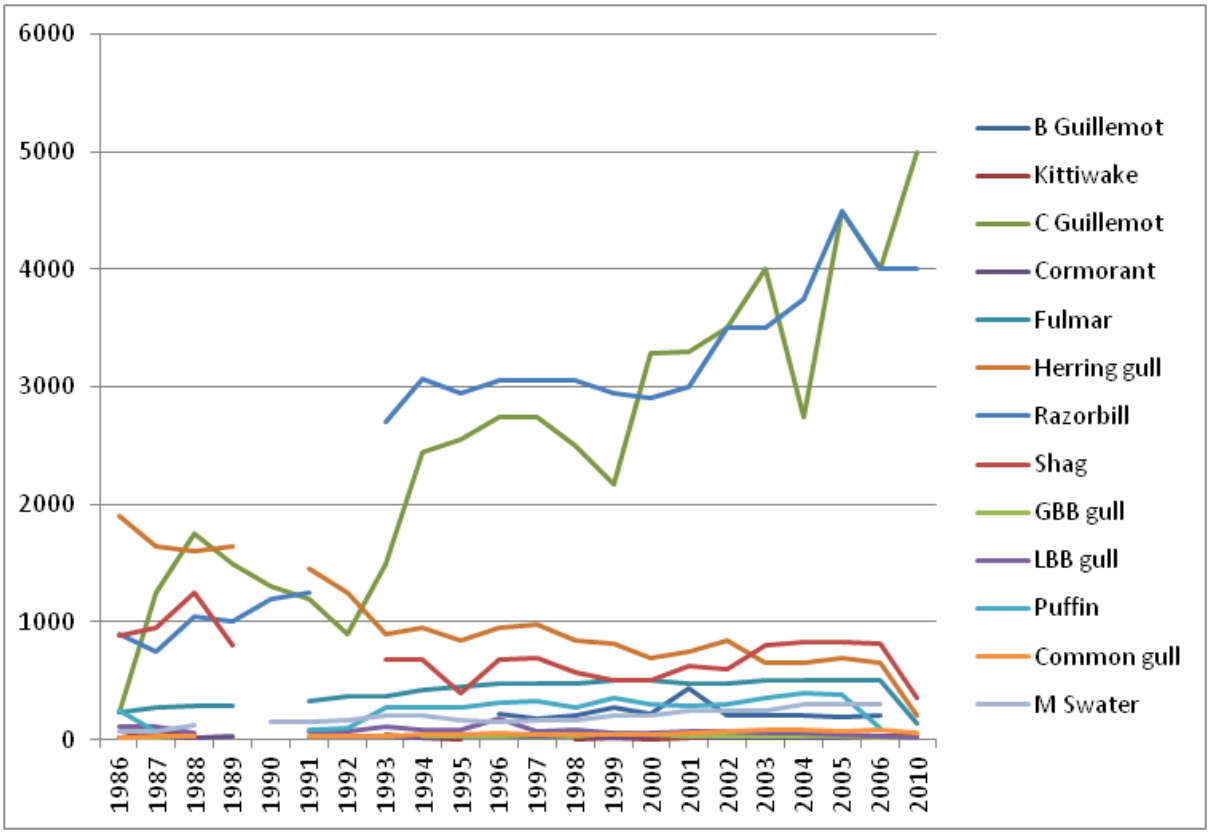
The Sanda Islands, located off the Mull of Kintyre are designated a SSSI (and are included within the boundary of the Clyde Sea Sill MPA) for breeding seabirds including, black guillemots, cormorants, fulmar, great black-backed gull, guillemot, kittiwake, Manx shearwater, puffin, razorbill, shag and storm petrel.[357] The location of the islands makes it an important outlying location and migration stop-over point for many seabirds, and is the biggest shag colony in the Clyde seabird population with internationally important numbers of this species and of razorbills.[358] The islands are also home to the most southerly established breeding colony of Manx shearwater and storm petrel in Scotland. Furthermore, the islands support a population of around 30 breeding pairs of cormorants.[359]

The assessment of seabird features at this site has found the breeding populations of black guillemot, cormorant, fulmar, guillemot, kittiwake, Manx shearwater, storm petrel and razorbill to be 'favourable maintained' while great black-backed gull were classified as 'favourable recovered'. Populations of puffin and shags were classified as 'unfavourable declining'.

Pressures identified on the island for the birds included suspected mink predation on black guillemots and climate change for razorbills, cormorants and fulmars. The national decline in seabirds could also be a contributing factor to seabird declines on this site.[360]

Figure 5.20 shows population changes from 1986-2010 on Sanda Island. The data shows declines in shag, herring gull, puffin and fulmar numbers and an increase in black and common guillemot and storm petrel (not shown in the graph, but 55 were counted in 1986 and 200 in both 1999 and 2006).

Figure 5.20. Populations of seabirds based on colony counts on Sanda Island 1986–2010[361]



355. Scottish Natural Heritage, 2016e
356. Joint Nature Conservation Committee, 2004
357. Scottish Natural Heritage, 2016a
358. Scottish Natural Heritage, 2011
359. Scottish Natural Heritage, 2011
360. Scottish Natural Heritage, 2016a
361. Joint Nature Conservation Committee, a



Oyster Catchers © PETER SANDGROUND

Clyde Sea Sill

Designated in 2015, the Clyde Sea Sill Marine Protected Area encompasses the Sanda islands, and among other marine features is designated for black guillemots (see Chapter 5.9 Protected areas for more information on the non-seabird features of this site). Study of these seabirds suggests that approximately 95% of foraging occurs within 2km of nesting sites,[362] and so the marine area near them is important and the MPA boundary is assumed to accommodate this. Although black guillemots are protected under the SSSI designation of the Sanda Islands, SSSI's are limited geographically to mean low spring water tides, and so foraging areas cannot be protected through the existing SSSI mechanism.

Black guillemots are the only bird species included in MPA Priority Marine Features (PMFs); this is because they do not fall under the protection of the European Commission Birds Directive as they are not considered migratory and over 80% of the population can be found in Scotland. Over 37,000 (around 88% of UK population) individuals were recorded in Scotland and over 1% of these are resident on Sanda and Sheep Island.[363]

A count made of the Sanda Islands population in 2013 shows a decline from 406 to 349 individuals from the previous survey carried out in 2001 for Seabird 2000. This is thought to be as a result of the 2013 survey being carried outside of the ideal count period when bird were still likely to have been in pre-breeding flocks.[364] A further decline has been seen from 2013 to 2014 when only 232 birds were counted, a 32% decrease. This decline may be down to day-to-day variability in black guillemot numbers in the pre-breeding period. It may also be as result of mink predation, which has been suspected on Sanda.[365]

Other important sites and activities within the Clyde Marine Region

Horse Isle is located 1km off the Ayrshire coast near Ardrossan. The island is an important site for high numbers of cormorants and lesser black-backed gulls. The gull population has increased here over the last 20-30 years after a cull of these species was stopped. The island is owned by Peel Holdings, but is managed as a nature reserve by the RSPB.[366] Pladda, Lady Isle, Little Cumbrae, the Ayrshire cliffs and Inchmarnock are also important sites for seabirds located around the CMR.[367]

Various dedicated local interest or specialist birding groups (both for sea and waterbirds) are active in the CMR, and these have contributed to our local knowledge of the life and habits of seabirds and waterbirds around the Clyde. Such groups include: the Buteshire, Arran and Glasgow Natural History Societies, Sanda birding group, Argyll Bird Club, the Scottish Ornithology Club, the Clyde ringing group and other British Trust for Ornithology (BTO) volunteers. Both Buteshire and Glasgow Natural History Societies produce their own publications, while the Arran Natural History Society produces the Arran bird atlas. The RSPB also has a number of local members groups around the CMR.

The Clyde ringing group operates over the region of the former Strathclyde Regional Council (an area wider than the CMR) and meets regularly to ring birds, an important activity which generates information on survival, productivity and movements of birds. The BTO reports ringing data on its website, by species and year for the wider Clyde area and the Clyde islands. In 2014, over 286 seabirds were ringed in the Clyde and 152 in the Clyde Islands. More information on this can be found on the BTO website.[368] The gull ringing project, led by University of Glasgow researchers, also colour rings gulls in the Clyde. This enables animals to be individually identified without having to be re-caught.[369]

362. Scottish Natural Heritage, 2014a
363. Scottish Natural Heritage, 2014a
364. Swann, 2013
365. Swann, 2014
366. Royal Society for the Protection of Birds
367. Monaghan and Zonfrillo, 1986
368. British Trust for Ornithologists, a
369. Arran Birding

Figure 5.21. Comparison of SMP population change data, percentage change in abundance in Scotland, classification under the Birds of Conservation Concern review and condition of seabird features at designated sites in the CMR

SPECIES	POPULATION CHANGE (%)[373]			% change in abundance in Scotland (1986-2011)[374]	BoCC 4	SITE CONDITION		
	1969-70 to 1985-88	1985-88 to 1998-2002	2000-2013			AILSA CRAIG SSSI	AILSA CRAIG SPA	SANDA ISLAND SSSI
Arctic tern	+50	-31	+6	-72				
Atlantic puffin	+15	+19	n/a		A			UD
Black guillemot	n/a	+3***	n/a	<+1*				FM
Black-headed gull	+5	0	+26	-53				
Black-legged Kittiwake	+24	-25	-47	-66	A	FM~	UD	FM
Common guillemot	+77	+31	+9	-24		FM~	FM	FM
Common tern	+9	-9	-17	-43				
European shag	+21	-27	-41	-47	A			UD
European storm-petrel	n/a	n/a	n/a					FM
Great black-backed gull	-7	-4	-24					FR
Great cormorant	+9	+10	-20					FM
Herring gull	-48	-13	-30	-58		FM~	UD	
Lesser black-backed gull	+29	+40	-48				UD	
Manx shearwater	n/a	n/a	n/a					FM
Northern fulmar	+77	-3	-13	-7				FM
Northern gannet	+39	+39**	n/a			FM	FM	
Razorbill	+16	+21	+13			FM~		FM
Sandwich tern	+33	-15	-7	-48				

** Change between censuses in 1984-5 and 2004-5
*** Change between censuses in 1982-91 and 1998-2002
* Not included in Operation Seafarer, the Seabird Colony Register or Seabird 2000
BoCC4 legend: The traffic light system used indicates the level of concern for each species, red being the highest level and green the lowest.
Where an 'A' is shown in the box, this means this bird was previously included in the Amber list, and the level of concern for the species has increased.
~ Part of breeding seabird assemblage, not assessed as an individual species
FM - Favourable maintained
FR - Favourable recovered
UD - Unfavourable declining

Clyde seabirds in context with UK and global population trends

Figure 5.21 above compares national trends from the SMP data, change in Scottish abundance trends (only calculated for 11 species),[370] the Birds of Conservation Concern fourth (BoCC4) review[371] and the site condition of seabird features of designated sites within the CMR.[372] The population changes shown in the data from the SMP illustrate that numbers of shag, kittiwake, herring gull, great black-backed gull, sandwich tern, common tern and arctic tern have decreased. While the Clyde data show a decreasing trend for puffin on Sanda, Kittiwake under the Ailsa Craig SPA, shag on Sanda, Herring gull on Ailsa Craig SPA and, to a lesser extent, lesser black-backed gulls on the Ailsa Craig SPA.

370. Foster and Marrs, 2012
371. BoCC is a review of the status of birds in the UK, Channel Islands and the Isle of Man; this review has seen three species (shag, puffin and kittiwake) move onto the red list from amber status (shown with an 'A' in the table), accompanying herring gulls and roseate terns under this status. The great cormorant is classified as green. The remaining 15 species are classified as amber and were also classified as amber under the third BoCC review.
372. The Seabird Monitoring Programme (SMP) has been routinely monitoring seabird colonies around Britain and Ireland since 1986; and some of its findings are reported here to provide context and further understanding of trends in seabird populations in the Clyde. Individual site count data from the SMP can be viewed on the Joint Nature Conservation Committees website, who coordinate this programme - http://jncc.defra.gov.uk/page-1550 (Accessed April 2016)
373. Joint Nature Conservation Committee, 2014
374. Foster and Marrs, 2012

Waterbirds

Introduction

Birds that live on or around water include: geese, swans, ducks (*Anseriformes*), waders, rails, grebes (*Charadriiformes*) and herons (*Ciconiiformes*) and are collectively known as waterbirds. Some waterbirds prefer freshwater habitats, while others prefer marine environments, or can move between these different aquatic environments.

The Inner Clyde estuary has been identified as an important site for wintering waterbirds and supports nationally important populations of: redshank (*Tringa tetanus*), oystercatcher (*Haematopus ostralegus*), goldeneye (*Bucephala clangula*), red breasted merganser (*Mergus serrator*), eider (*Somateria mollissima*), cormorant and red-throated diver (*Gavia stellate*). This has led to this site being designated as an SSSI, for its assemblage of wintering waterbirds and its habitat features, and a Special Protection Area (SPA) and a Ramsar site for wintering redshanks. However, waterbirds are found throughout the CMR coastline, at lochs and some inland water bodies.

For clarification, shags are covered above in the seabirds section and only count data for cormorants at the Inner Clyde estuary are included in this section as they are listed as a feature of the Inner Clyde estuary SSSI; other details on cormorant numbers in the CMR are provided above in the seabirds section.

Gathering data in the Clyde Marine Region – Wetlands Bird survey

The Wetlands Bird survey (WeBS)[375] is the principal scheme for monitoring the UK's non-breeding wintering waterbird populations. It provides a valuable indicator of their status and the health of wetlands around the UK. It also highlights particular sites of interest for waterbirds within the CMR.

There are core counts which take place monthly at wetlands during winter. In addition there are also occasional supplementary WeBS low tide counts which aim to identify key feeding areas. The coverage of counts and sites is dependent on the availability and location of volunteer groups who carry out the counts. The count data summarised here is a snapshot and does not take into account connectivity of sites and movement of birds between sites or from sites outwith the CMR. Further investigation needs to be made into this and other factors which may provide insight into changes in count numbers.

There are 16 sites in the CMR where counts take place, aside from the Inner Clyde estuary, including:



Grey Heron © PETER SANDGROUND

Bute, Black Cart water, Culzean pond, Dalmuir park pond, Forth and Clyde canal (Mayhill locks to Great Western Road and Clydebank to Bowling), Girvan Harbour, Girvan to Turnberry, Glen moss, Greenan Loch, Hogganfield Loch, Holy Loch, Hunterston to Fairlie, Kelvingrove Park, Knightswood park and Loch Long. Inland sites have been included as they may be important for connectivity to marine sites. Full details of these counts, going back across all years they have been carried out (the table opposite only looks at count data over 5 years) can be found on the WeBS Numbers and Trends reporting page- http://app.bto.org/webs-reporting/.[376]

Other known sites of importance for waterbirds in the CMR that do not appear in the WeBS counts and on which we have little data include Burnt Islands and Horse Island, which have two of the biggest colonies of eiders on the west coast. Eiders are also common around Inchmarnock, near Bute.

Wetlands Bird Survey count data in the Clyde Marine Region

Sites with the highest diversity of species counted are: Inner Clyde estuary (54 species), Black Cart Water (27 species), Holy loch (25 species), Girvan to Turnberry (25 species) Hogganfield Loch (24 species), and Greenan Loch (19 species). Sites with the highest average of birds counted over five years, which may be an indicator of their importance to the CMR are: Inner Clyde estuary (27,039), Bute (3,215), Black Cart Water (1,975), Holy Loch (1,305) and Hogganfield Loch (1,088). The rest of the CMR sites recorded averages below 1,000 birds. The total number of species at all sites in the CMR from 2010-2015 is recorded in figure 5.13 over.

375. British Trust for Ornithology, b
376. British Trust for Ornithology, c

Table 5.13 WeBS count data for all species across all sites included in the CMR from 2010/11 – 2014/15[377]

SPECIES	YEAR OF COUNT				
	2010/11	2011/12	2012/13	2013/14	2014/15
Bar-headed Goose	1	0	0	0	0
Barnacle Goose	6	86	0	11	0
Bar-tailed Godwit	31	46	5	11	18
Bean Goose	0	3	0	0	0
Black-tailed Godwit	9	7	3	6	6
Black-throated Diver	16	28	15	25	24
Brent Goose	1	2	1	0	0
Brent Goose (Light-bellied)	1	2	1	0	0
Canada Goose	589	425	150	271	324
Common Sandpiper	19	15	26	27	14
Common Scoter	2	35	36	16	0
Coot	163	130	123	117	120
Curlew	208	181	175	189	180
Dunlin	1,014	1,037	1,025	695	895
Eider	3,277	2,218	2,620	3,095	2,538
Gadwall	58	28	16	34	24
Golden Plover	2	1	421	0	0
Goldeneye	358	312	255	304	245
Goosander	100	46	75	99	89
Great Crested Grebe	228	205	216	125	117
Great Northern Diver	2	8	5	14	18
Greenshank	1	0	2	2	1
Grey Heron	85	65	56	112	78
Grey Plover	0	2	0	0	4
Greylag Goose	10,130	4,223	3,287	2,365	2,961
Greylag Goose (domestic)	0	5	5	3	3
Jack Snipe	2	5	6	1	0
Knot	14	15	12	7	14
Lapwing	1,728	1,837	1,512	1,243	1,479
Little Grebe	70	46	44	24	46

SPECIES	YEAR OF COUNT				
	2010/11	2011/12	2012/13	2013/14	2014/15
Long-tailed Duck	2	1	1	3	1
Mallard	1,535	1,208	1,420	1,539	1,242
Moorhen	80	84	71	100	146
Mute Swan	393	380	380	461	479
Oystercatcher	5,895	5,197	5,220	5,173	5,130
Pink-footed Goose	33	60	25	41	250
Pintail	8	11	3	4	2
Pochard	87	45	50	43	48
Purple Sandpiper	3	0	0	1	0
Red-breasted Merganser	221	141	186	136	200
Redshank	1,512	1,319	1,214	1,424	1,490
Red-throated Diver[369]	198	159	257	244	54
Ringed Plover	213	213	171	156	165
Ruddy duck	3	2	1	0	1
Ruff	0	1	0	0	0
Sanderling	3	0	0	7	3
Scaup	8	10	11	13	8
Shelduck	308	208	207	262	226
Shoveler	12	10	1	3	0
Slavonian Grebe	84	70	64	97	15
Snipe	127	132	148	176	93
Spotted Redshank	0	0	2	0	0
Teal	1,779	1,038	1,282	1,083	1,214
Tufted Duck	574	343	483	255	227
Turnstone	183	150	182	168	95
Water Rail	3	2	10	3	4
Whimbrel	7	1	6	15	2
White-fronted Goose	230	193	165	190	160
Whooper Swan	154	104	93	68	81
Wigeon	1,414	1,256	1,275	1,138	1,608
Woodcock	1	1	1	0	1

Overall counts for the CMR appear to be showing declines in numbers counted for 28 of the 61 species recorded in the WeBS counts for these years; counts over more years and examining other factors which may be affecting numbers would need to be investigated further. Species appearing to show an especially large decrease in numbers counted, over the period of years shown include: Canada goose (*Branta Canadensis*), dunlin (*Calidris alpine*), gadwall (*Anas strepera*), great crested grebe (*Podiceps cristatus*), greylag goose (*Anser anser*), lapwing (*Vanellus vanellus*), mallard (*Anas platyrhynchos*) and oystercatcher. Six species appear to show an increase in numbers counted including black-throated diver, great northern diver, moorhen, mute swan, pink-footed goose and widgeon.

The SNH waterbird biodiversity indicator for Scotland, from 2014, notes that the overall trend for wintering waterbirds (ducks and swans, geese, waders, grebes and coot) has now dropped below

377. Supplementary counts were carried out 10/11, 11/12 and 13/14, but not 12/13.

the 1975 baseline, when counting began and none of the groups have sustained their peak levels. Duck and swan numbers have shown a small increase over the winters of 12/13 and 13/14. Three species – pochard (*Aythya farina*), scaup (*Aythya marila*), and eider are at an all-time low. Collectively, waders have shown the largest decline. Numbers of great crested grebe (*Podiceps cristatus*), cormorant and coot show an overall decrease and coot reached an all-time low in 2011/12. Looking at the results in table 5.13, the national trend for declines is similar to what is seen in the Clyde, particularly for eider, pochard and goldeneye. In the Inner Clyde estuary, there is a similar trend in declines for eider, goldeneye, cormorant, redshank, Slavonian grebe (*Podiceps auritus*) and oystercatcher.

Redshanks were thought to be no longer impacted by the adverse factors which caused the large decline of the 70's and 80's and began to improve after this period until around 1999/2000 when their numbers began to decline again.[378] This may be as a result of declining numbers across the UK and may not be related to local factors. The BTO annual report of the Wetlands Bird Survey showed a decline of 22% in the 10 year trend from 2003/04-2013/14, down from the 10 year period 02/03-12/13 which showed a decline of 26%, suggesting a tentative recovery.[379] However, numbers in the UK are still down about 30% from a peak in the 1990s. Data for Scotland alone show a similar trend, with declines of about 40% since the 1999/2000 peak.[380]

Looking at the status of species included in table 5.13 at a national scale, curlew and Slavonian grebe are classified as having red status in the fourth review of BoCC4; both were previously classified under the amber list. Redshank, eider, goldeneye, oystercatcher and greenshank are classified as under the amber list; with greenshank being downgraded from the green list under the previous report. The decline for redshank overall across the CMR appears small, however considering the Inner Clyde Estuary in isolation, there would appear to be a larger decline at this site. Red-breasted merganser, which was previously amber listed, has been classified as having green status. The BTO WeBS report for 2013/14 reports that UK trends for shelduck, curlew, dunlin, redshank and oystercatcher have shown a steady decline.[381]

The history of the eider in the CMR has been particularly well recorded. At the start of the twentieth century these birds were a rare sight, but populations rose over the next 20 years across all parts of the CMR. In 1996 a monitoring programme was established by a network of local birders to carry out annual counts. This group recorded a population of 20,000 in 1997, making the Clyde home to the largest population of eiders in the UK; one in every four eiders in the UK was from the CMR. By 2000 the birds began to decline substantially for unknown reasons to the numbers recorded in table 5.14 (non-breeding individuals, winter count). Declines were seen across the entire CMR and there is no evidence of the birds moving elsewhere, either within or outside the region. Additionally, there is no evidence of a massive mortality event.[382] It is not currently known what caused the decline in eider numbers but more recent information shows that eider numbers are stabilising.[383]

The Inner Clyde estuary

The Inner Clyde Estuary is an SSSI (a national designation), an SPA (a European designation) and a Ramsar site (an international designation). Their boundaries are coincident and include the intertidal zone from Clydebank in a 20km strip along shores of the river to Helensburgh on the north bank of the river and Greenock on the south shore and landwards to Mean High Water Springs. The site of the largest single number of birds in the CMR and a heavily industrialised estuary, it is of national importance for its populations of waterbirds and is the most northerly of the UK's west coast estuaries. The habitat consists mostly of tidal mudflat with some saltmarsh and a shoreline of unmanaged semi-natural coastal vegetation.[384]

Table 5.14 highlights the population numbers for species which are either of national or international importance or are an SSSI or SPA feature. Many species found at the site in large numbers are not reflected in this list such as: mute swan (*Cygnus olor*), greylag goose, Canada goose common shelduck (*Tadorna tadorna*), wigeon (*Mareca penelope*), teal (*Anas crecca*), mallard (*Anas platyrhynchos*), great crested grebe, lapwing, dunlin, common snipe (*Gallinago gallinago*) and turnstone (*Arenaria interpres*). These can be viewed at the WeBS Numbers and Trends reporting page for the Inner Clyde location.[385]

Population counts for 05/06-14/15 are presented in table 5.14 and show that numbers across this period for non-breeding eider, goldeneye, oystercatcher, redshank and Slavonian grebe are decreasing. Numbers of non-breeding red-throated divers and red-breasted merganser curlew and greenshank for this period appear to be fluctuating.

Please note that the WeBS survey site extends beyond the boundary of the Inner Clyde SPA and SSSI, and so the numbers reported in this table will be higher than those reported for site condition monitoring of these designated sites.

378. Harding, 2008
379. Frost et al., 2016
380. Scottish Natural Heritage, 2014b
381. Frost et al., 2016
382. Waltho, 2011
383. Firth of Clyde Eider News, 2015
384. Scottish Natural Heritage, 2016f
385. British Trust for Ornithology, c

Table 5.14 WeBS counts for the Inner Firth of Clyde site for waterbirds 05/06– 14/15[386]
N.B. the boundary of the BTO survey area is more extensive than the boundary of the SPA/SSSI.

SPECIES	YEAR OF COUNT									
	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	20012/13	2013/14	2014/15
Eider	8,055	9,590	3,960	3,262	2,932	3,019	1,952	2,277	2,281	1,972
Goldeneye	636	688	609	215	270	227	235	204	221	157
Red-breasted merganser	252	195	168	202	158	202	128	152	103	140
Red-throated diver	202	182	199	139	177	191	140	245	233	40
Slavonian grebe[394]	35	41	73	49	47	84	70	64	96	15
Oystercatcher	5,880	5,308	5,836	4,101	5,042	4,938	4,369	4,631	4,363	4,400
Curlew	1,417	2,017	1,673	1,716	1,845	1,443	1,644	1,563	1,511	1,560
Cormorant	740	875	389	555	327	326	202	359	350	395
Greenshank	13	13	17	10	8	16	13	15	18	21
Redshank	1,984	1,915	1,901	1,965	1,596	1,293	1,042	1,038	1,131	1,244

Blue – exceeds British national important threshold
Green – exceeds international importance threshold
Orange – Indicates that a supplementary visit under the WeBS Core Count Survey was undertaken.

Inner Clyde SSSI

The SSSI has been notified for the following features: cormorant (discussed in seabirds but details given here as a feature of this designation), eider, goldeneye, oystercatcher, red-breasted merganser, red-throated diver, redshank and for the saltmarsh habitat. The site also contains large areas of nationally scarce dwarf eelgrass (*Zostera noltei*) and other plants and invertebrates that support the species which winter here.[387]

The management objectives for the SSSI designation are:

- To maintain the extent and condition of saltmarsh habitat
- To maintain the extent and forage value of intertidal sand and mudflats
- To maintain or increase the populations of wintering wildfowl and waders.

At the last site assessment (carried out in 2014, apart from redshanks which was carried out in 2007) all the waterbird features of the site and the saltmarsh (assessment of saltmarsh carried out in 2011) were found to be 'favourable maintained'.[388]

Improvements in sewage treatment in the CMR have been linked to a decline in invertebrate abundance and this has been cited as a potential cause for scaup declines.[389, 390] As a result, scaup are no longer noted as a feature of the Inner Clyde SSSI.[391] Improvements in sewage treatments are also thought to have been the cause for redshank, dunlin and lapwing declines in the 1970's and 1980's.[392, 393]

Inner Clyde SPA

The SPA has been designated based on the internationally important wintering population of redshank. The conservation objectives of the SPA are:

- To avoid deterioration of the habitats of the qualifying species (redshank) or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and
- To ensure for the qualifying species that the following are maintained in the long term:
  - population of the species as a viable component of the site
  - distribution of the species within site
  - distribution and extent of habitats supporting the species
  - structure, function and supporting processes of habitats supporting the species
  - no significant disturbance of the species[394]

386. British Trust for Ornithology, c
387. Slavonian grebe are not a feature of the Inner Clyde SPA but are counted as having internationally important numbers by the WeBS survey data as the BTO Inner Firth of Clyde survey area is much more extensive than the Inner Clyde SPA.
388. Scottish Natural Heritage, 2016f
389. Burton *et al*., 2001
390. Scottish Natural Heritage, 2016c
391. Scottish Natural Heritage, 2016c
392. Furness *et al*., 1986
393. Harding, 2008
394. Scottish Natural Heritage, 2016g

The site qualified as an SPA in 2002, with a winter peak mean of 2,107 redshanks; 1% of the east Atlantic flyway and 2% of the British population.[395] At the last SPA condition monitoring survey in 2007, the redshanks were assessed to be in 'favourable maintained' condition.[396] Although WeBS counts cover a larger area than the SPA boundary, they show a significant decline in redshanks in the area (also reflected in the UK and Scottish trends noted above) which might indicate there would be a decline in the features assessment in the next monitoring cycle.

Main pressures affecting waterbirds

The main pressures identified for waterbirds include: intermittent risk of disturbance from cockle gathering on Pillar bank and recreational activities, in particular dog walking, bait digging and wildfowling. These activities are considered to be carried out at low intensity across the entirety of the CMR but there is evidence of some localised impacts.

Anticipated long-term sea-level rise is likely to have significant effects on the extent and distribution of intertidal and saltmarsh habitat. Landward migration is impeded by man-made sea defences. This may be offset if saltmarsh can gain height through accumulation of sediment.[397]

For further information on this and managed realignment opportunities, see Chapter 3.2 Climate change – sea-level rise and coastal flooding.

ECOSYSTEM SERVICES[398]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Regulating	Biological control	As a top predator and their role in marine food webs, seabirds contribute to biological control as they feed on marine organisms.
	Waste breakdown and detoxification	Scavenging bird contribute to waste breakdown at low levels, enabling species lower down the food web to feed on organic products. Herring and lesser black-backed gulls in particular have an impact on removing organic matter.
Cultural	Tourism and nature watching and sense of place and associated health benefits	Bird watching is an important recreational activity around the CMR and contributes to our knowledge and enjoyment of the natural history of the region. Visiting well-known seabird sites contributes to people's sense of place and interaction with the marine environment.
	Research and knowledge systems	Long term studies and research of seabirds and waterbirds has contributed to our knowledge of the marine environment and the impacts which may be affecting it and the wider ecosystem.
Supporting services underpin the provision of other services		The diversity of seabirds and waterbirds found in the CMR feed at different trophic levels; some are top predators feeding on fish while others forage in the intertidal zone on invertebrates. All play an important role in ecosystem functioning and maintaining ecological balance. Seabirds are consumers of primary production and transport nutrients from pelagic waters to coastal breeding sites.
		Burrow nesting seabirds, such as puffins and Manx shearwater make a significant physical impact to habitat by improving soil fertility and structure. All seabird breeding sites and colonies are part of the seascape. Seabirds are considered to be an indicator of marine health and if populations are in decline, this could be an indicator of problems or changes in the wider ecosystem or with other ecosystem services.

395. Harding, 2008
396. Scottish Natural Heritage, 2016g
397. Scottish Natural Heritage, 2016f
398. Burdon *et al*., 2017

5.9 Protected areas – nature conservation

Seabirds



Others



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SNH site condition monitoring
gateway.snh.gov.uk/sitelink/

NCMPA surveys
www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-(mpa)/mpa-survey-research-reports/

Scotland's Marine Atlas: score not included

Introduction

Over the past 30-40 years, various pieces of Scottish, UK and European legislation have been introduced in order to help protect locations which are recognised for their natural, ecological and/or cultural value. This can be for landscapes, plants and animals, rocks, fossils and landforms. Their protection and management help to ensure that they remain in good condition for all to enjoy, both now and for future generations.

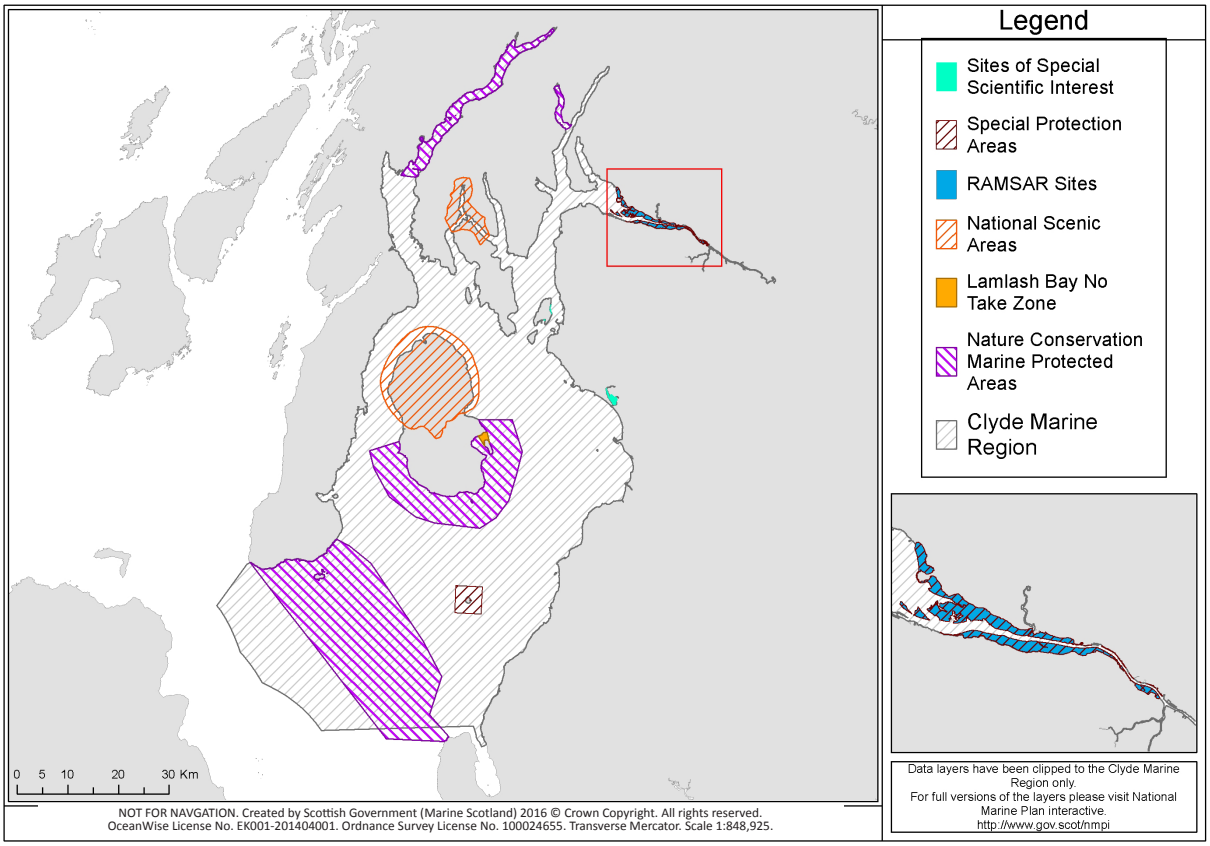
The Clyde's Marine Protected Area network includes Nature Conservation MPAs, Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs) and Ramsar sites. This network makes a significant contribution to the protection of Scotland's nationally important marine wildlife, habitats, geology and undersea landforms.

For a full list and further information about the features and condition of nature conservation protected areas around the Firth of Clyde see Appendix II.

The SSSI and Natura sites designated for habitats and species are generally in favourable condition with the exception of the following:

SITE	ISSUE AND COMMENTARY
Ailsa Craig SPA	Kittiwake (*Rissa tridactyla*), Lesser black-backed gull (*Larus fuscus*) and Herring gull (*L. argentatus*) form part of the SPA designation and are 'Unfavourable Declining'. Declines in the three gull species at least partly reflect national declines and may result in part from reductions in food availability.
Western Gailes SSSI	Long-term lack of grazing has resulted in some loss of habitat diversity in the sand dune habitats, and encroachment by non-native scrub. This has reduced the availability of habitat for sand dune insects. Strandline vegetation and insects that live on strandline vegetation and detritus have suffered losses due to unauthorised mechanical beach cleaning. Mechanical beach cleaning has now ceased.
Sanda Islands SSSI	Black guillemot (*Cepphus grille*), Puffin (*Fratercula arctica*), Shag (*Phalacrocorax aristotelis*), Great black-backed gull (*L. marinus*) and Kittiwake form part of the SSSI designation and are all showing a 25% or greater population decline. It is believed that this is not due to local issues but part of a wider UK seabird decline in some species.
Kames Bay, Cumbrae SSSI	Sandflats have no site condition assessment. Feature status under review.
Ballochmartin Bay, Cumbrae SSSI	Sandflats have no site condition assessment. Feature status under review.
Troon Golf Links and Foreshore SSSI	Long-term lack of grazing of sand dunes has resulted in some loss of habitat diversity and encroachment by native and non-native scrub. Scrub management by the golf course has restored some dune grassland and further measures are under discussion.
South Coast of Arran SSSI	Some decline in habitat condition has been attributed to localised under-grazing and bracken encroachment. Management measures have recently been agreed in some areas to control bracken and promote grazing. The shingle vegetation has suffered minor damage from small-scale shingle extraction and vehicle use.
Bogside Flats SSSI	Mudflat feature under review.

Map 18. Protected areas with a marine element in the Clyde Marine Region



Special Protection Areas (SPAs)

Inner Clyde SPA

The Inner Clyde estuary supports nationally important populations of several wading birds and has consequently been designated as a Site of Special Scientific Interest. The population of redshank (*Tringa tetanus*) is sufficiently large to be of international importance and the site has also been classified as a Special Protection Area (and Ramsar Site) (see Chapter 5.8 Seabirds and waterbirds for detailed information on waterbirds).

Ailsa Craig SPA

Numbers of gannets (*Morus bassanus*) on Ailsa Craig increased steadily in line with the national trend, from 13,000 Apparently Occupied Sites (AOS) in 1970 to 23,000 AOS in 1985 and 32,500 in 1995.[399] The aerial census in 2004 suggested that overall numbers of breeding gannets on Ailsa Craig had declined to 27,130 AOS.[400] However, this may be a result of the survey being completed too early in the season (see Chapter 5.8 for detailed information on seabirds).

Nature Conservation Marine Protected Areas (NCMPAs)

This type of protected area has been more recently established with designation orders in July 2014 under the Marine (Scotland) Act.

Clyde Sea Sill[401]

This site has been designated for Marine Geomorphology, Fronts, Black Guillemot and Circalittoral and offshore sand and coarse sediment communities. Fronts can concentrate nutrients and plankton, creating feeding hotspots for fish which in turn attract other higher marine predators. The sea bed at the sill is a dynamic environment; the sands and gravels on the sea floor are moved around, creating sandbank ridges or extensive sand ribbon and sand wave fields. Despite this highly mobile environment, there is a range of animals adapted to thrive here, taking advantage of the productive waters. Clam shells and polychaete worms (*Polychaeta*) live beneath the sediment, while fish (*Pisces*), starfish (*Asteroidea*), brittlestars (*Ophiuroidea*), sea mice (*Aphrodita aculeata*) and hermit crabs (*Paguroidae*) are found on the surface. In the north-west of the MPA a colony of breeding black guillemots relies on the rich feeding grounds around Sanda, Sheep Island and Glunimore Island.

399. Mitchell *et al.*, 2004
400. Wanless *et al.*, 2015
401. Scottish Natural Heritage, a

South Arran[402]

Designated for Burrowed mud, Maerl beds (*Corallinales*), Kelp (*Laminariales*) and seaweed communities on sublittoral sediment, Ocean quahog (*Arctica islandica*) aggregations, Seagrass (*Alismatales*) beds, Maerl or coarse shell gravel with burrowing sea cucumbers (*Aspidochireta*) and Shallow tide-swept coarse sands with burrowing bivalves:

The maerl beds support an array of other red and brown seaweeds as well as various sea anemones (*Zostera spp*.), starfish, juvenile fish and shellfish. Where the maerl is interspersed with coarse gravel, a variety of tube building worms (*Serpulidae*) are to be found, as well as sea cucumbers. Other areas of shallow tide-swept coarse sands are home to burrowing bivalves including tellins (*Tellinidae*) and surf clams (*Spisula solida*). A recent paper assessing juvenile cod distribution and growth suggested that protecting mixed gravel habitat could be beneficial to support the recruitment of juvenile cod.[403]
A narrow band of seagrass fringes the bottom of the shoreline along the south coast at Kildonan and Kilmory and a more substantial bed (believed to be the largest in the Clyde) is located in the shallow waters of Whiting Bay to the south-east of the island. Burrowed mud is widely distributed around the outer regions of the MPA and supports a range of animals including *Nephrops*, squat lobster (*Galatheidae*), crabs (*Brachyura*), worms (*Playtyhelminthes, Nematoda, Sipuncula, Echiura* and *Annelida*), ocean quahogs and the slender seapen (*Virgularia mirabilis*). There is also a record of flameshell (*Limaria hians*).[404]

Upper Loch Fyne and Loch Goil[405]

Designated for Ocean quahog aggregations, Burrowed mud, Flame shell (*Limaria hians*) beds, Horse mussel (*Modiolus modiolus*) beds, Sublittoral mud and specific mixed sediment communities:

The still waters of these sea lochs are the ideal environment for a range of muddy seabed habitats to develop. Loch Shira is home to fireworks anemones. At Castleton, there is a flame shell bed which benefits from the increased currents caused by the tide being forced around the headland at Otter Spit. Large aggregations of sea cucumbers are present in mixed muddy sediments on the sill at the entrance to the mouth of Loch Goil, alongside clumps of horse mussels and sea squirts. Ocean quahog can be found throughout the MPA along with slender seapens and tube dwelling sea anemones (*Ceriantharia*).

Management of Fishing Activity within Nature Conservation MPAs

Following lengthy consultation, fisheries management measures were established for some NCMPAs by March 2016. Different regimes exist in different parts of the NCMPA network in order to allow fishing activities to take place where possible, whilst conserving or recovering the features of the site. Map 19 (over) shows measures for the South Arran and Upper Loch Fyne and Loch Goil NCMPAs within the Clyde Marine Region. Management measures for the Clyde Sea Sill will be introduced at a future date. For more information see www.gov.scot/Topics/marine/marine-environment/mpanetwork/inshorempas.

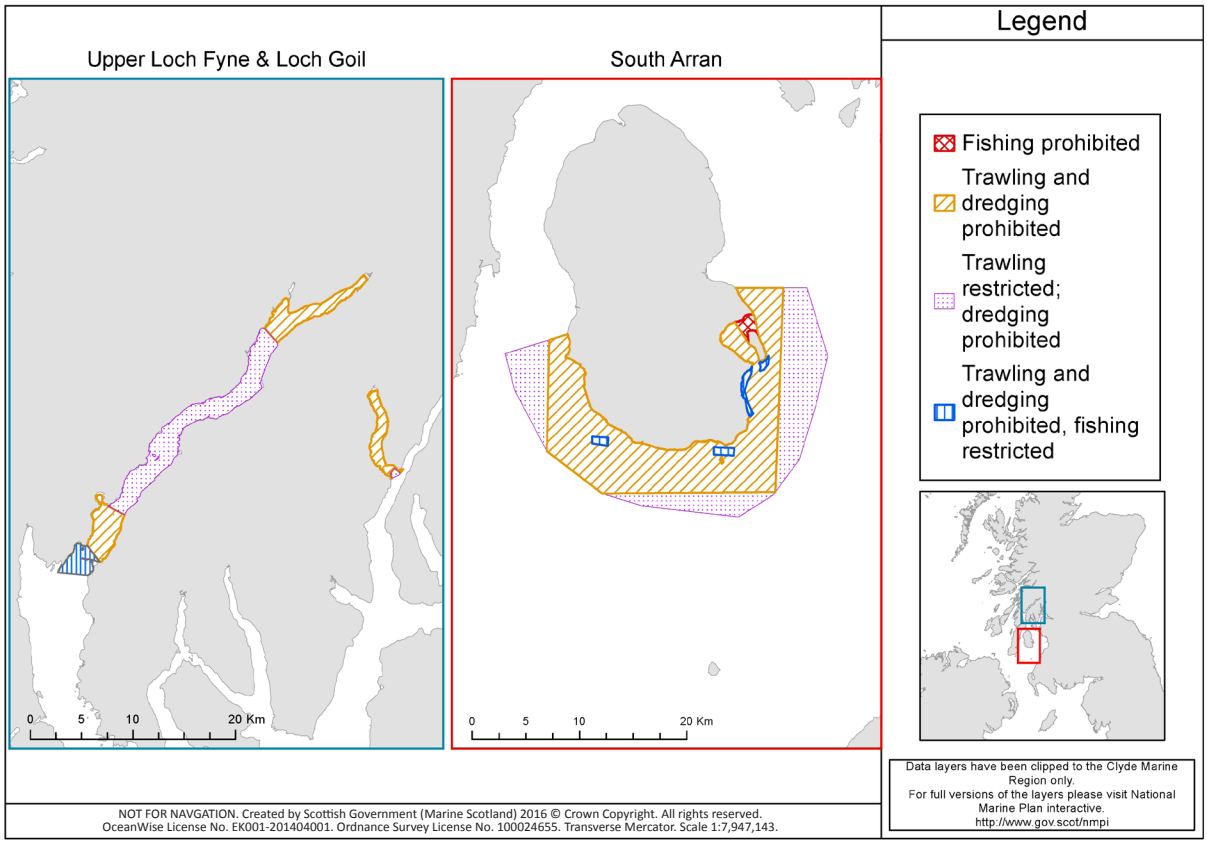
Lamlash Bay – No Take Zone

In September 2008, Scotland's first No Take Zone came into effect in part of Lamlash Bay, off the Isle of Arran. It is underpinned by fisheries statute as this was the only appropriate legislation available at the time.[406] Its establishment is a result of campaigning by the Community of Arran Seabed Trust (COAST) over many years, aiming to conserve and enhance the biodiversity of the Bay, and the subsequent work of a voluntary Working Group of the main interested parties: Clyde Fishermen's Association, COAST, SNH, Marine Scotland Science, Scottish Government and chaired by the Firth of Clyde Forum. Following lengthy discussions and broad agreement by all parties, the No Take Zone was established. It now lies within the larger South Arran Marine Protected Area and is now legally enforced as part of the South Arran Marine Conservation Order.

A number of surveys have been undertaken and are ongoing in order to assess how the No Take Zone is responding to protection. They show that the population dynamics of crustaceans have changed. Whilst the size and abundance of lobster has markedly increased over time, and the size, age and biomass of scallops have also increased,[407] the abundance of Brown Crab has decreased when compared to the area outside the No Take Zone. Fieldwork for a PhD thesis at York University has shown evidence from photo quadrats that species which attach to the seabed (such as maerl, seaweed, hydroids, bryozoans and sponges) are more abundant within the No Take Zone than the surrounding area.[408]

402. Scottish Natural Heritage, c
403. Elliott *et al*., 2016
404. National Biodiversity Network Atlas
405. Scottish Natural Heritage, d
406. The Inshore Fishing (Prohibition on Fishing) (Lamlash Bay) (Scotland) Order 2008
407. Howarth *et al*., 2011
408. Howarth, L., 2013

Map 19. Fisheries management measures South Arran and Upper Loch Fyne and Loch Goil



Ecosystem Services

Protected areas provide a wide range of ecosystem services as part of the natural environment. These have been highlighted under the relevant habitat and species chapters within this section of the Assessment. In addition, protected areas provide the cultural ecosystem services indicated below.

ECOSYSTEM SERVICES		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Cultural	Tourism and recreation	Protected areas provide aesthetic, educational and spiritual benefits which can be enjoyed by visiting the site and through recreational activities.
	Wellbeing	There is a non-use value of particular relevance to protected sites whereby people value knowing that iconic species and habitats exist without necessarily using them and that they will be available to benefit future generations.[409]
	Research and knowledge systems	Studying the changes within Marine Protected Areas can increase our knowledge and understanding of the marine environment, the impact of human activities on it, and how best to protect our natural resources.
Supporting services underpin the provision of other services		Protected areas safeguard important habitats such as spawning and nursery grounds for various species of commercial value, such as *Nephrops*, scallops and gadoids. MPAs also have a role in supporting ecological connectivity and functioning within the CMR and across Scotland's seas.

409. Jobstvogt *et al*., 2014

5.10 Marine Non-Native species



Colours are explained in the key at the beginning of the document

KEY SUPPORTING EVIDENCE

SEPA Water Body data 2013, 2014 and 2015

Scotland's Marine Atlas score: 'Some concerns and stable'. Regional assessment includes water bodies at risk of deterioration and increase in number of species found.



Wireweed © CMPP

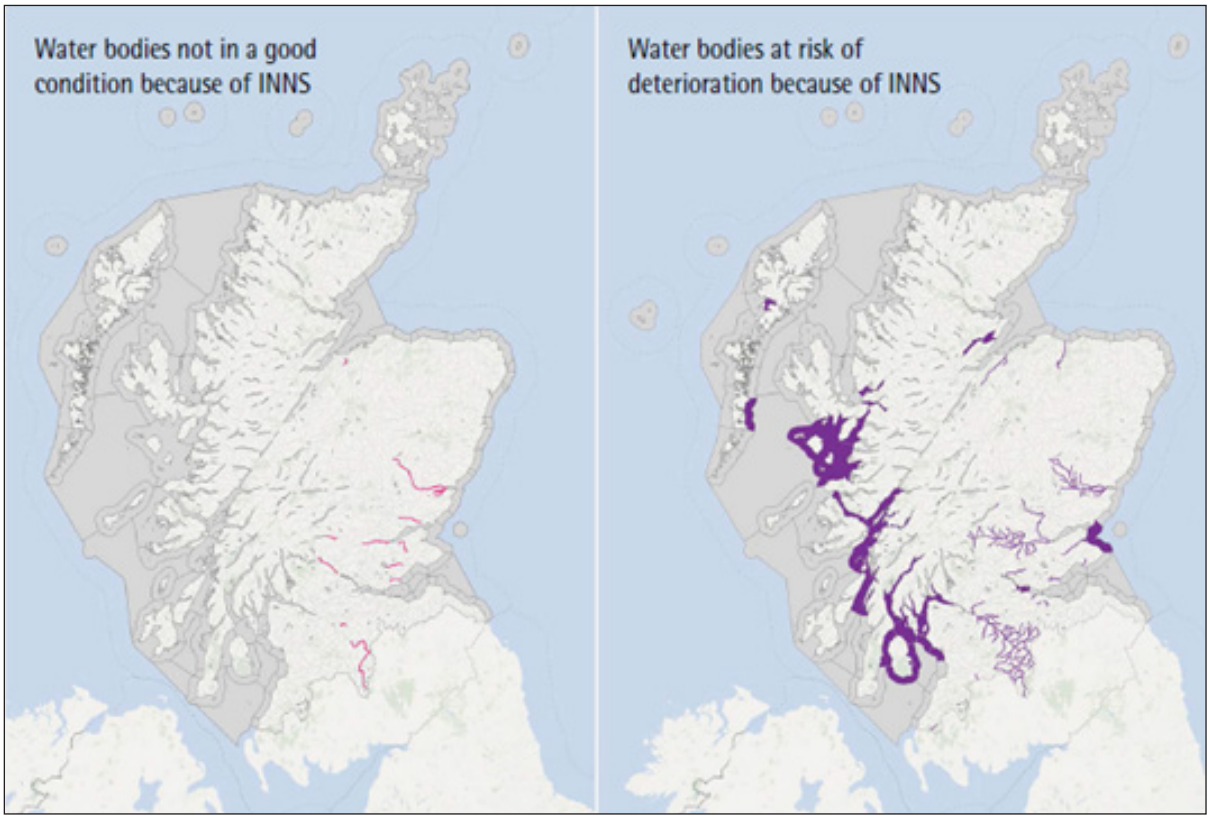
Introduction

Non-native species (NNS) are those that have been intentionally or unintentionally introduced outside their native range as a consequence of human activity. Once established, if these species then threaten biodiversity and/or cause economic damage they are referred to as 'invasive'. More than 90 marine NNS have been identified in British and Irish waters (including Republic of Ireland and Northern Ireland), of which 17 are now established in Scotland.[410, 411] Approximately 15% of NNS go on to become invasive (INNS). The classification of NNS as INNS is species and site specific.

Monitoring and status

The presence of a NNS can lead to the failure of a sea area to achieve Good Environmental Status (GEnvS) under Descriptor 2 of the EU Marine Strategy Framework Directive (MSFD). Under the Water Framework Directive (WFD) the presence of NNS can result in a water body not achieving Good Ecological Status (GEcS). In the River Basin Management Plan released by SEPA in 2015 18 water bodies around

Figure 5.22. Surface Water Bodies which are not in Good condition and Water bodies at risk from the spread of invasive non-native species



Source: SEPA, 2015

410. AquaNIS
411. Minchin *et al.*, 2013

Scotland were not achieving Good status because of NNS. None of the 18 areas are in the Clyde. However SEPA identify 150 areas which are at risk of failing due to NNS; 12 of which are in the Clyde Marine Region (CMR).[412]

The presence of NNS alone does not prevent a water body from achieving *Good* status. The NNS must have become established and be self-supporting before it is considered a high impact (i.e. invasive) species. For example a Chinese mitten crab (*Eriocheir sinensis*) shell was found in the inner CMR in 2015, this is a potentially highly invasive species, but has not resulted in the downgrading of the water body. The discovery of the shell was followed by a series of kick sample surveys which have, to date, not found an established population.

If NNS become invasive they can be very destructive to both the natural and manmade environment. In the correct conditions INNS can overwhelm, outcompete, consume or destroy indigenous wildlife. If a species becomes invasive this can be indicated by the development of a monoculture environment and changes to the local species profile. As they proliferate, depending on the characteristics of the species in question, they can also clog, smother, damage and disable machinery, water intakes other structures such as lock gates, pontoons, boat hulls and other under water structures.[413]

The estimated cost of INNS to the economy in Great Britain (GB) is £1.7bn a year, of which £245m is estimated to be attributable to Scotland. The annual cost to marine-based industries (e.g. shipping and aquaculture) in GB is estimated to be £39.9m (£7m for Scotland), although this is probably an underestimate, as there is little distinction made between native and NNS during pest control operations.[414]

NNS move via a number of pathways and vectors, including natural dispersal as well as on boat hulls and equipment and in ballast water or sediment. The aquaculture industry has tight biosecurity and animal health controls, which aim to limit the spread of NNS, however other industries are not so closely controlled. At present, there are significant risks from boat, equipment and stock movements. It should be noted that the problem of INNS is not just one of new species arriving in the UK but the UK also exports species which become INNS in other parts of the world.

NNS, once established, are very difficult to eradicate. They are also quick to exploit ecological niches which favour them if the ecosystem is degraded in any way. This is especially true in the marine environment where additional difficulties include identification, isolation of target species and control of spread.[415]

NNS – Policy and Legislation

In Scotland, amendments to Section 14 of the Wildlife and Countryside Act[416] and the accompanying Code of Practice on Non-Native Species[417] have significantly strengthened the law in relation to NNS. Two further offences have been added to the existing offence of releasing a non-native animal from captivity in the 1981 Act. The new offences are:

- allowing an animal to escape from captivity outwith its native range, and:
- causing an animal to be in a place outwith its native range.

The Scottish offences in relation to non-native plants and animals are 'strict liability offences' so knowledge, intention, recklessness or negligence do not have to be proved.

Two other significant Scottish legal drivers are:

- The Environmental Liability (Scotland) Regulations (SI 2009/226). These have established a civil law mechanism based upon the 'polluter pays' principle.[418]
- The Nature Conservation (Scotland) Act 200[419]

The MSFD and the WFD set a wider strategic and operational context for preventing the spread of NNS and their control. An EU Regulation on Invasive Alien Species has recently been published.[420, 421, 421]

In 2013, SEPA published a supplementary plan on managing invasive species in Scottish waters.[423] The plan describes the roles of organisations and partners involved in risk assessment, monitoring, classification, data collection, and prevention and control mechanisms.

Following the identified needs of marine industries, particularly marine tourism and recreation businesses, Scottish Natural Heritage published guidance in 2014 on how to construct a marine biosecurity plan for a site or operation based on the Code of Practice.[424] Marine Scotland are supportive of the biosecurity planning approach to risk management in the marine environment with regard to NNS and have also produced a Code of Conduct to accompany the revision of the WANE(S) Act. Marine Scotland leads on the enforcement of the WANE(S) Act, and as part of this work convenes the marine NNS working group which coordinates activity and shares information across relevant departments, organisations and agencies.

412. Scottish Environment Protection Agency, 2015b
413. Holt and Cordingley, 2011
414. Williams *et al.*, 2010
415. Cook *et al.*, 2016
416. Wildlife and Natural Environment (Scotland) Act, 2011
417. The Scottish Government, 2012a
418. The Environmental Liability (Scotland) Regulations, 2009
419. Nature Conservation (Scotland) Act, 2004
420. European Commission Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)
421. European Commission, 2016f
422. Council Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species.
423. Natural Scotland, 2013
424. Cook *et al.*, 2014

NNS in the Clyde Marine Region

The CMR is heavily used by commercial and recreational marine traffic and is an important focus for UK and international commercial shipping routes. Other recreational activities such as sea angling, scuba diving, sea kayaking, personal watercraft (also known as jet ski), wind and kite surfing are also growing in popularity. These activities increase the movement of boats and equipment in and out of the Clyde and therefore increase the possibility of introducing and spreading NNS. The GB non-native species secretariat, supported by The Green Blue, has an awareness raising campaign, 'Check Clean Dry' which targets this sector.

The CMR is also strategically placed as a hub for NNS with the Crinan and Forth and Clyde Canals offering short cut routes to new sites for infestation. However, it is also thought that the canals may offer some biosecurity protection as salt water species do not thrive in freshwater environments and may be killed by prolonged immersion in the canal system.

The CMR is now known to have 10 marine NNS and the arrival of other species already present in England, Wales and/or Ireland is likely. SEPA track and report on (via WFD water body status reports) a number of important INNS which are present in the Clyde, including leathery sea squirt (*Styela clava*), colonial tunicate/carpet sea squirt (*Didemnum vexillum*), Chinese mitten crab, wireweed (*Sargassum muticum*) and common cord-grass (*Spartina anglica*). Also present in the Clyde are a bryozoan (*Tricelleria inopinata*), a hydroid (*Cordylophora caspia*), the acorn barnacle (*Elminius modestus*), an orange sheath tunicate (*Botrylloides violaceus*), green sea fingers (*Codium fragile fragile*), Japanese skeleton shrimp (*Caprella mutica*) and orange tipped sea squirt (*Corella eumyota*).

The Firth of Clyde Forum produced a Biosecurity Plan for the Clyde area in 2011.[425] The Biosecurity Plan provides a platform for local action to address the issue of INNS. The Plan has a lifespan of five years and as part of an adaptive management cycle its outcomes and impacts will be monitored, reviewed and incorporated into the Clyde Regional Marine Plan. The outcomes to date include a series of workshop style training events, a range of publications for public and industry use and engagement with Marine Scotland's marine NNS working group. The Biosecurity Plan was also the starting point for the development of the Marine Biosecurity Planning Guidance, which was published in 2015 and has now been adopted by the statutory agencies across the UK.

Under the WFD 2013, SEPA included an assessment of NNS in water bodies for the first time. Eighteen water bodies within the CMR have recorded the presence of NNS (termed Alien Species in line with European documentation) as indicated in table 5.15 over.[426] It should be noted that where no NNS are recorded, but confidence levels are recorded as 'low', this should not be taken as confirmation of absence; this was demonstrated in the Inner Clyde Estuary where the recent discovery of Chinese mitten crab shell had been preceded by several years of 'low' confidence ratings. This is likely to be indicative of the capacity (both time and expertise) to undertake extensive surveys which are expensive and difficult to undertake effectively. The 2015 WFD classification results do not show any change of classification due to NNS when compared to 2014.

To date, the impact of NNS and INNS in the CMR has not been as catastrophic as once feared. For example, wireweed was once thought of as a high impact species of great concern due to its vigorous growth potential and fast spreading nature and its ability to clog machinery, including propellers. Now widespread in the Clyde, the impacts on biodiversity have not been as extreme as anticipated. In the Clyde ecosystem wireweed seems to have fulfilled some ecosystem services and not created areas of monoculture or negatively affected local species. By comparison, the carpet sea squirt, which is a more recent invader to the Clyde, and was first found in the Largs Channel in the CMR in 2010,[427] has been shown to have a negative impact on species diversity and abundance on the Georges Bank, northeast US and in the Netherlands and is of significant concern and the cause of several water bodies failing to achieve GEcS in those countries.[428, 429]

Wireweed remains a species of high interest to biologists and the agencies tracking marine NNS, as it is a useful indicator species, acting to highlight areas which are at risk from new and potentially invasive species.

It should be noted that, whilst not specifically marine, Japanese knotweed (*Fallopia japonica*) is spread by the sea along the Clyde coastline. In addition, American mink (*Neovison vison*) habitat is often alongside water bodies, including coasts, and this species has had a detrimental impact on some ground nesting birds and water voles (*Arvicola amphibius*).[430]

In the latest River Basin Management Plan, SEPA[431] states that it will undertake a number of strategies with regard to management of NNS:

'During the period 2015 to 2027, we will continue the approach developed over the period 2009 to 2015:

- *We will take a zero tolerance approach to actions that could result in introductions of invasive species.*

425. Mills, 2012b
426. Scottish environment Protection Agency, h
427. Beveridge *et al.*, 2011
428. Lengyel, 2009
429. Gittenberger, 2007
430. GB non-native species secretariat
431. Scottish Environment Protection Agency 2015a

- *Police Scotland will work with other public bodies to ensure legislation banning or restricting the possession, sale and release into the wild of invasive non-native species is rigorously enforced.*
- *Public bodies and non-government organisations will continue to work together to raise awareness of how invasive species can spread and the steps businesses and the public need to take to minimise risks using biosecurity measures.*
- *This will include developing further biosecurity plans, where appropriate.*
- *Public bodies, voluntary organisations and other institutions will work together to carry out and coordinate the monitoring needed to give us early warning of the first appearance of new invasive species, including encouraging help from businesses and the public.*
- *Where there are early warnings of the appearance of new species, we will take such rapid action as is feasible and proportionate to destroy or contain the species concerned before they can become established.*

Table 5.15. SEPA 2013/14 Water Body Classification data sheet information[432]

Surface water bodies are classified using a system of five quality classes – *High*, *Good*, *Moderate*, *Poor* and *Bad*
Note that results for 2015 are available and there is no change for NNS from the 2014 results.

WATER BODY TYPE	SUB BASIN	WATER BODY	Overall water body status /Status of NNS in that WB / Confidence Level regarding NNS status /INNS Species Identified (2013)	Overall status water body/Status of NNS/ Confidence Level (2014)
TRANSITIONAL	CLYDE	Ayr Estuary	Good / High / Low	Good / High / Low
		Ballantrae Lagoon North	High / High / Low	High / High / Low
		Ballantrae Lagoon South	High / High / Low	High / High / Low
		Clyde Estuary- Inner (incl. Cart)	Moderate / High / Low	Moderate / High / Low
		Clyde Estuary- Outer	Moderate / High / Low leathery sea squirt, colonial tunicate/carpet sea squirt	Moderate / High / Low
		Gare Loch	Good / High / Low leathery sea squirt, colonial tunicate/carpet sea squirt	Good / High / Low
		Girvan Estuary	Good / High / Low	Good / High / Low
		Garnock/Irvine Estuary	Good / High / Low	Good / High / Low
		Stinchar Estuary	Good / High / Low	Good / High / Low
COASTAL	CLYDE	Ayr Bay	Good / High / Low	Good / High / Low
		Ballantrae	Good / High / Low	Good / High / Low
		Culzean	Good / High / High	Good / High / High
		East Arran	Moderate / Good / Low leathery sea squirt, colonial tunicate/ carpet sea squirt	*Moderate / Good / High*
		Firth of Clyde inner- Dunoon and Wemyss Bay	Good / High / High leathery sea squirt, colonial tunicate/carpet sea squirt	*Good / High / High*
		Firth of Clyde inner- Cumbraes	Good / High / High leathery sea squirt, colonial tunicate/carpet sea squirt	*Good / High / High*
		Firth of Clyde Middle (offshore)	Moderate / High / Low	Moderate / High / Low
		Firth of Clyde Outer (offshore)	Good / High / Low	Good / High / Low
		Girvan	Good / High / Low	Good / High / Low
		Holy Loch	Good / High / Low	Good / High / Low
		Irvine Bay	Moderate / High / Low leathery sea squirt, colonial tunicate/carpet sea squirt	Moderate / High / Low
		Kyles of Bute	Good / High / Low leathery sea squirt, colonial tunicate/carpet sea squirt	Good / High / Low

432. Scottish Environment Protection Agency, F

WATER BODY TYPE	SUB BASIN	WATER BODY	Overall water body status /Status of NNS in that WB / Confidence Level regarding NNS status /INNS Species Identified (2013)	Overall status water body/Status of NNS/ Confidence Level (2014)
COASTAL	CLYDE	Largs Channel (Fairlie Roads)	Good / Good / High leathery sea squirt, colonial tunicate/carpet sea squirt	Good / Good / High
		Loch Goil	Moderate / High / Low	Moderate / High / Low
		Loch Striven	Good / High / Low leathery sea squirt, colonial tunicate/carpet sea squirt	Good / High / Low
		Rothesay	Good / High / Low leathery sea squirt, colonial tunicate/carpet sea squirt	Good / High / Low
		Seamill and Ardrossan	Moderate / Good / High common cord-grass, colonial tunicate/carpet sea squirt	Moderate / Good / High
		Sound of Bute	Moderate / High / High leathery sea squirt	Moderate / High / High
		South Arran	Good / High / Low leathery sea squirt	Good / High / Low
		Loch Long North	Moderate / High / Low	Moderate / High / Low
		Loch Long South	Moderate / High / Low	Moderate / High / Low
		Loch Riddon	Good / High / Low leathery sea squirt	Good / High / Low
	ARGYLL AND LOCHABER	Campbeltown Loch	Good / High / High	Good / High / High
		Kilbrannan Sound	Good / High / High leathery sea squirt, colonial tunicate/carpet sea squirt	Good / High / High
		Loch Fyne Middle	Good / High / High leathery sea squirt	Good / High / High
		Loch Fyne Outer	Good / High / High leathery sea squirt, colonial tunicate/carpet sea squirt	Good / High / High
		Loch Fyne Upper	Good / Good / High leathery sea squirt	Good / Good / High
		Mull of Kintyre-South East	Good / Good / High	Good / Good / High

- *We will work with government administrations across the UK to ensure action is taken to reduce the risk of introductions via ship ballast water, in line with protocols established by the International Maritime Organization.*
- *We will continue to support further research aimed at developing effective eradication methods.'*

UK and EU measures

The UK Government and the devolved administrations take the issue of marine NNS seriously and various task forces and working groups exist at a policy level. The Scottish Government hosts the Marine NNS working group, a group of experts who meet regularly to discuss action and policy with regard to marine NNS.

At a UK level, the Marine Pathways project was undertaken by statutory and non-statutory organisations within the UK and Ireland and contributed to the delivery of the Non-Indigenous species descriptor of the Marine Strategy Framework Directive (MSFD). The overall aim of the project is to protect marine biodiversity in the UK and Ireland by managing key pathways by which marine INNS are introduced and spread. Formal funding for the project ended in April 2015, although, the steering group remains in place and strategic work continues.[433]

The GB Secretariat for Non-Native Species is the co-ordinating body for action and policy on terrestrial, aquatic and marine NNS and the 2015 strategy builds on the work of the 2008 strategy and covers the whole of the UK.[434]

433. Great Britain non-native Species Secretariat, c
434. Great Britain Non-native Species Secretariat, a

ECOSYSTEM SERVICES[435]		
SERVICE TYPE	**BENEFITS PROVIDED**	**COMMENTARY**
Provisioning	Food (fish and shellfish	INNS may reduce an ecosystem's provisioning ability. Carpet sea squirt is present in the CMR and could impact aquaculture installations; however, there is no evidence of this currently.
Regulating	Clean and Safe waters	INNS may impinge on an ecosystem's ability to self-regulate.
Cultural	Tourism & Recreation Wellbeing	INNS can reduce the amenity value of an area and can have significant economic impact on the businesses affected.
Supporting services underpin the provision of other services		INNS reduce native species' ability to fulfil their role in the ecosystem. However it has been observed that some NNS have fulfilled some ecosystem roles in their new range. There is concern that wireweed may impact full ecosystem functioning on intertidal rock and sediments in the CMR, however, there is no evidence of this currently.

435. Marine Climate Change Impacts Partnership, 2015a

6. Productive
ECONOMIC CONTRIBUTION, PRESSURES AND IMPACTS

6.1 Introduction

The Productive section of the assessment analyses key economic and spatial data concerning human activities and interactions within the Clyde Marine Region (CMR). The activity has been defined and broken down by sector and based on definitions outlined in Scotland's Marine Atlas (2011).[436] A detailed definition of each sector is presented within the individual chapters.

Each sector has been reviewed in terms of:

- economic contribution
- main activities and geographic distribution;
- socio-economic and environmental pressures and impact of human activity
- regional look forward which provides a qualitative analysis of future opportunities and challenges that will impact both the sector and the CMR.

Where data are available, a 10-year period has been considered from 2005, in order to identify historical trends and set the wider context. The economic contribution of the sectors (employment, turnover and Gross Value Added)[437] has been captured using Standard Industrial Classification (SIC) coding. The United Kingdom Standard Industrial Classification of Economic Activities (SIC) is used to classify businesses by the type of economic activity in which they are engaged, broken down by industrial sector.[438]



Energy production at Loch Striven © JOHN DONNELLY

436. Baxter *et al.*, 2011
437. Gross Value Added measures the contribution (goods and services) to the economy of individual producers, industry or sectors. This can be calculated by subtracting the intermediate consumption (considered as direct input costs and overheads) from the total output (value of sales).
438. Companies House, 2015

SCOTLAND'S MARINE ATLAS	CLYDE MARINE CHAPTER
Renewable Energy and Power Cables	Energy, Subsea Cables and Pipelines
Gas Storage	Energy, Subsea Cables and Pipelines
Waste Disposal - dredge disposal	Shipping and Transport
Telecommunication Cables	Energy, Subsea Cables and Pipelines
Coastal Protection and Flood Defence	Some aspects within Chapter 3.2 Climate change - Sea Level Rise and coastal flooding. All Clyde figures included in full in Scotland's Marine Atlas (pages 160 and 161).

Reporting structure

The sectors reviewed in the Productive section are based on the definitions set out in Scotland's Marine Atlas. However, it should be noted that the following sectors/chapters have been restructured as follows.

Sectors not included in the Productive assessment as there is no identified activity in the CMR are:

- Aggregates;
- Carbon Capture and Storage; and
- Oil and Gas production.

Sectors that have been included in the Productive Assessment but incorporated into other sector definitions are listed in the table above.

Pressures and Impacts of human activity

The use of the marine environment to generate economic activity has the potential to create wider positive and adverse impacts on both the socio-economic and environmental landscape within the CMR. The assessment contains a qualitative review of the potential pressures and impacts generated by human activity within each sector.

Please note that the assessment does not comment on the likelihood or scale of any (positive or negative) impact resulting from socio-economic or environmental pressures. This section of the assessment does not identify which of the pressures are of main concern – this will be developed through work with all stakeholders during the development of the Issues and Options Paper. However the Clean & Safe and Healthy and Biologically Diverse sections do give further indication of past and present human activities that are putting pressure on the environment.

The pressures and impacts are considered in terms of:

Socio-economic pressures and impacts – this relates to social and economic impacts, for example some sectors will be important for supporting rural communities and creating jobs, however, some sectoral activity might also conflict with other marine sectors. Socio-economic pressures and impacts are categorised as either having positive or negative effects.

Environmental pressures and impacts – this relates to the wider environmental impacts generated through human activity, for example, the impact on water quality. The approach to assessing the environmental pressures and impacts is based on categorising the broad pressure themes and then identifying specific impacts and challenges at the CMR level. Where there is monitoring, legislation or regulation in place to minimise any adverse impacts this is highlighted in the text. Environmental pressures have been classified by the following themes based on the JNCC Pressures-Activities matrix.[439]

Pressures contributing to climate change

Please note that many human activities contribute to climate change through emission of greenhouse gases such as CO_2. Every sector in the Productive section contributes to some degree and therefore this pressure has not been included within each chapter. For a full range of impacts from climate change see Chapters 3.1 and 3.2. Wherever there are initiatives to mitigate climate change by reducing emissions this has been included in the relevant sectoral chapter.

439. Joint Nature Conservation Committee, 2016a

Table 6.1 Environmental pressures and impacts

PRESSURE THEME	PRESSURES	EXAMPLE IMPACT
Hydrological	• temperature change • salinity change • water flow/wave exposure change	Water abstraction for power stations returns water to the sea at a slightly higher temperature which could increase water temperature locally.
Pollution and chemical	• introduction of hazardous substances • radionuclide contamination • de-oxygenation • nutrient enrichment • organic enrichment	Food and faecal material gathering on the sediments beneath fish farms may result in the de-oxygenation and organic enrichment of the local seabed.
Habitat change	• habitat damage • habitat loss • siltation rate change	Mobile fishing gear (trawl and dredge) may damage or destroy sensitive seabed habitats.
Other physical	• litter • electromagnetic changes • underwater noise • barrier to species movement • death or injury by collision	Recreational and fishing activities can introduce litter (plastic, polystyrene, rubber, metal and glass) to the marine environment. Wildlife may become entangled in or ingest the litter.
Biological	• visual disturbance • genetic modification • introductions of INNS • introduction of microbial pathogens • removal of species (target and non-target) at unsustainable levels	Human activity has introduced the carpet sea-squirt (*Didemnum vexillum*) Non-Native Species to the CMR. This species may become invasive at some point in the future causing smothering impacts for the environment but also for the aquaculture sector.

Regional Look Forward

While a review of historical trends helps set the 'baseline' and wider context, there is also value in considering the future opportunities and challenges for the region. For example, the growth prospects of marine sectors, proposed infrastructure developments (harbour/port expansions, bridges, or other civil engineering projects at, in or over the water), and any potential changes in legislation that could impact activity, for example fishing quotas or CO_2 output limits, can usefully be considered.

The regional look forward will be more qualitative in nature, informed by forecast data and consultation with stakeholders from the Clyde Marine Planning Partnership.[440]

Study approach

The Productive assessment has been informed via two main work streams:

- desk-based and Online research of relevant data, statistics, journals, and reports.
- consultation with stakeholder organisations.

Geographic scope and mapping

The CMR extends from the normal tidal limit of the River Clyde in Glasgow City centre, seawards to the outer firth in Argyll and Ayrshire. It includes the Mull of Kintyre, the Clyde's sea lochs, and the islands of Arran, Bute and the Cumbraes. Where data are available, the Productive assessment measures activity based on this boundary, for example, the value and tonnage of fish landed in the Clyde.

However, a proportion of both the core and supporting marine sector activity is derived from land based activity, for example, fish/shellfish processing, boat repair and tourism operators. It is therefore important that we identify and measure this land based activity to highlight the wider linkages and impacts generated by the CMR and capture the true value of activity. In addition to the CMR boundary, the Productive section of the Assessment (where appropriate) reports against two further land based geographic boundaries.

440. Clyde Marine Planning Partnership, 2016

Clyde Marine Region – this is based on an assessment of coastal communities that are likely to be directly impacted by activity within the Clyde. The geographic boundary has been defined using Census Area Statistics (CAS) Ward 2003 and Multi-member Ward 2007 data for those wards that are considered to be coastal or close to the coast – see Appendix III.

Wider Clyde Marine Region – sector based economic data (turnover and Gross Value Added (GVA)) is only available at planning authority level. There are nine Planning Authorities (including Loch Lomond and The Trossachs National Park) with responsibility for future planning and development activity within the CMR. The geographic boundary has been defined using current Local Authority boundaries (Local Government Boundary Commission for Scotland). For most Local Authorities the entire coastline sits within the CMR. For Argyll and Bute, however, data at the wider CMR level includes all data for Argyll and Bute, including the west coast from the southern tip of Mull of Kintyre up to north of Oban and including Mull, Coll and Tiree (map 20), which are outwith the CMR. Figures for turnover and GVA will therefore be inflated at the wider CMR level and cannot be directly compared with other data.

Scotland – to compare and benchmark activity.

Data sources and limitations

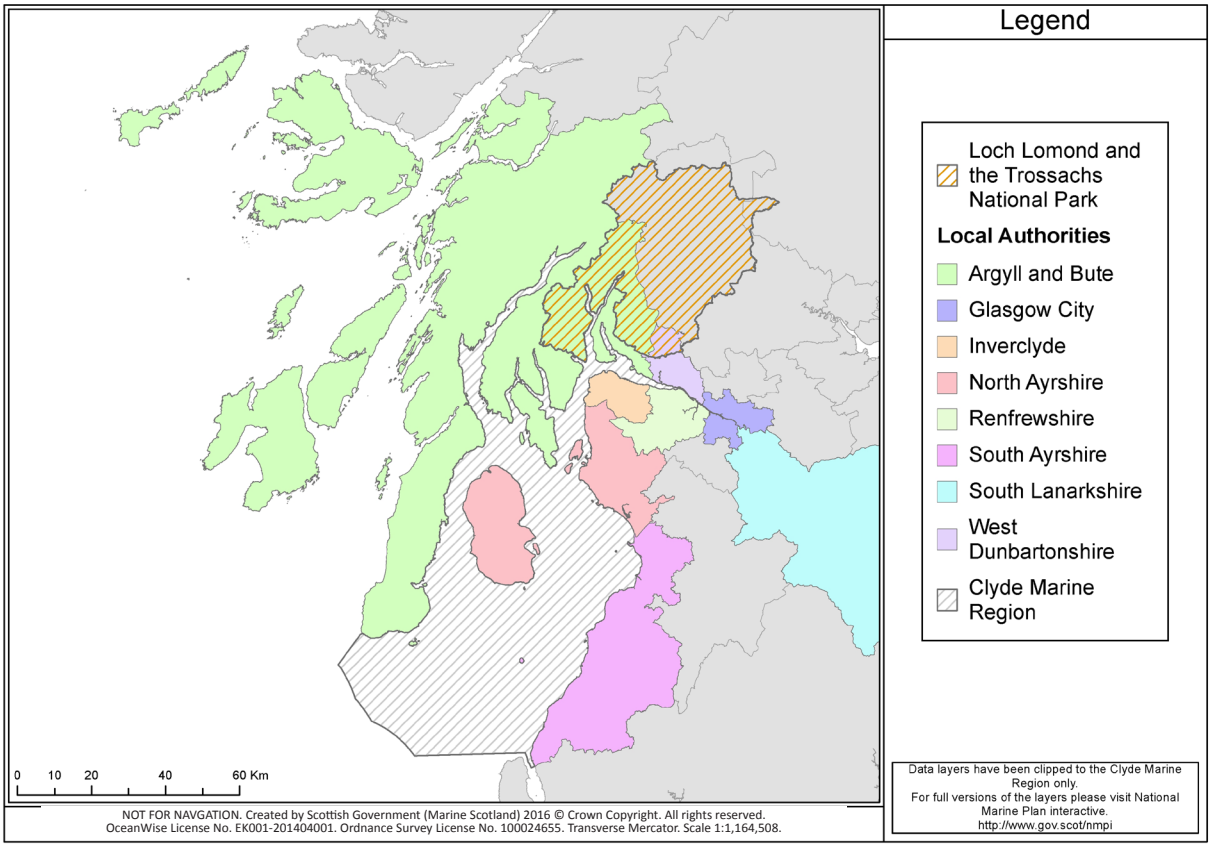
References used within the Productive section are included in the reference list and sources are indicated under the relevant figure where applicable. However, it is important to note that there are a number of challenges when gathering and analysing data at the regional level. These can be categorised as:

Availability of data – there are numerous sources of rich economic, sectoral and wider data that can be utilised within this Assessment. However, these data sources are all subject to discrepancies with regards publication, in particular, the frequency of publication (monthly/quarterly/annually, and by time of year), geographic disaggregation, and data suppression. Where data allows, the format and reporting against the individual sectors is consistent throughout this section.

Geographic disaggregation – the CMR covers a fairly large geographic area that is not based on 'traditional reporting boundaries'. As a result, for some sectors and indicators we have adopted a 'best fit' approach.

Data suppression – publicly available data that could potentially identify individuals or businesses cannot be disclosed due to commercial confidentiality. Therefore, at lower geographic and sectoral levels, there will often be data that is not disclosed. Please note that when analysing trend data, supressed data are included to calculate the overall change.

Map 20. Wider Clyde Marine Region



6.2 Sea fisheries

Summary

Sea fisheries include all commercial fishing activity within inshore waters including trawling, dredging, pots/creeling and diving. Historically, the Clyde Marine Region (CMR) was renowned for its herring fishery. However, stocks collapsed by the mid-1980s, probably due to a decline in spawning stock, high fishing mortality and lack of recruitment to the spring-spawning stock.[441] Other fisheries for cod, hake, saithe and plaice have also been important from the 1960s. However, stocks have now declined such that these fisheries are no longer currently commercially viable, with a resulting decline in an economic contribution from these stocks.

The majority of commercial activity within the Clyde is undertaken by smaller vessels under 15m and is now focused on the trawl and creel fishery for *Nephrops*, also known as prawns, langoustine, scampi or Dublin Bay Prawn, taking up 83% of total weight and 85% of total value in 2014. Quotas for this fishery are managed by Marine Scotland, based on the Directives set out in the EU Common Fisheries Policy (CFP) and scientific advice provided by the International Council for the Exploration of the Sea (ICES). King scallops, and now rarely queen scallops are also taken, mainly by dredging vessels.

The quotas imposed for prawns have fluctuated within the CMR over recent years in order to manage and protect stocks of this species. Landings have also fluctuated, although not directly in line with quota.

The economic contribution of the fisheries sector in the CMR has been decreasing over a number of years; both the annual landings and the value of fish has seen a decline from a high of £17.2m and 7,723 tonnes in 2012 to £14.8m and 5,742 tonnes in 2014. That being said, the sector remains important for supporting both direct and supply chain employment, in particular within the more rural communities, for example, the Kintyre Peninsula.



Tarbert harbour © CLAIRE PESCOD

Table 6.2 Marine fishing change in activity, 2010–2014

INDICATOR	CHANGE
WIDER CLYDE MARINE REGION	
Turnover*	+14%
GVA*	-18%
CLYDE MARINE REGION	
Employment	+24%
Tonnage	-12%
Value of landings	+12%
Effort (kW days)	+6%

* 2009 to 2013 and adjusted to 2013 prices

Defining the sector

The economic contribution of the sea fisheries sector is measured through the following SIC codes; 03.11: Marine Fishing.

A summary of the changes across economic indicators (2010 to 2014) is presented in table 6.2. For fish processing activities, see Chapter 6.4 Processing – Fisheries and Aquaculture. It should be noted that this chapter has not been able to include supply chain economic data as this is not captured within SIC code classification. Research by the Fraser of Allander Institute[442] estimated the number of supply chain jobs for the fishery sector and resultant multipliers. It concluded that for creel fisheries for every 1 job on a vessel there would be 0.25 other jobs in processing and supply of services and materials. For demersal (trawl) fisheries this increases to 1.1 other jobs (as the catch is more likely to be processed prior to sale).

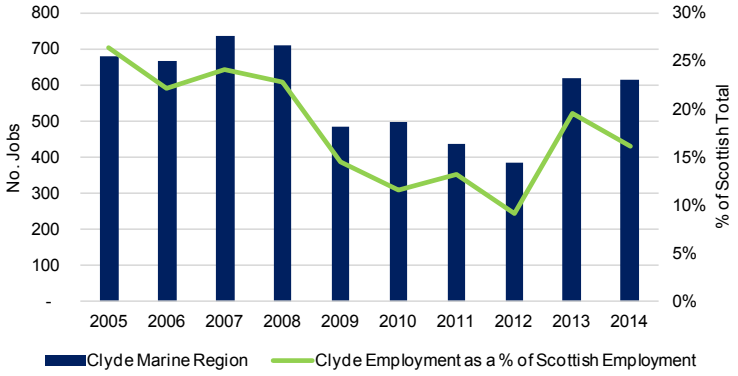
441. Bailey *et al*., 1986
442. Fraser of Allander Institute for research on the Scottish Economy, 2002

6.2.1 Contribution to the Economy

Employment

Across the CMR, there are approximately 600 people working in the fishing sector in 2014, of which 84% are 'full time', see figure 6.1.

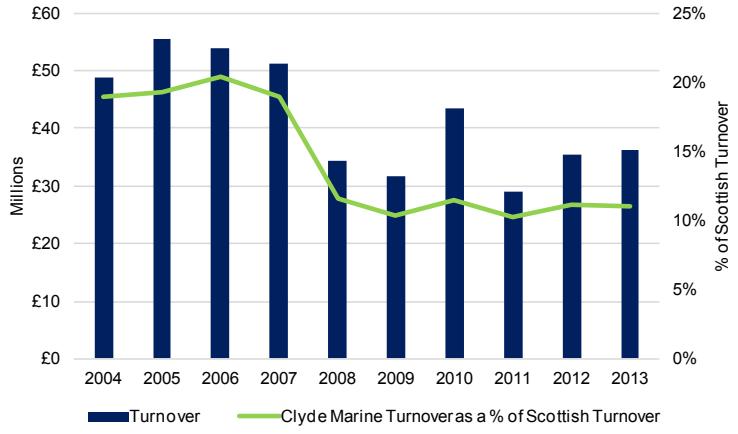
Figure 6.1 Clyde Marine Region: Fishing employment, 2005–2014



* 2009 to 2013 and adjusted to 2013 prices

Fishing employment has fluctuated over the past ten years from a high of 734 in 2007 and a low of 383 in 2012. Over the last five years, the sector has experienced an increase in jobs of +24%, while at the national level there has been a fall of -11%. Total Scottish employment in the fisheries sector in 2014 was 3,820 jobs, of which, activity in the CMR accounted for 16%.

Figure 6.2 Wider Clyde Marine Region: Fishing turnover, 2004–2013



Source: Annual Business Survey (ABS). Adjusted to 2013 prices. Note: these figures include all of Argyll and Bute local authority area.

The bulk of fishing employment (+90%) is located in South Ayrshire and Argyll and Bute, with the remaining local authority areas contributing very small levels of fishing employment. Location Quotients (LQ) provide information on the representation of marine industry sectors in the Clyde in comparison with Scotland. The LQ compares the industry's share of regional employment with its share of national employment; an LQ greater that one indicates a greater concentration of sector employment than in Scotland as a whole, whilst an LQ lower than one indicates a lesser concentration.

As much of the CMR has no, or very low fishing employment, the overall LQ for the area is low, at 0.26. However, many small rural communities still rely on the fishing sector as a major source of employment, with fishing operations and vessels often being family concerns. The LQ data for the more rural local authority areas (Argyll and Bute and South Ayrshire) show that both have LQs greater than one, indicating a greater reliance on the sector (table 6.3).

Table 6.3 Sea fisheries Location Quotient, 2014

AREA	LOCATION QUOTIENT
Argyll & Bute	1.77
South Ayrshire	1.29
Renfrewshire	0.13
Inverclyde	0.09
North Ayrshire	0.02
Glasgow	0.01
South Lanarkshire	0.00
West Dunbartonshire	0.00
Clyde Marine Region	**0.26**

A report by the Argyll and Bute Economic Forum[443] recognised that whilst a small proportion of total employment (4%) is in the traditional sectors of agriculture, forestry and fisheries, these have obvious rural and local importance.

Economic output – turnover and GVA

Both Turnover and GVA have exhibited a similar trend, with a fall in overall terms and as a share of Scotland around 2007. Since then Turnover has been on a gradual upwards trajectory, whilst GVA has trended down (figures 6.2 and 6.3).

Reviewing the GVA to turnover ratio provides an insight into the relative levels of productivity within the sector. Across the CMR, performance has been similar to that in Scotland, with a general trend towards lower levels of productivity since 2009,

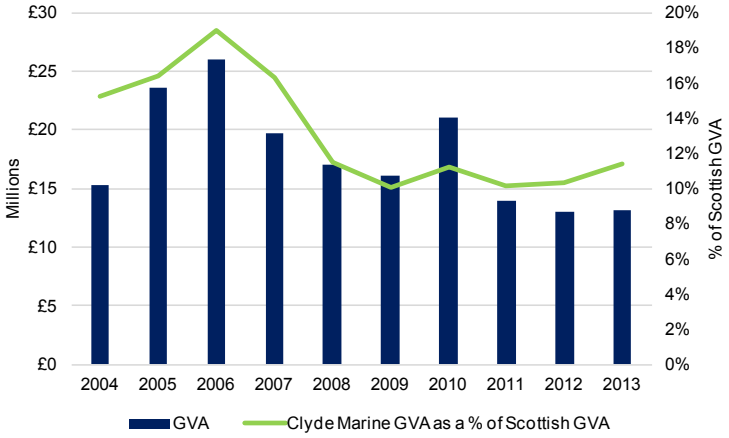
443. Argyll and Bute Economic Forum, 2016

i.e. input costs have increased at a disproportionate rate than revenue. This is likely to be driven by increases to fuel costs over the period (figure 6.7).

Sea fisheries activity

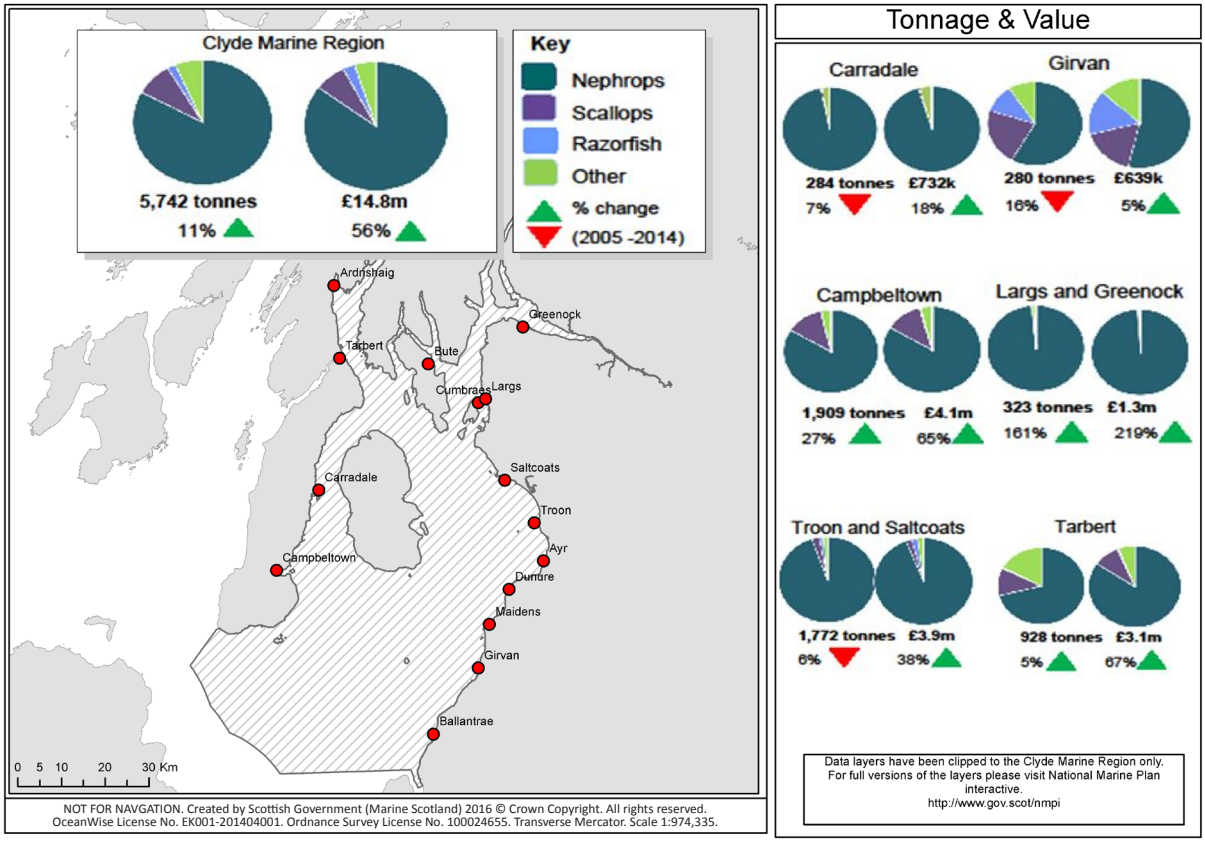
There are 14 landing sites within the CMR, however, due to low tonnage/value landed in the smaller ports, data cannot be published for reasons of commercial confidentiality.[444] Landings data are presented for the six top landing sites (map 21). Tables 6.4 and 6.5 show the annual value and tonnage landed since 2005, broken down by species. A total of 5,742 Tonnes of sea fish and shellfish was landed in 2014. Almost the entire amount (99.6%) was shellfish, with *Nephrops* by far the most important species, accounting for 83% of total landings. Table 6.3 shows the landings by selected species of shellfish, fish and total tonnage of landings. Data for individual demersal and pelagic species are not shown due to data suppression. Reviewing the landings data by value gives a similar picture, underlining the region's reliance upon *Nephrops*, as it accounts for £12.6m (85%) of the total £14.8m value of landings (table 6.4). It should be noted that the increase in razor fish landings since 2006 is believed to be due to the increase in the use of electrofishing which is currenty illegal.[445]

Figure 6.3 Wider Clyde Marine Region: Fishing GVA, 2004–2013



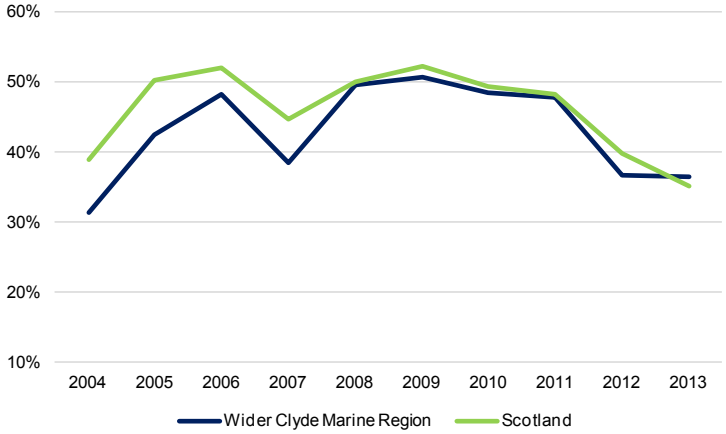
Source: ABS. Adjusted to 2013 prices. Note: these figures include all of Argyll and Bute local authority area.

Map 21. Tonnage and value of landings at ports in the Clyde Marine Region, 2014



444. Data are subject to suppression in datasets to prevent identification of individual enterprises
445. Breen *et al*., 2011

Figure 6.4 Marine Fishing GVA to turnover ratio, 2004–2013



Source: ABS. Adjusted to 2013 prices.

Across Scotland, overall landings are down 12% (from 2010), with the biggest absolute decline in shellfish (-13,000 tonnes). Despite this decline in landings, values have risen due to the rising price of fish. As a percentage of the total landings, the CMR is not a big player in the Scottish fishing industry, accounting for 2% of the tonnage and 3% of the value in 2014.

That being said, the Clyde accounts for 11% of all shellfish in Scotland (by weight) and within this, almost a quarter (24%) of the total Nephrops landed in Scotland, this highlighting the importance of this species to the Clyde.

Table 6.4 Clyde Marine Region: Tonnage landed by selected species, 2005–2014

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	CHANGE SINCE 2010	% CHANGE SINCE 2010
Nephrops	2,990	4,123	5,858	4,998	3,993	4,913	5,425	5,476	4,557	4,768	-146	-3%
Scallops	635	512	646	735	795	551	464	745	781	497	-55	-10%
Razor Fish	109	66	91	74	167	100	188	339	389	112	+12	+12%
Crabs-Brown (Edible)	35	86	88	88	36	44	82	116	92	111	+67	+154%
Crabs-Velvet (Swim)	127	51	40	78	76	56	104	92	54	84	+28	+50%
Whelks	60	91	3	8	8	3	0	17	18	55	+52	-
Scallops-Queen	699	495	15	56	676	714	480	462	64	52	-662	-93%
Lobsters	8	12	11	13	12	14	19	17	16	40	+26	+186%
Shellfish Total	4,675	5,451	6,763	6,065	5,772	6,401	6,774	7,268	5,975	5,722	-1,679	-11%
Demersal Total	511	578	349	119	17	91	19	9	9	5	-86	-95%
Pelagic Total	-	-	165	54	269	49	92	446	77	15	-34	-69%
Total	**5,186**	**6,030**	**7,277**	**6,239**	**6,059**	**6,540**	**6,886**	**7,723**	**6,061**	**5,742**	**-798**	**-12%**

Source: Marine Scotland

Table 6.5 Clyde Marine Region: Value landed by species, 2005–2014

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	CHANGE SINCE 2010	% CHANGE SINCE 2010
Nephrops	£6.7m	£9.9m	£13.3m	£11.7m	£9.1m	£11.2m	£13.4m	£14.3m	£11.9m	£12.6m	+£1.4m	+13%
Scallops	£1.1m	£1m	£1.3m	£1.4m	£1.4m	£962k	£958k	£1.4m	£1.9m	£1.1m	+£96k	10%
Razor Fish	£280k	£178k	£254k	£210k	£378k	£268k	£523k	£969k	£1.2m	£404k	+£137k	+51%
Brown Crabs	£41k	£89k	£93k	£87k	£37k	£48k	£33k	£48k	£46k	£86k	+£38k	+78%
Velvet Crab	£206k	£87k	£69k	£140k	£143k	£82k	£144k	£138k	£91k	£155k	+£74k	+90%
Whelks	£32k	£36k	£*	£*	£*	£*	£*	£11k	£11k	£47k	+£45k	-
Queen Scallops	£331k	£266k	£*k	£23k	£250k	£271k	£195k	£189k	£29k	£26k	-£245k	-91%
Lobsters	£78k	£128k	£119k	£139k	£126k	£139k	£174k	£160k	£149k	£379k	+£240k	+172%
Shellfish Total	£8.7m	£11.7m	£15.2m	£13.7m	£11.4m	£12m	£15.4m	£17.2m	£15.3m	£14.8m	+£2.8m	+20%
Demersal Total	£738k	£879k	£502k	£120k	£17k	£214k	£28k	£14k	£10k	£*	-	n/a
Pelagic Total	£*	£*	£28k	£15k	£72k	£21k	£50k	£111k	£17k	£*	-	n/a
Total	**£9.5m**	**£12.6m**	**£15.8m**	**£13.9m**	**£11.5m**	**£13.2m**	**£15.5m**	**£17.3m**	**£15.4m**	**£14.8m**	**+£1.6m**	**+12%**

Source: Marine Scotland Note: Values below £10,000 are suppressed

Figure 6.5 shows the intensity of fishing activity for otter trawls, beam trawls and boat dredges within the OSPAR area which includes the CMR. The map highlights the CMR as one of the most intensively fished zones within the area, and this also highlights the importance of the CMR to the inshore fishing industry.

Different types of fishery operate within the Clyde including trawl, *Nephrops* trawl, dredge, creel and hand diving. The table below presents the relative importance of fisheries for *Nephrops* and scallops by value for different distances from the shore within the whole of the South West Inshore Fisheries Group area.

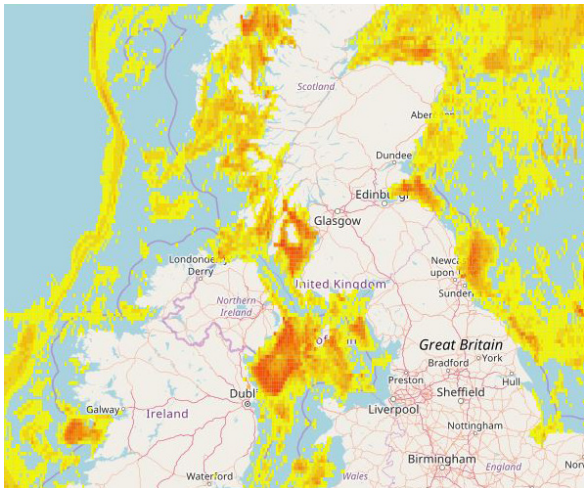
Table 6.6 Percentage value of catch by gear type and distance from shore for *Nephrops* and scallops for the South West Inshore Fisheries Group area

ZONE	*NEPHROPS*		SCALLOPS	
	TRAWL	CREEL	DREDGE	HAND DIVE & CREEL
0-1NM	54%	46%	67%	33%
0-3NM	63%	37%	75%	25%
0-6NM	67%	33%	76%	24%
0-12NM	69%	31%	81%	19%

Source: Marine Scotland Science, 2014

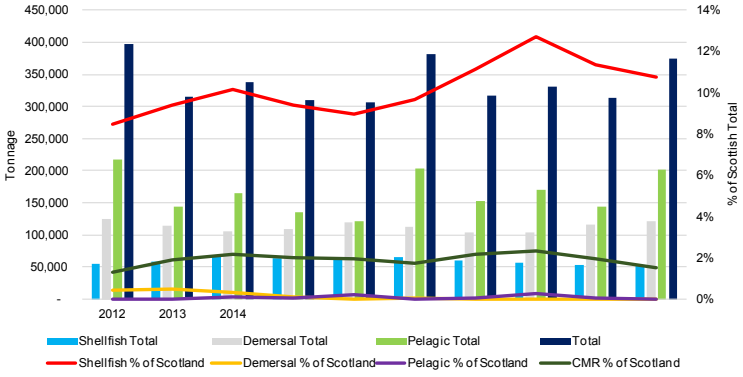
Nephrops landed in Scotland (table 6.6) are sold on the domestic and overseas markets and are available in whole form or as tails. Whole *Nephrops* can be fresh, frozen or live and are mostly exported overseas. The main export markets for *Nephrops* are Italy, Spain and France.[446] In 2015 the level and value of all exports from Scotland were down on the previous year, and the value of *Nephrops* exports decreased by c. £10m for the year between June 2014 and 2015. This was due in part to the strength of the Pound against the Euro.[447] Export data are limited in both type of good and geography. Data are available for the export of shellfish[448] at the Scottish level. This includes shellfish from both commercial fishing and aquaculture (table 6.7).

Figure 6.5 ICES/OSPAR mapping of bottom fishing intensity using VMS data in the OSPAR area, including the CMR



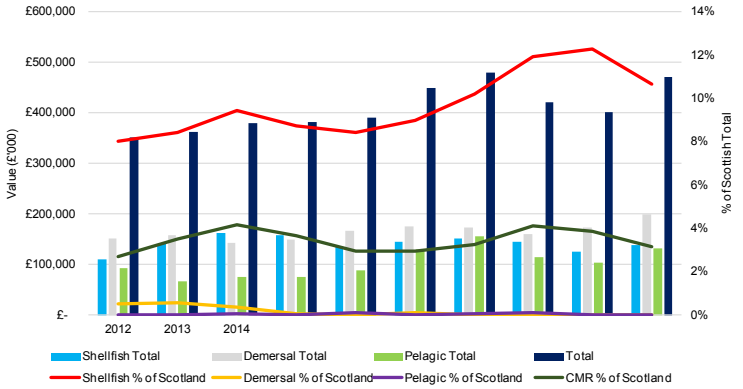
Source: ICES Special request, Advice September 2014 Version 2, 26-09-2014

Figure 6.6 Tonnage Landed: Scotland and Clyde Marine Region as a percentage of Scotland, 2005–2014



Source: Marine Scotland

Figure 6.7 Value: Scotland and Clyde Marine Region as a percentage of Scotland, 2005–2014



Source: Marine Scotland

446. Natural Scotland, 2006
447. Marine Scotland, 2015
448. Defined as 'Crustaceans, molluscs and aquatic invertebrates, whether in shell or not, fresh (live or dead), chilled, frozen, dried, salted or in brine; crustaceans, in shell, cooked by steaming or boiling in water, whether or not chilled, frozen, dried, salted or in brine; flours, meals and pellets of crustaceans, fit for human consumption.'

Table 6.7 Shellfish exports as a percentage of total production (Tonnes)

YEAR	FISHING	AQUACULTURE	TOTAL	EXPORTS	% EXPORTED
2010	66,225	7,486	73,711	34,889	47%
2011	60,792	7,286	68,079	31,676	47%
2012	57,218	6,527	63,745	27,593	43%
2013	52,718	6,936	59,654	25,941	43%
2014	53,142	7,981	61,123	25,856	42%

Source: Marine Scotland, HMRC

It is difficult to estimate the total amount of shellfish exported from the CMR from these figures, as they represent the whole of Scotland, however it would be reasonable to assume that at least the Scottish level, and likely more, as anecdotal evidence indicates that a large proportion of *Nephrops* are exported outside of Scotland.

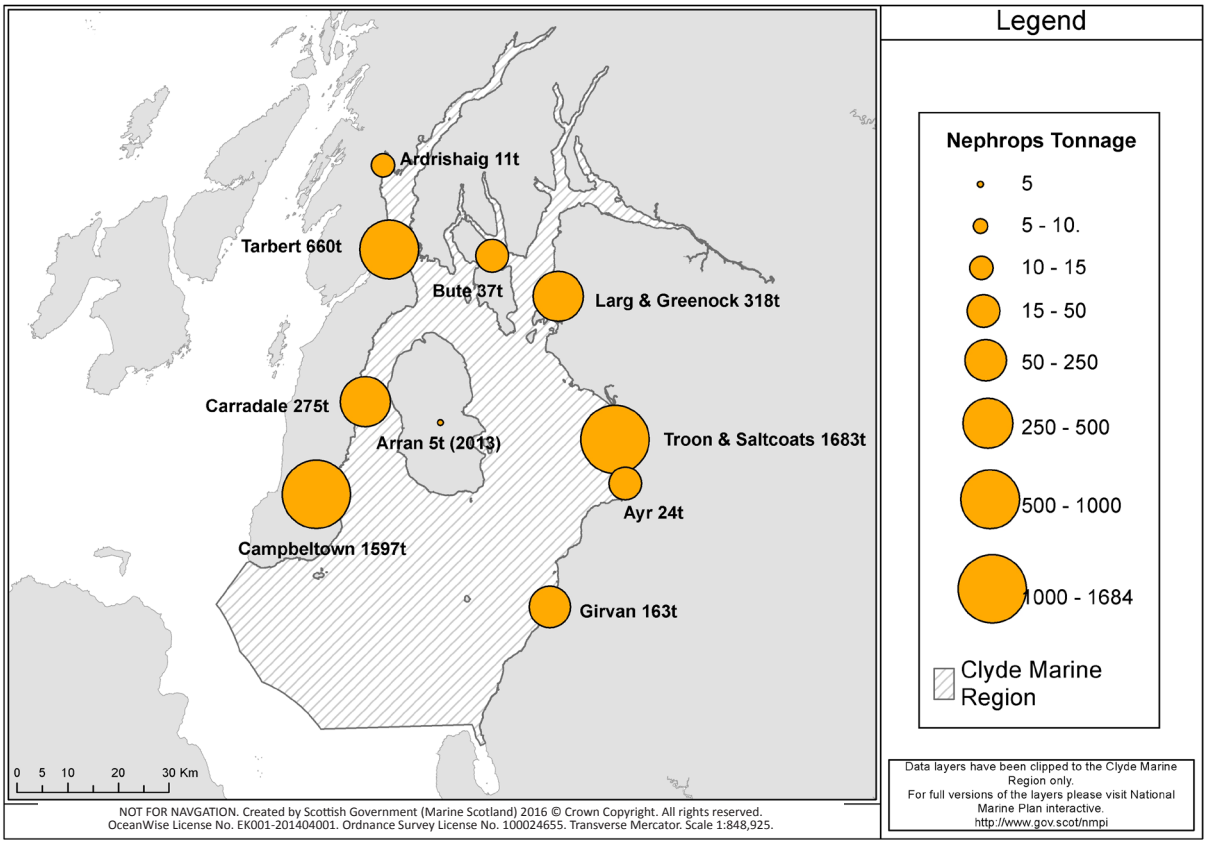
Map 22 presents a breakdown of the main landing ports for *Nephrops* and shows that Troon and Saltcoats, and Campbeltown are where the bulk of the landings occur (accounting for 76% of total landings).

Figure 6.8 outlines the quota for *Nephrops* in the West of Scotland, relative to total landings.[449] It is notable that landings have been under quota in all of the last five years. Prior to 2010, where data are only available for UK quota in West of Scotland waters, the uptake ranges between 61% and 83% from 2005 to 2010. This suggests that there is potential to increase *Nephrops* landings in the CMR, particularly when comparing uptake rates of other species such as cod, haddock and herring, which are close to 100% every year.[450] In 2014 total landings were around 2,000 tonnes lower than the quota and the value of quota not taken up is estimated at £5m.[451]

There are 188 fishing boats currently registered in the CMR, down -7% from 2005, but up +3% since 2010, with the majority of vessels registered to ports in Argyll and Bute and South Ayrshire, see Figures 6.9 and 6.10. It is worth noting that not all will be active and some will also operate outside the CMR.

However, those registered in the CMR are not the only boats which land fish in CMR ports. An additional 135 boats land in the region but are not registered in the area and this provides a further

Map 22. Main ports for *Nephrops* landings, 2014



449. Data for quotas unavailable at Clyde Marine Region level.
450. Munro and Wallace, 2015
451. Based on an average price of £2,600 per tonne of *Nephrops* – 2014 data.

boost to the supply chain e.g. processors.[452] Most boats that fish in the region are registered in Scotland; however, a significant minority (18%) of boats landing in the CMR are registered in Northern Ireland (table 6.10).

Table 6.8 Country of registration of boats landing in Clyde Marine Region

COUNTRY REGISTERED	NO OF BOATS LANDING	% OF TOTAL
Scotland	246	76%
Northern Ireland	59	18%
Isle of Man	9	3%
England	7	2%
Wales	1	0.3%
Jersey	1	0.3%
Total	**323**	**100%**

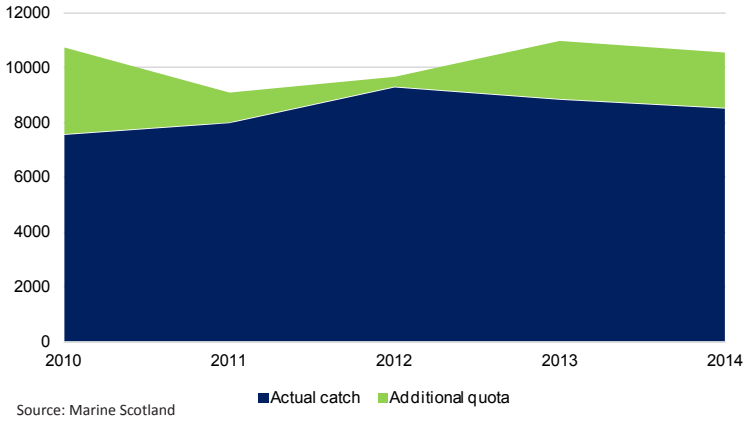
Source: Marine Scotland

Note that there is no CMR specific data available for vessels that fish in the Clyde but land outwith the region. However, anecdotally, there are boats that do land fish caught in the Clyde in other ports and the value and economic impact of this is therefore spread outside the region.

Kilowatt (kW) effort days are based on the power of a vessel's engine and helps determine the fishing capacity of the fleet as per EU regulations (figure 6.11).

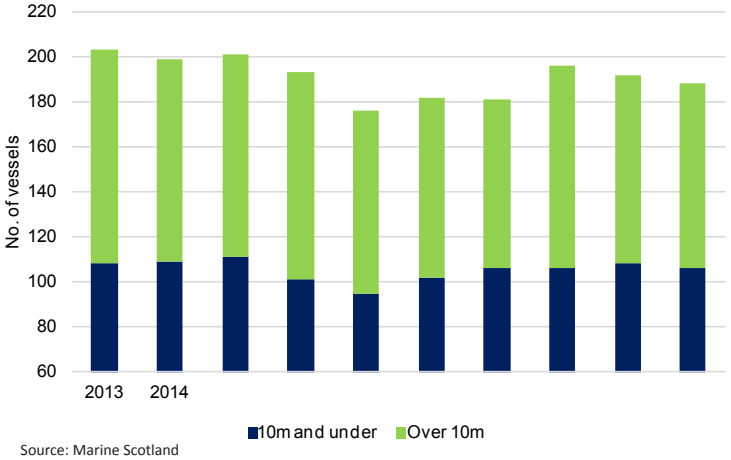
The overall pattern of effort correlates with the changing make-up of the fishing fleet which has increased overall, as has the number of vessels +10m (larger vessels requiring more powerful engines). The tonnage caught has also increased over the same period.

Figure 6.8 *Nephrops* quota and landings in west of Scotland



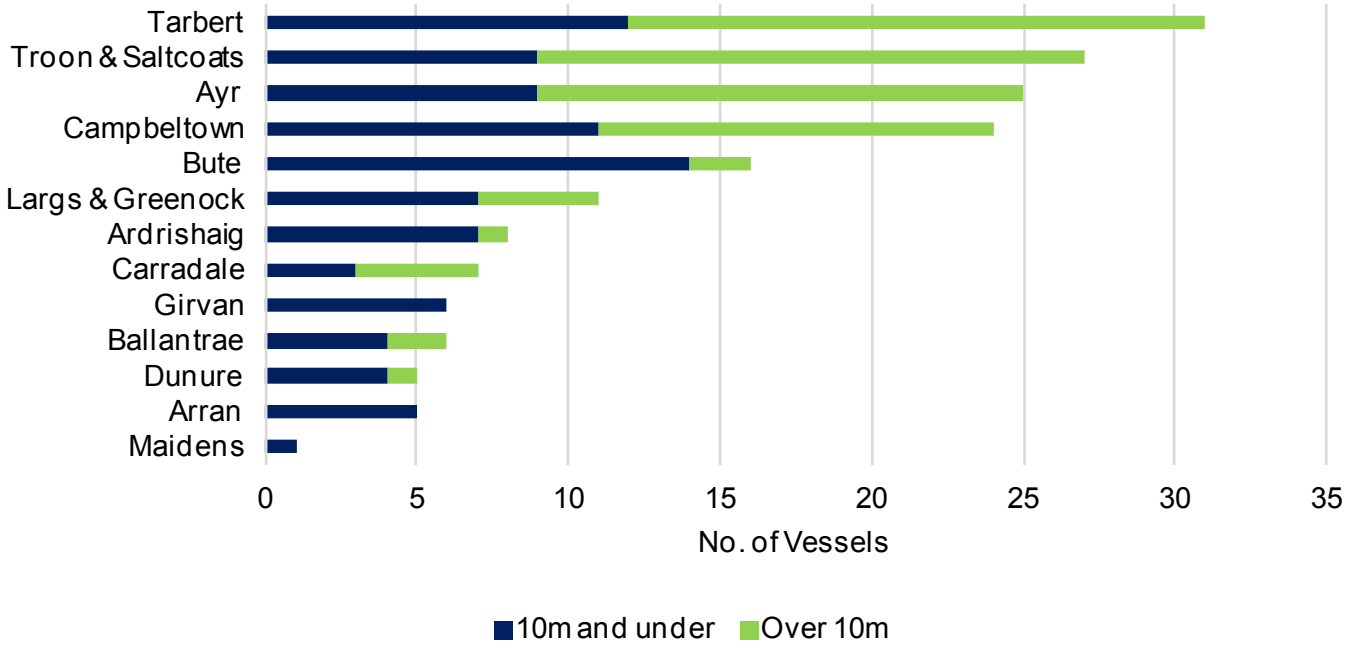
Source: Marine Scotland

Figure 6.9 Total number of vessels registered in the Clyde Marine Region, 2005–2014



Source: Marine Scotland
Note: vessels can be registered at the port/harbour that is nearest to their agent's office – not necessarily where they operate.

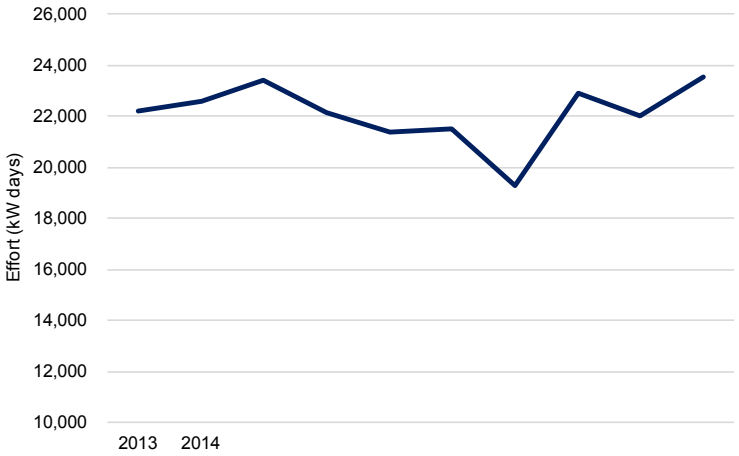
Figure 6.10 Number of vessels by port in the Clyde Marine Region, 2014



Source: Marine Scotland, Note: Data supressed, rounded to nearest whole number

452. Marine Scotland Data Request

Figure 6.11 Effort (kW Days) Clyde Marine Region, 2005–2014



Source: Marine Scotland
Note: Data for some ports supressed – underrepresents total effort kW days



Tarbet harbour © CLAIRE PESCOD

6.2.2 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of human activity in the fisheries sector is provided below.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Contributes to key sector growth - food and drink • Driver for export activity – majority of *Nephrops* are exported to Europe (France, Spain, Italy) • Supports rural communities - retaining jobs and wages • Important supply chain links e.g. processing and distribution	• Spatial conflict with other sectors e.g. energy, leisure moorings, aquaculture and recreational angling • Removal of species historically targeted by the angling sector • Conflict within the sector between mobile and static gear fisheries. This is considered to be a major issue in some areas and has been the subject of a consultation by the Scottish Government • Declining employment and the age profile of the workforce raises questions about the sustainability of the sector; proposals to develop a fisheries training centre is being developed by the Argyll and Bute and South Ayrshire Fisheries Local Action Group (FLAG)

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Habitat change	Habitat damage and loss	A 2012 study[453] found that trawling for *Nephrops* in the Clyde has *"reduced overall habitat and community diversity, suggesting that trawling had already reduced habitat complexity in the Clyde area" and dredging "can change the granulometric properties of the substrate, potentially altering its suitability for settlement for larval animals" and it also "reduces benthic community complexity and reduces heterogeneity between previously different habitats"*.
Other physical	Litter: discarded gear, particularly static	Fishing can be a source of marine litter. Ghost fishing can occur where species are trapped in the discarded pots and creels or entangled in lines. There is little information on the impact of discarded nets and creel pots. However, within the Clyde region, the impacts are thought to be minimal.[454] For example, most fish species have been shown to escape from lost or discarded creel pots.[455] Fishing For Litter Scotland is a project designed to reduce the amount of marine litter in the seas by removing it and to promote waste management amongst the fleet. Across Scotland there are 15 harbours currently participating and providing cost free landing facilities for marine litter from fishing vessels, including Tarbert, Rothesay, and Campbeltown in the Clyde region.[456]
Biological	Removal of target and non-target species	Historic patterns of fishing in the Clyde have contributed to a change in the diversity, abundance, and age and size profile of individual species, to the point that there are no commercially exploitable stocks of demersal and pelagic fish.[457] Simplified ecosystems can be more vulnerable to disease and the effects of eutrophication and climate change.[458] In the Firth of Clyde and Sound of Jura, discards of undersized and poor quality *Nephrops* were estimated by ICES to be 20.2% from 2011-13, with survival rates of 25%.[459] The west of Scotland *Nephrops* fishery has fairly high discard rates for whiting, haddock and cod despite the introduction of trawl-design improvements such as square mesh panels and increased mesh size.[460, 461] In 2002, an analysis of the total weight of discards in the Clyde region (including all non-fish species) by the *Nephrops* fleet concluded that on average there were 9kg of discards per 1kg of Nephrops. In the south of the CMR there were higher catches of *Nephrops* and fish, whereas in the north there were more invertebrates.[462]

6.2.3 Regional Look Forward

Direct employment in fisheries is somewhat modest; however the importance of the sector for supporting the rural communities within the Clyde should not be understated. Continued affordable access for fishing boats to ports, harbours, and other port side infrastructure is identified as important to support the sustainability of the sector.[463] There is little meaningful data on the future growth of fishing in the CMR. However, there are a number of external pressures that will play a significant role in shaping its future.

1. The health of fish stocks

This will dictate activity in the sector. Years of over-fishing has meant that the structure of the main target species in the Clyde has been altered, with many species too small to land. The Clyde is considered to be *'markedly deficient in large commercially marketable individuals'*.[464] That being said, the same study also found that there is a large and healthy population of *Nephrops* living on the sea bed and this is very likely to continue to be the main source of fishing activity within the Clyde.

453. Ryan and Bailey, 2012
454. McIntyre *et al.*, 2012
455. Ryan and Bailey, 2012
456. Fishing for litter
457. McIntyre *et al.*, 2012
458. Howarth *et al.*, 2013
459. Seafish, 2014
460. Williams and Carpenter, 2016
461. Fernandes *et al.*, 2011
462. Bergmann *et al.*, 2002
463. Ross *et al.*, 2009
464. Heath and Speirs, 2011

2. Fisheries management

It will be important to safeguard future viability of the *Nephrops* fishery through setting quotas and licensing. Currently, fisheries management in the Clyde is guided by the Clyde Inshore Fisheries Group (IFG) Management Plan (2012).[465] The West Coast Regional IFG is currently developing an up-to-date fisheries management plan for the area and will be responsible for communicating and implementing any actions in partnership with others including spatial or effort management.

3. Marine Protected Areas

The designation and management of MPAs will influence areas where certain types of fishing may not take place (see Chapter 5.9 Protected areas – nature conservation). Whilst most *Nephrops* grounds in the CMR are still available to trawlers, there is a Marine Conservation Order for the South Arran MPA prohibiting certain types of fishing from operating in parts of the MPA in order to protect designated habitats and species, (e.g. maerl beds, which are a nursery habitat for young scallops and other fish and shellfish, see Chapter 5.9. As a consequence, there may be displacement of fishing effort and increased pressure on other areas as fishermen seek to operate elsewhere in the CMR. There may also be opportunity for other types of fishery, such as hand diving and creeling.

4. Impending legislative changes

The EU 'Landing Obligation'. Currently, vessels discard catches that do not meet the size or quota requirements. However, under the landing obligation all catches, with some exceptions, will be required to be kept on board, landed and counted against the quotas. This will serve to improve selectivity (where vessels operate) and provide greater reliability when collecting and reporting catch data.

The Landing Obligation will be phased in to the Clyde from 2016 – 2019 for all quota species.[466] Under this new legislation, **static** *Nephrops* fisheries (pot, traps and creel) can continue to discard undersized *Nephrops* at the point of capture, as this fishery has a high survivability exemption, i.e. it has been demonstrated that a high number of small individuals will survive if directly returned to the sea after capture. The *Nephrops* **trawl** fishery has been allowed a *'De Minimus'* exemption[467] and may discard up to 7% of undersized *Nephrops*.

By 2019, boats operating in the CMR will be obliged to land all quota species that are caught including Whiting, Cod, Saithe and Haddock. Fishermen may choose to change to more selective gear type to avoid catching quota species and/or apply for quotas for these species. In any case, any quota species caught that are below Minimum Conservation Reference Size will need to be separated, stored and landed for non-direct human consumption (food additives and fish protein-based products).

The implications of the Landing Obligation include an increased cost to fishermen, but also an increase in revenue from additional landings. It remains unclear at this point exactly how species with very low or no Total Allowable Catch (TAC) – Whiting, Cod, Saithe, and Haddock – will be managed, as the TAC may be reached very quickly and boats would then be unable to target *Nephrops* for the rest of the year.

Other

The Scottish Government is committed to reviewing existing fisheries legislation by 2020, with a view to a new Fisheries Bill being placed before Parliament.

A recent report[468] modelled the potential economic impact of introducing a restriction to mobile (trawl and dredge) fishing within certain distances of the shore. In the South West Inshore Fisheries Group (SWIFG) area, of which the CMR is a part, the 0-6NM area represents a bigger proportion of overall catch than for the rest of Scotland. In the SWIFG area, however, the model did predict higher overall employment and Net Economic Value results after 20 years if mobile gear were restricted within 0-3NM (and in all but the least favourable scenario after 10 years), due to an uplift in the recreational sector. This is, in part, influenced by the high population living close to the SWIFG area.

465. Clyde Inshore Fishery Group, 2011
466. Quota species are those fish and shellfish species that have Total Allowable Catch (TAC) levels set by the EU in order to manage stocks.
467. *De Minimus* exemptions are available where increases in selectivity are very difficult to achieve or there are disproportionate costs of handling unwanted catches.
468. Marine Scotland Science, 2014

6.3 Aquaculture

Summary

Aquaculture is the production of marine species such as finfish and shellfish within aquaculture installations including cultivated shellfish beds. It also includes the growing and harvesting of seaweed, however, there is no commercial seaweed activity within the Clyde Marine Region (CMR) although there is some wild harvesting. Marine aquaculture sites are generally situated in coastal areas within a few miles of the shore, for example, in sea lochs. The CMR therefore has numerous natural assets that make it an ideal location for aquaculture production.

Aquaculture is a major contributor to the Scottish economy with direct turnover of over £550m and supporting 2,800 jobs, many in rural communities (2012);[469] there are also notable supply chain benefits and impacts. Within salmon farming, Scottish supply chain jobs are estimated at 6,500.[470] Within the CMR, the aquaculture sector comprises Atlantic salmon, mussels, oysters and scallops across 43 production sites. Finfish farming accounts for 28 production sites, with activity concentrated in and around Loch Fyne. Scotland is the biggest producer of farmed salmon in the EU and provides significant exporting opportunities (current value of exports is estimated at £480m).[471] Shellfish farming in the Clyde is generally smaller scale, single owner businesses. Again, activity is largely concentrated at Loch Fyne which has five production sites with other sites located at Loch Striven, Loch Riddon and Lamlash Bay, Arran.

The sector remains important for supporting rural and coastal communities both directly and through supply chain linkages, however, there has been an overall decline in employment.

Defining the sector

The economic contribution of the aquaculture sector is measured through the following SIC code: 03.21 Marine Aquaculture.

A summary of the contribution across economic indicators (2010 to 2014) is presented in table 6.9. This is direct aquaculture only, for supply chain figures see Chapter 6.4 Processing – Fisheries and Aquaculture.

6.3.1 Contribution to the Economy

Employment

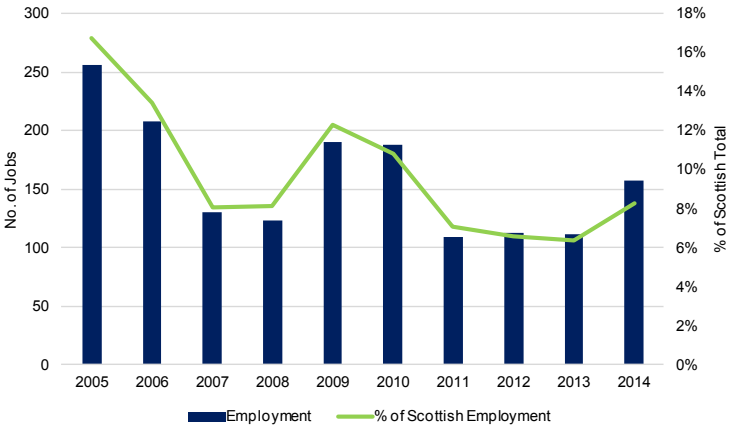
Activity in the aquaculture sector is clustered around Argyll and Bute, which has over 95% of total employment of the CMR. The sector is a relatively small employer in absolute terms, however, provides year round employment for fragile rural communities in the region. Total direct employment is 160 jobs, although the employment base has declined by 30 jobs (16%) since 2010, whilst Scottish employment has increased by 160 (9%). In 2010, the CMR accounted for 11% of total aquaculture employment in Scotland; however, there has been a gradual decline over the past 5 years with the region now representing only 8% of total employment.

Table 6.9 Aquaculture change in activity, 2010–2014

INDICATOR	CHANGE
WIDER CLYDE MARINE REGION	
Turnover*	+21%
GVA*	+51%
CLYDE MARINE REGION	
Employment	-16%
Tonnage	Mussels 0%[479]
	Oyster and Scallops -75%
	Salmon +40%*
Value	+44%*

* Based on combined two year figures due to two year cycles in Salmon harvesting. See Figure 6.12 for more details. Turnover and GVA adjusted to 2013 prices.

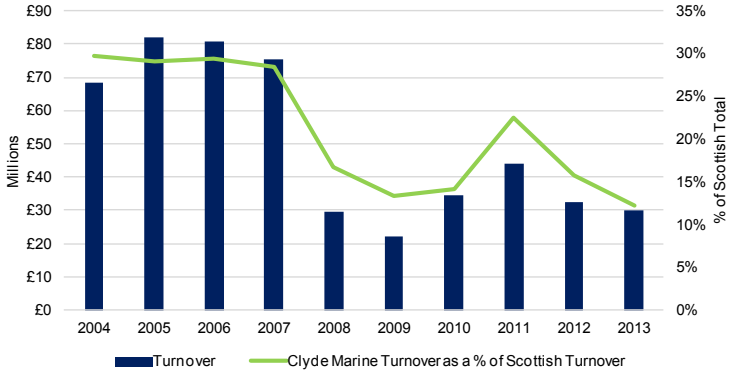
Figure 6.12 Clyde Marine Region direct aquaculture employment, 2005–2014[472]



Source: Business Register and Employment Survey and Annual Business Survey
NB. 2005-2008 data measured using SIC code 05.02: Operation of fish hatcheries and fish farms

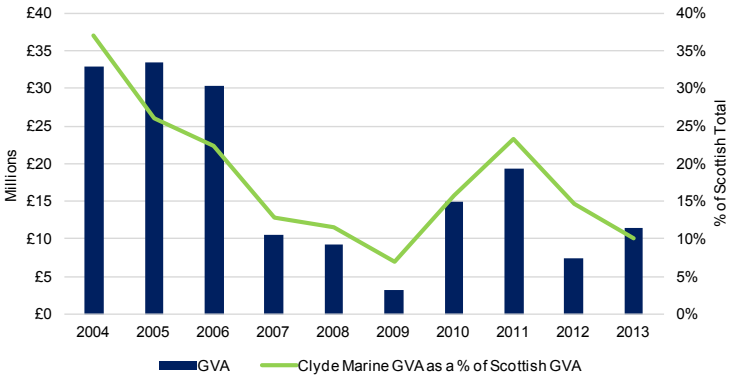
469.Marine Scotland, 2014b
470. The Scottish Salmon Producers Organisation
471. Marine Scotland Data Request
472. Change in activity within Mussel production uses 2005 as a base year as 2010 was a peak year that skews the assessment

Figure 6.13 Wider Clyde Marine Region Marine: Aquaculture turnover, 2004–2013



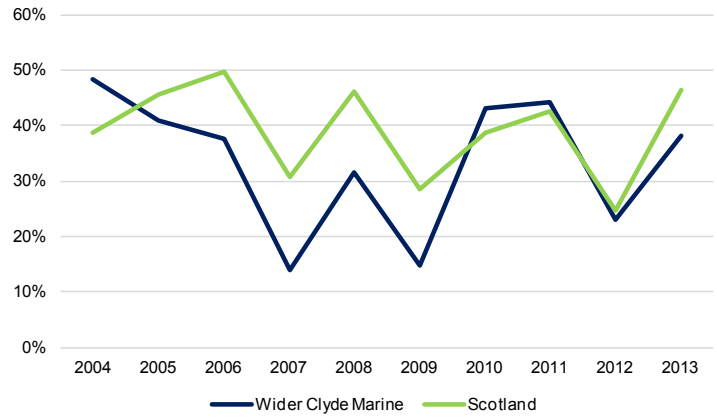
Source: ABS. Adjusted to 2013 prices.
Note: these figures include all of Argyll and Bute local authority area

Figure 6.14 Wider Clyde Marine Region Marine: Aquaculture total GVA, 2004–2013



Source: ABS. Adjusted to 2013 figures
Note: these figures include all of Argyll and Bute local authority area

Figure 6.15 Wider Clyde Marine Region Aquaculture GVA to turnover ratio, 2004–2013



Source: ABS. Adjusted to 2013 figures.

This is due to both falling employment in the CMR and increasing employment in Scotland as a whole, See figure 6.12. Please note that over the same period, Orkney and Shetland's aquaculture sector has grown substantially and now accounts for around one third of Scottish aquaculture employment.

Please note that data from sector bodies such as the Scottish Salmon Producers Organisation (SSPO) identifies that official data sources used in the assessment may undervalue the true direct employment impact of the sector. In addition to these direct jobs, the aquaculture sector has strong links to the supply chain, for example, feedstuff, medical, research and development, specialist processing, and transport. Therefore the wider impact of the sector, particularity in more fragile rural communities, should not be overlooked.

Economic output – turnover and GVA

Both turnover and GVA declined around 2007/08 by approximately 60%, but have since recovered to some extent, figures 6.13 and 6.14.

The economic output of the aquaculture sector is driven by the co-ordinated stocking, harvesting and fallowing pattern by area in accordance with production area management strategies. It is therefore challenging to get an accurate annual flow of productivity. The changes to the GVA to turnover ratio observed in the CMR has been consistent with Scotland over a number of years, and since 2009 indicates an increase in productivity, figure 6.15. This in part will be driven by the increase in turnover but a decrease in employment i.e. businesses are growing turnover but with less employees. This is likely to be due to greater levels of automation across the sector.

Aquaculture Activity

There are 33 aquaculture sites (at the time of writing) across the CMR, 12 shellfish sites and 22 finfish sites. There are a number of freshwater research and development and breeding and hatching sites for Atlantic salmon.

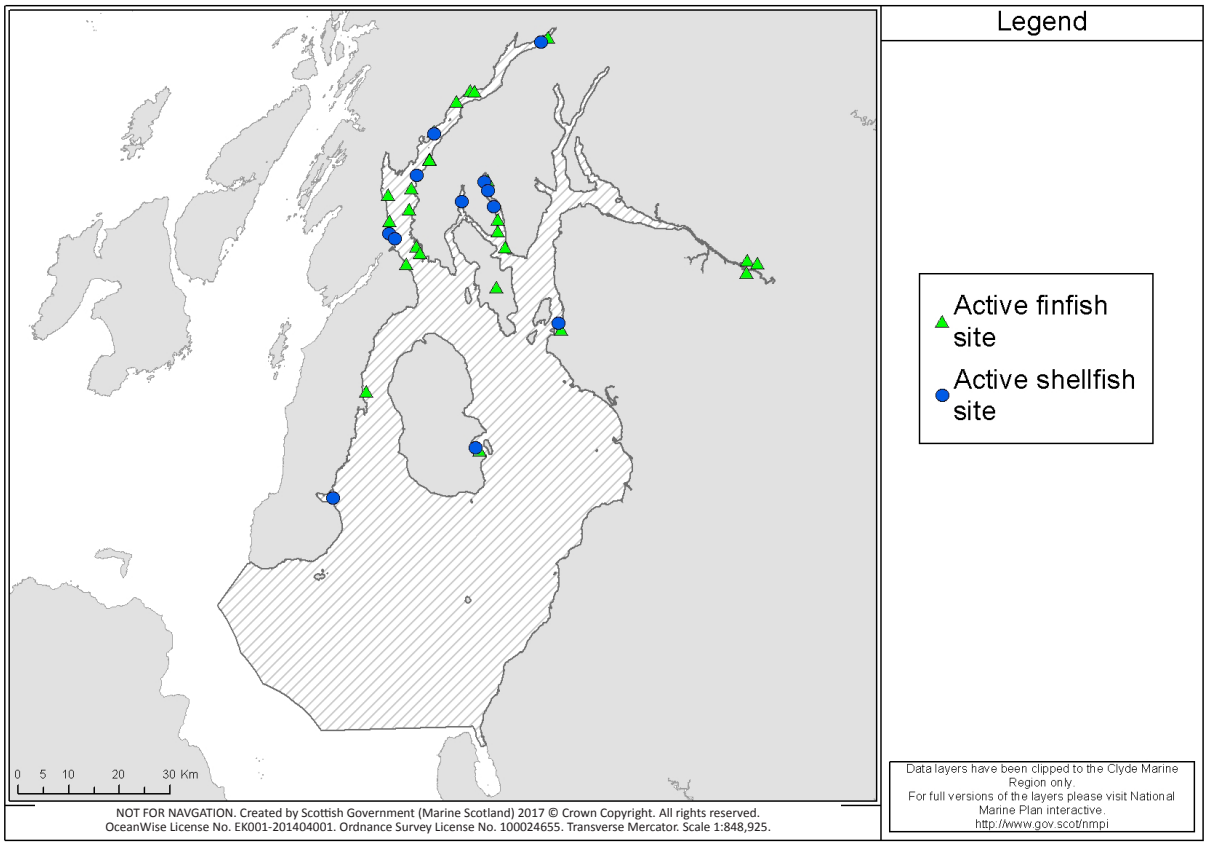
A variety of different fish species are farmed, the most common being Atlantic Salmon, Pacific Oysters, Common Mussels and Queen Scallops, figure 6.16.

As there are relatively few producers that operate these sites, some data has been supressed and others rounded to avoid disclosure,[473] see figure 6.17 to 6.19. Please note that due to data suppression, the information provided in figure 6.17 to 6.22 should be treated with caution, as it could under- or over-represent activity in a given year. A 'trend line' to outline the general trend over the period has therefore been included. Value data had been provided in terms of pound per tonne or pound per shell which has been multiplied by production data. Again, due to the fact that production data has been rounded, value information should be treated with caution.

473. Data are suppressed in to prevent identification of individual operators activities and preserve anonymity

Map 23. Clyde Marine Region aquaculture production sites, January 2017

The data for this map is updated frequently and an up to date version is available on NMPi

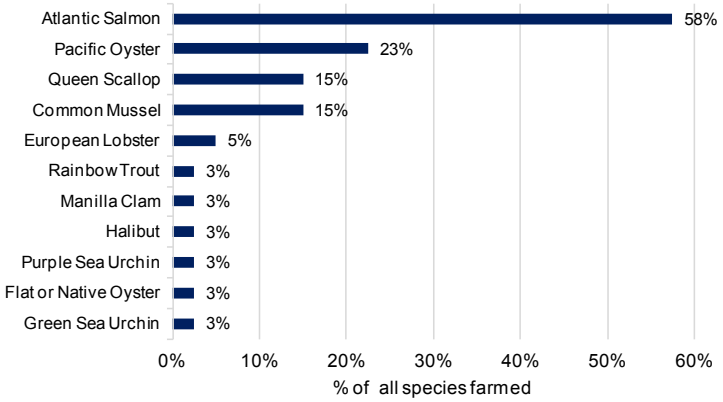


Assigning value to oyster and scallop production was challenging due to there being no breakdown between the two species and the large amount of rounding. However, due to oyster production far outstripping scallop production at the Scotland level,[474] we have used price per oyster to determine total value, figure 6.18. Due to the nature of salmon farming, harvesting occurs in two year cycles.

Therefore the official data shows there are big spikes in production and activity every two years i.e. when the salmon is sold to the market. Due to this, it is difficult to plot an annual trend (as with other types of aquaculture activity). Overall, the production of salmon has been on an upward trend and remains a key export product.

There have been annual fluctuations across the three main species. In part, this is likely to be due to data suppression and rounding. Overall, there appears to have been an increase in tonnage of farmed salmon and mussels, but a steep decline in the number of oysters and scallops. The value and price of fish remains high, particularly in export markets. However, the production of salmon far outweighs that of shellfish, with salmon accounting for at least 97% of total value in all but one of the last ten years.

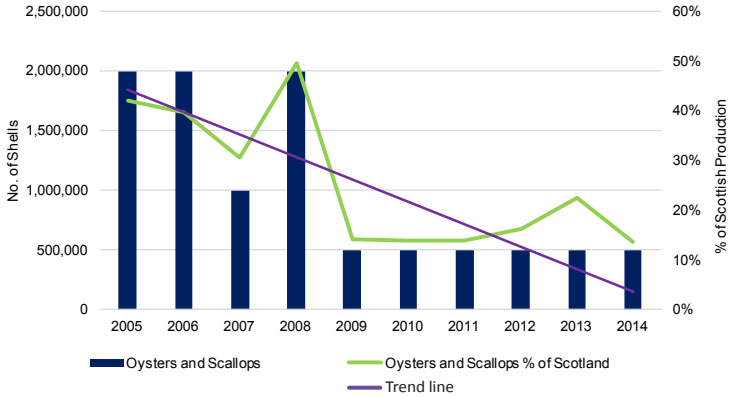
Figure 6.16 Aquatic species farmed in Clyde Marine Region, 2014



Source: Scotland's Aquaculture – http://aquaculture.scotland.gov.uk/map/map.aspx

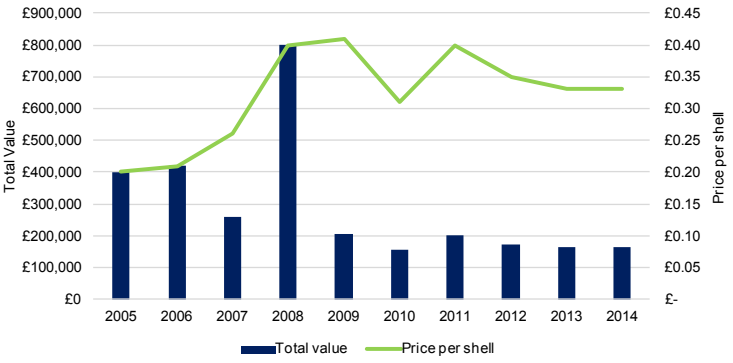
474. Breen *et al.*, 2011

Figure 6.17 Clyde Marine Region: Oyster and scallop production, 2005–2014



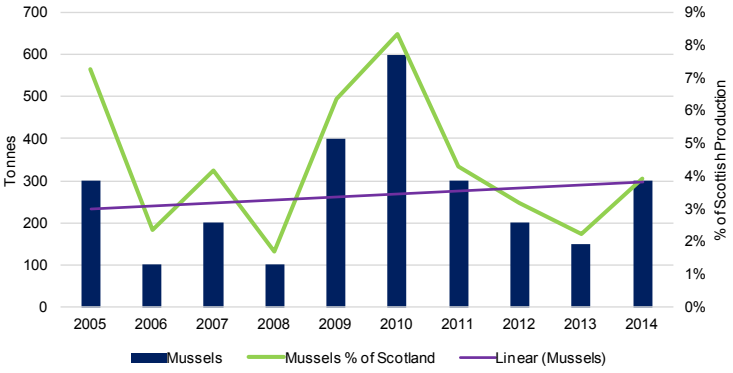
Source: Marine Scotland
Note: Data supressed, rounded to nearest whole number

Figure 6.18 Clyde Marine Region: Oyster and scallop value, 2005–2014



Source: Marine Scotland, Note: Data supressed, rounded to nearest whole number

Figure 6.19 Clyde Marine Region: Mussel production, 2005–2014



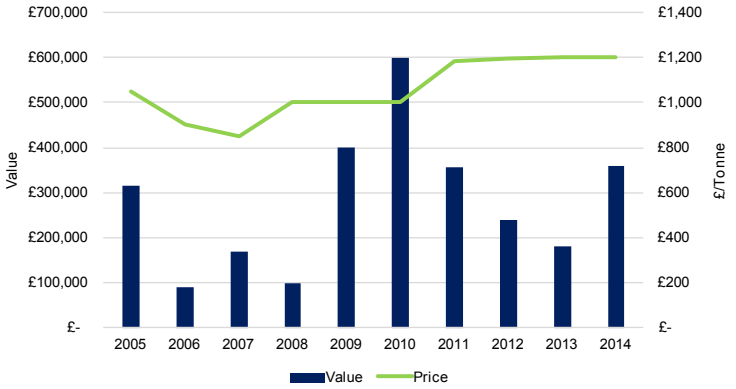
Source: Marine Scotland
Note: Data supressed, rounded to nearest whole number



Aquaculture in the Clyde © PETER SANDGROUND

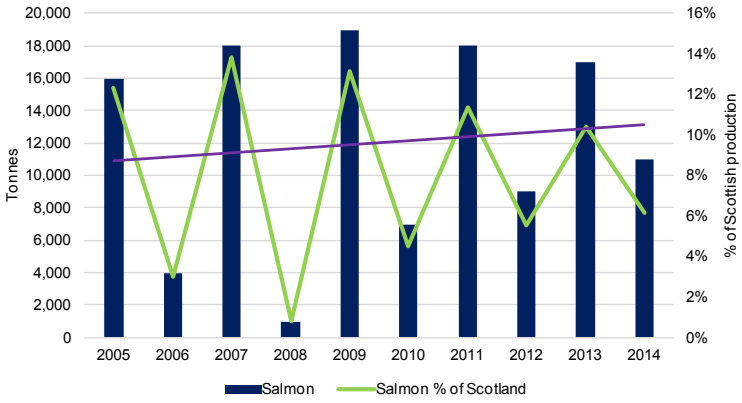


Figure 6.20 Clyde Marine Region: Mussel value, 2005–2014



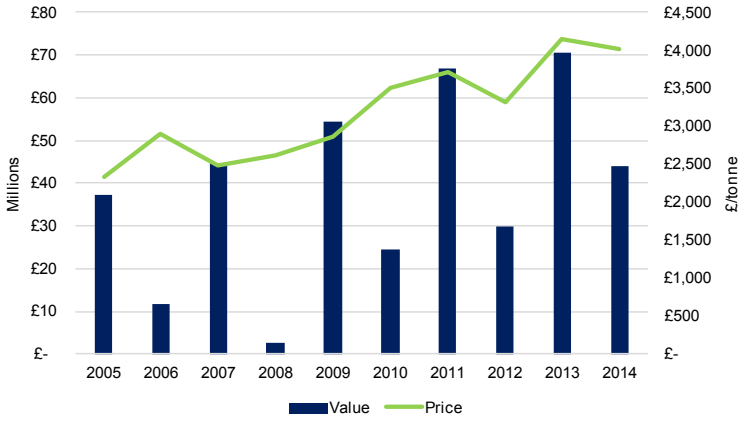
Source: Marine Scotland
Note: Data supressed, rounded to nearest whole number

Figure 6.21 Clyde Marine Region: Salmon production, 2005–2014



Source: Marine Scotland
Note: Data supressed, rounded to nearest whole number

Figure 6.22 Clyde Marine Region: Salmon value, 2005–2014



Source: Marine Scotland
Note: Data supressed, rounded to nearest whole number



Fish boxes © CLAIRE PESCOD

6.3.2 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of the aquaculture sector is provided below. Please note that the finfish aquaculture sector is subject to monitoring and legislation implemented by the Scottish Environmental Protection Agency (SEPA) to minimise adverse impact on the environment, including water quality.[475] Both fish and shellfish producers are also controlled by a range of other consents including planning permission, marine licensing and an Aquaculture Production Business authorisation from Marine Scotland.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Farmed Scottish salmon is a key export for the food and drink sector and a driver for export activity • Contributes to key sector growth – food and drink • Supports rural communities – retaining jobs and wages • Important supply chain links, for example smolt and feed supplies, and transport and distribution	• Potential conflict with other marine sectors - Competing access to coastal locations and impacts on wild salmon and trout angling, (in particular, genetic modification and lice infection). • Visual impact on coastal locations, although it should be noted that the impact upon visual amenity will be considered within the planning approval process

475. Scottish Environment Protection Agency, b

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Pollution	Nutrient enrichment and de-oxygenation	Fish farms release nutrients and waste into the environment, which if not appropriately managed, can affect the water column and seabed. Please note that SEPA licenses all aquaculture activity that may have an impact on water quality and this includes monitoring tidal and current strength to mitigate against any impact on water quality.
	Introduction of hazardous substances	Current approaches to protect farmed fish from disease and sea lice are to use husbandry, mechanical and biological strategies where possible but chemicals are also used. Antifoulants are used for sea cages. There is a potential adverse environmental impact from introducing these chemicals into the marine environment although this is regulated by SEPA.[476] The Scottish Aquaculture Innovation Centre (SAIC) is currently undertaking research to assess the effectiveness of different options for sea lice control, for example deploying native fish species such as wrasse and lumpsuckers, freshwater treatment and mechanical removal.[477] It is likely that the industry will become less reliant on chemical treatments over time. Use of wrasse has involved wild harvesting which has raised concerns over sustainability of this practice.[478] In 2015, the SAIC began a research project which will look at improving the culture of wrasse for use in fish farms.[479]
Biological	Genetic modification	In the CMR, research found that 2.8% of the wild salmon catch is escaped farmed salmon, compared to 0.3% nationally[480] (this would equate to around 60 salmon per annum). In June 2015, 16,000 farmed salmon escaped from an aquaculture site at Carradale on the east coast of the Kintyre Peninsula. The Salmon and Trout Association have highlighted that the escaped Salmon could migrate into important salmon rivers in the Clyde, genetically diluting wild stocks.
	Introduction of microbial pathogens and non-native species	There is increasing evidence that Pacific oysters (*Crassostrea gigas*), which are cultured in Loch Fyne, may now be able to spawn in Scottish waters. These oysters have been seen to spawn in The Netherlands and research is ongoing into what conditions are required to trigger spawning in order to ascertain whether this species could be a threat in Scotland at some point in the future, in particular due to climate change.[481] There is also a risk that introduced species will carry other non-native species or foreign pathogens which could impact the health of native fish species. Cages can also provide a substrate for non-native species.
	Sustainability of fish feed	Farmed fish are fed on food pellets containing fish meal (which is often sourced from fisheries in Europe, Scandinavia and South America), soy protein or other animal protein. There is concern over the sustainability and environmental impact of this practice. SAIC is currently supporting two projects; the first is looking at identifying alternative sources of protein that are locally sourced and have a low environmental impact. The second project will investigate reasons for inefficient digestion to improve growth efficiency of salmon.[482]
	Other	Issues with salmon lice in farmed stock negatively impact wild stocks of salmon. Whilst the extent of the impact is a matter of debate, lice infection is thought to have a moderate impact on the population of wild stocks.[483] This issue also generates considerable cost to the industry. There are concerns over the effect on hearing and behaviour in particular of marine mammals due to exposure to Acoustic Deterrent Devices sometimes used at fish farms.[484]
Other physical	Litter and discarded net, cages, pots, etc.	There is a general environmental risk to fish species from discarded nets and litter. Large numbers of plastic fish feed containers were found washed up at the Saltings Local Nature Reserve in 2012 after a storm.[485] There are potential impacts of anti-predator nets on birds and mammals and the potential impact of noise from acoustic deterrent devices. This is assessed and mitigated where appropriate through the EIA process.

476. The Scottish Government, 2012d
477. Scottish Aquaculture Innovation Centre, 2015a
478. Horton J., 2017
479. Scottish Aquaculture Innovation Centre, 2015b
480. Green *et al*., 2012
481. Mills, 2012b
482. Scottish Aquaculture Innovation Centre, 2015c
483. Torrissen *et al*., 2013
484. Coram *et al*., 2014
485. Communication from Clydebelt community group at Firth of Clyde Forum beach cleaning meeting 18th July 2012

6.3.3 Regional Look Forward

In order to support sustainable growth in the sector, the Marine Scotland Strategy for Aquaculture, *A Fresh Start: The renewed Strategic Framework for Scottish Aquaculture* (2009)[486] identifies five strategic priorities:

- healthier fish and shellfish;
- improved systems for licensing aquaculture developments;
- improved containment;
- better marketing and improved image; and
- improved access to finance.

Emerging from this strategy, the Scottish Government introduced a **Designation Order** in 2013 to protect Scotland's shellfish growing waters; shellfish need a source of clean water to ensure a high quality product that is suitable for human consumption. The water quality in designated areas is regularly monitored by SEPA, see Chapter 4.3 Microbiological contamination – shellfish water protected areas.

With due regard to the marine environment and carrying capacity, the National Marine Plan identifies the following growth forecasts for sustainable production by 2020 – 210,000 tonnes of finfish, +28%, (up from 164,000 tonnes in 2012) and 13,000 tonnes of shellfish, +50% (up from 6,500 tonnes). The 2014 fish farms annual production survey shows that the sector is well on its way to achieving these targets (finfish production was 185,000 tonnes), however shellfish production is not currently in line to meet the target.[487] Through direct and supply chain activity, this growth in production could generate turnover of £1.1bn and support 7,000 jobs in Scotland.[488] Companies involved in the industry have expressed their interest in increasing the size and number of farms in the CMR.

Within the CMR, all the sea lochs (Loch Fyne, Loch Long, Loch Goil and Loch Striven) are classified as **category 3** by the Scottish Locational Guidelines for Aquaculture which indicates *'there is potential environmental capacity for expansion of the industry.'*[489] This takes into account potential environmental capacity but does not include other factors such as conflict for space, landscape/seascape considerations or interaction with wild fish. There is therefore environmental scope to increase production in the region.

A recent report from the Argyll and Bute Economic Forum[490] suggested that Argyll & Bute is well-placed to take advantage of a growing aquaculture industry and recommended that (whilst maintaining environmental controls), the planning process be streamlined, that there could be better communication between the Local Authorities and aquaculture industry and that there could be a diversification of products into more shellfish. The Loch Fyne Integrated Coastal Zone Management Plan (2009)[491] identified six finfish and two shellfish farms that have potential to expand production (ranging from 20% to 80%). Further, there are nine additional sites that could accommodate small to medium sized farming activities. However, these smaller scale sites may not be viewed as commercially viable by the sector.

The cultivation of seaweed for harvesting is currently an active area of research, whether as a single species or for Integrated Multi Trophic Aquaculture where a number of different species, such as fish, shellfish and seaweed are grown at one site and the by-products are recycled to become inputs for another. Marine Scotland is currently developing a Seaweed Policy Statement on seaweed cultivation. Marine Scotland is also consulting on policy for a sustainable approach to the wild harvesting of seaweed, although this would not strictly fall within the description of 'aquaculture'.



Loch Fyne aquaculture © PETER SANDGROUND

486. Marine Scotland, 2009a
487. Munro and Wallace, 2015
488. Marine Scotland, 2014b
489. Marine Scotland Science, 2016
490. Argyll and Bute Economic Forum, 2016
491. Argyll and Bute Council, 2009

6.4 Processing – Fisheries and Aquaculture

Summary

The key supply chain activity that supports the core marine sectors of fishing and aquaculture is considered as primary and secondary processing activities:

- primary processors are involved in the cutting, filleting, picking, peeling, shelling, washing, chilling, packing, freezing, heading and gutting of fish and shellfish.
- secondary processors are involved in brining, smoking, cooking, freezing, canning, deboning, breading, battering, vacuum and controlled packaging and the production of ready-to-eat meals.

Processing activities were traditionally located near coastal locations (to minimise the time and costs to transport the landings from the harbour/port) and are an important local employer, particularly in more rural locations.

Please note that there is wider supply chain activity that supports both the core and ancillary marine sectors including; the building and maintenance/repair of boats, (covered in Chapter 6.9 Shipping and Transport), transport and distribution, research and development activity, and wholesale and retail activities. However, due to the cross-cutting nature of the supply chain it is not possible to identify the activity that is explicitly supported through the core and ancillary marine sectors and has therefore been discounted from the assessment.

Defining the Sector

The economic contribution of the processing sector is measured through the SIC code: 10.20: Processing and preserving of fish, crustaceans and molluscs.

A summary of the contribution across economic indicators (2010 to 2014) is presented in table 6.10.

6.4.1 Contribution to the Economy

Employment

Employment in fish processing has grown annually over the past ten years and more than doubled in the region since 2005, rising from around 1.5% of Scottish employment to over 5% in 2014. This is primarily due to an increase in employment around Loch Fyne to support the aquaculture sector, figure 6.23.



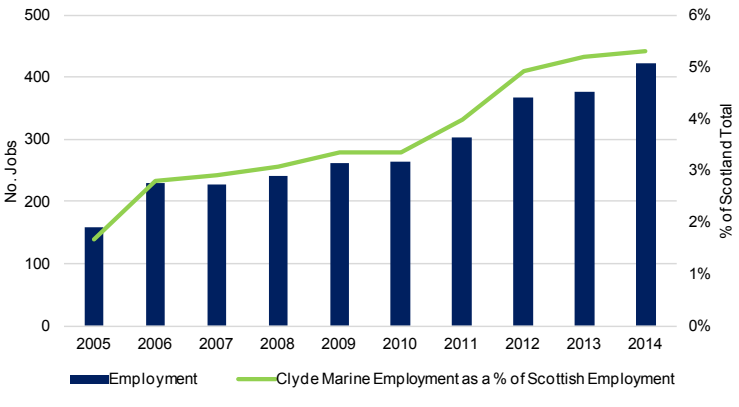
Loch Fyne © PETER SANDGROUND

Table 6.10 Clyde Marine Region: Processing Change in Activity, 2010–2014

INDICATOR	CHANGE
WIDER CLYDE MARINE REGION	
Turnover*	+46%
GVA*	+48%
CLYDE MARINE REGION	
Employment	+60%

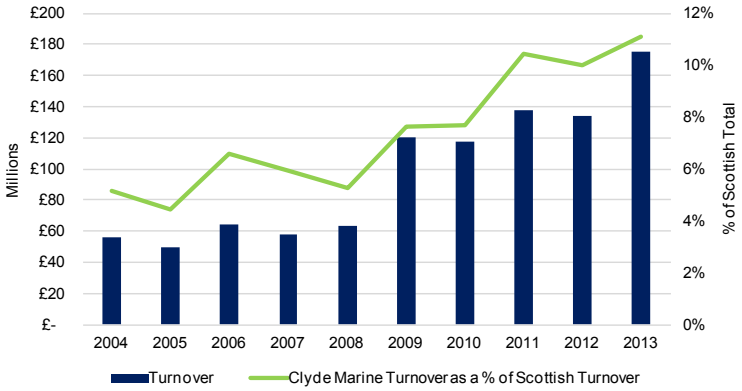
* 2009 to 2013 and adjusted to 2013 prices

Figure 6.23 Clyde Marine Region: Fish Processing Employment, 2005–2014



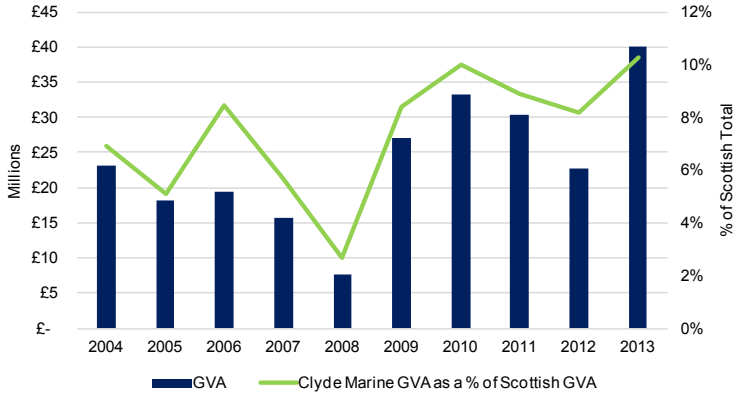
Source: BRES

Figure 6.24 Wider Clyde Marine Region: Fish Processing Turnover, 2004–2013



Source: ABS. Adjusted to 2013 prices.
Note: these figures include all of Argyll and Bute local authority area

Figure 6.25 Wider Clyde Marine Region: Fish Processing GVA, 2004–2013



Source: ABS. Adjusted to 2013 prices.
Note: these figures include all of Argyll and Bute local authority area

Economic Output – Turnover and GVA

The sector has also experienced a steady rise in turnover and GVA (however the GVA output has tended to fluctuate), figures 6.24 and 6.25.

Please note that the economic output figures are considered at the wider Clyde Marine Region (CMR) level. There are large fish processing operations in Argyll and Bute and South Lanarkshire that are not in the direct CMR that are likely to be contributing to the growth in turnover and GVA.

It is important to consider the activity within the sea fisheries and aquaculture sector at the regional level over the last few years; total sea fisheries landings have decreased and within aquaculture, scallop and mussel production has decreased notably, while salmon production has risen. Over the same time, activity in the fish processing sector has remained buoyant and shown steady growth. A potential driver for this is the diversification of fish processing operations, with many processors moving from primary processing to secondary processing or mixed processing; this allows the opportunity to work with and support fisheries outwith the region (i.e. process fish that was landed outwith the region, including overseas).

6.4.2 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of human activity in the fisheries and aquaculture supply chain is provided below.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Contributes to key sector growth – food and drink • Supports rural communities – retaining jobs and wages • Important supply chain links e.g. transport and logistics	• No direct adverse impacts identified

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
No direct adverse pressures or impacts identified		



Kintyre © PETER SANDGROUND

6.4.3 Regional Look Forward

The supply chain sector will be directly affected by wider activities within both the sea fisheries and aquaculture sector. Some of the key challenges include:

- the health of fish stocks;
- quotas and fisheries management; and
- capacity to expand aquaculture production, particularly at sites around Loch Fyne.

In order to remain competitive, there has been a general trend towards diversification and rationalisation across the sector, with businesses undertaking both primary and secondary processing activities, and the emergence of fewer, but larger processing plants/facilities. This means businesses are able to extend their reach across Scotland and overseas, i.e. they will be involved in the processing of fish/shellfish that is caught and landed outwith the region. There may also be potential for an increase in small processors of high value secondary processing products, such as smoked fish.

In terms of future development activity, Argyll and Bute Council has granted planning permission (October 2015) for a new fish processing plant on a brownfield site at Ardyne Point. The proposed development is estimated to cost £19m and will create 150 on-site jobs, increasing the fish processing employment in the CMR by around one third.

6.5 Sport, recreation and tourism

Summary

Sport, recreation and tourism is a broad sector that combines marine recreation and tourism including operators of marine activities, accommodation, and food and beverage providers. There are 23 marine recreation and tourism activities as defined in the Scottish Marine Recreation and Tourism Survey (SMRTS)[492] identified as: those activities which involve travel away from one's 'habitual' place of residence, which have as their host or focus the marine environment and/or the coastal zone and includes a wide range of activities from sailing, to wildlife watching and beach sports. Marine recreation and tourism is reliant on healthy coasts and seas.

Certain parts of the region are within a one-hour driving time of a significant population in the greater Glasgow area and two international airports. The region is therefore popular with visitors from inside and outside Scotland, both as a day trip destination and for longer visits.

The Clyde Marine Region (CMR) has deep sheltered waters and islands, which makes it an ideal location for sailing and power boating, including commercial charters and attracts significant numbers of recreational boaters every year (data on cruise ships is presented in Chapter 6.9: Shipping and Transport). In 2015, Scotland was voted the 'World's Best Cruising Ground' in the Sailing Today Awards.[493] There are more than 5,000 resident and visitor berths/moorings (within the Clyde and Solway Firth) and there has been notable investment and growth in the capacity of marinas over the past ten years. That being said, the existing capacity and potential demand for additional berths/moorings is unknown and this may be constraining the growth of the sector.

There are numerous water sports that take place in the region, including diving, wind and kite surfing, surfing, kayaking and paddle boarding. Sportscotland's National Watersports Centre is located on the island of Cumbrae and offers accommodation, teaching facilities, equipment hire and courses/training for a wide range of water sports. Sea and land based fishing/angling was once a popular past-time in the Clyde region (generating £24m per annum), however, decreasing fish stocks and changes to legislation (for salmon fishing – Spring Conservation Measures) has meant there has been a decline in activity over recent years.



Wind surfing and kite surfing, Troon © PETER SANDGROUND

492. LUC, 2016
493. Sail Scotland, 2015

There are also opportunities for activities such as walking coastal paths (particularly popular in Arran, Bute and along the Ayrshire coast), and wildlife watching - which includes commercial operations that offer wildlife watching tours.

Having access to good accommodation is vital to sustain and grow the tourism sector and the Wider CMR provides a range of accommodation choices, including; hotels, hostels, guest houses, B&Bs, and campsites. The region also has a developing 'foodie scene' which has evolved around utilising local produce and this contributes to attracting people to the region.

Sport, recreation and tourism also supports a number of local supply chains, for example: the building and maintenance/repair of boats, equipment hire/purchase, service sector activity (accommodation providers and food and beverage provision).

Defining the Sector

There are challenges with measuring the economic activity generated by the sport, recreation and tourism sector, as it encompasses a broad definition that cuts across many industry sectors. It is even more challenging to separate strictly marine tourism from terrestrial tourism.

In order to provide a broad estimate of direct economic activity we have used the Scottish Government definition of 'Sustainable tourism'. Please note that 'Sustainable tourism' includes activities related to both terrestrial and marine based tourism and will therefore *overestimate* the true impact of the sector. With this in mind it is reasonable to present the data with an emphasis on *trends* analysis rather than exaggerating the confidence in the headline figures.

In order to provide a more accurate picture of sport, recreation and tourism related to marine activity, the chapter has been supplemented with feedback from the SMRTS and identifies the most popular marine recreation activities that take place in the region.

Sustainable tourism is defined using the following SIC codes (2007):**55.10**: Hotels and similar accommodation, **55.20**: Holiday and other short stay accommodation, **55.30**: Camping grounds, recreational vehicle parks and trailer parks, **56.10**: Restaurants and mobile food service activities, **56.30**: Beverage serving activities, **79.12**: Tour operator activities, **79.90**: Other reservation service and related activities, **91.02**: Museum activities, **91.03**: Operation of historic sites etc., **91.04**: Botanical and zoological gardens and nature reserve activities, **93.11**: Operation of sports facilities, **93.199**: Other sports activities (not including activities of racehorse owners) not elsewhere classified, **93.21**: Activities of amusement parks and theme parks. **93.29**: Other amusement and recreation activities.

A summary of the changes across economic indicators (2010 to 2014) is presented in table 6.11.

Table 6.11 Sport, Recreation and Tourism Change in Activity, 2010–2014

INDICATOR	CHANGE
WIDER CLYDE MARINE REGION	
Turnover*	-19%
GVA*	+0.3%
CLYDE MARINE REGION	
Employment	+7%

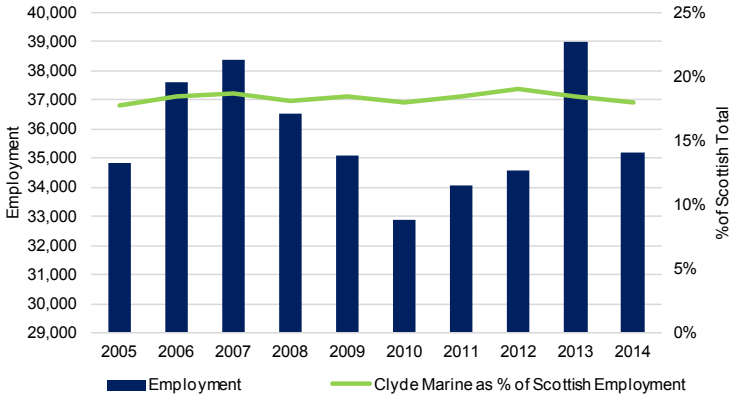
* 2009 to 2013 and adjusted to 2013 prices
Data presented for 'Sustainable tourism' sector

6.5.1 Contribution to the Economy

Employment

Employment in sustainable tourism jobs in the CMR in 2014 was 35,000 jobs (18% of all sustainable tourism jobs in Scotland), see figure 6.26. Over this time the proportion of jobs in the wider CMR relative to Scotland has remained constant (indicating that the region reflects national trends).

Figure 6.26 Clyde Marine Region: Sport, Recreation and Tourism Employment, 2005–2014



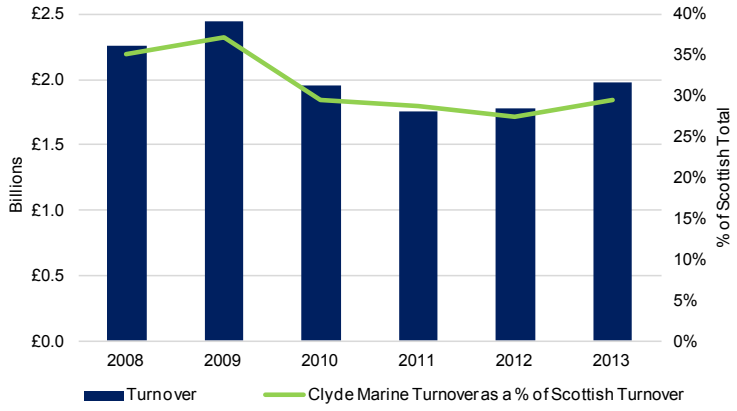
Source: BRES
Data presented for 'Sustainable tourism' sector

Economic Output – Turnover and GVA

Total sustainable tourism turnover in the Wider CMR was just under £2bn in 2013. It should be noted that around £950m is attributed to the Glasgow City Council area; this is most likely to be from service sector activities, such as restaurants and accommodation providers, and therefore unlikely to be directly attributable to marine activity.

The negative impact of the economic recession on the sector should be considered when reviewing these figures - the sector in the Wider CMR experienced a significant decline following the economic recession with turnover falling by around -20%, 2009 – 2010, see figure 6.27.

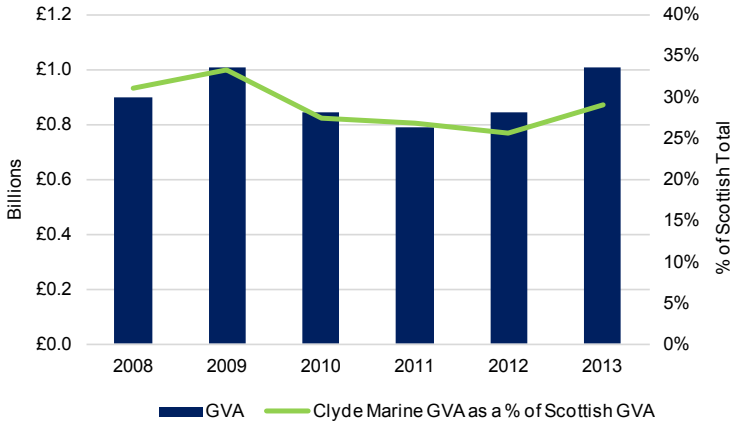
Figure 6.27 Wider Clyde Marine Region, Sport, Recreation and Tourism Turnover, 2008–2013



Source: Scottish Government. Adjusted to 2013 prices.
Data presented for 'Sustainable tourism' sector

Total GVA reached £3.47bn for Scotland in 2013 and of this, £1bn (29%) was generated in the Wider CMR, see figure 6.28.

Figure 6.28 Wider Clyde Marine Region, Sport, Recreation and Tourism GVA, 2008–2013



Source: Scottish Government. Adjusted to 2013 prices.

Note on Economic Activity

As highlighted above, the economic activity data (employment, turnover, and GVA) captures the wider tourism activity and not just that related to marine activity. In order to provide some context to the figures, it is assumed that around 10% to 50% of the economic activity can be attributed directly or indirectly to the marine sport, recreation and tourism sector.

A recent report looking at tourism in Argyll and Bute[494] concluded that tourism is their largest private sector employer, with 15% of all jobs and 25% or private sector jobs (note that this is all tourism and not just that directly associated with marine activities) and that this is the fastest growing sector. The report recommended that there is a need to support the fast growing marine tourism sector with initiatives in the CMR such as:

- Support for more moorings and pontoons in Loch Fyne from Tarbert/Portavadie up to Cairndow
- Expansion of Campbeltown, Tobermory and Tarbert marinas

Scottish Marine Recreation and Tourism Survey

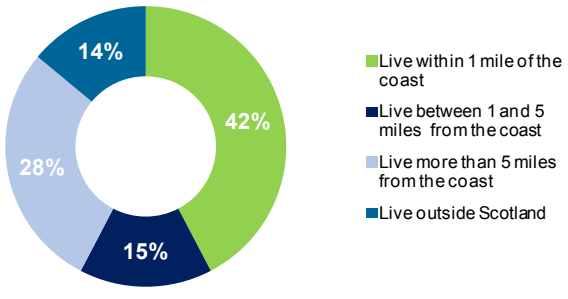
The Scottish Marine Recreation and Tourism Survey (SMRTS) was used to capture spatial information on where people engaged in different marine recreation activities and to follow this with a series of questions about their activity over the previous 12 months. The detailed feedback from survey respondents that undertook activities in the CMR in the preceding 12 months has been extrapolated and reviewed as part of this study. In total, 666 of the individuals who took part in the survey had undertaken one or more activity in the CMR.

Please note that this data does not provide a comprehensive and representative review of marine recreation activities in the CMR, however, it does provide a useful 'snapshot' of the most popular activities in the region and helps to identify key characteristics. For more information on the approach to sampling, questionnaire design, delivery and data assumptions and caveats, please see the SMRTS.[495]

The key findings from within the region include:

- more than half (57%) of those who use the CMR for marine tourism and recreation live within five miles of the coast (see figure 6.29);
- the most popular activities are general recreation, coastal walks, visiting historic sites and visitor attractions, bird watching, sailing and activities such as coastal drives/bus tours;
- wildlife is a significant factor in recreation activities in the area;

Figure 6.29 Location of Clyde Marine Tourism and Recreation Users



N=666. Source: Scotland Marine Tourism and Recreation Survey

494. Argyll and Bute Economic Forum, 2016
495. LUC, 2016

- when recreation and tourism users were asked what was the single most important activity that they undertook, almost one third (30%) identified sailing;
- activity peaks during the summer months; and
- average spend across all activities is £89 per day (see figure 6.33), although higher for sea angling from a boat (£136) and sailing (£118).

Figure 6.30, shows the percentage of survey respondents who had participated in each activity over the previous 12 months, along with the single activity that they reported was most important to them.

More than three quarters of respondents (76%) had participated in general marine and coastal recreation. This includes beach games, beach combing, rock pooling, painting, kite flying, sunbathing, naturism, picnicking, yoga, paddling, walking less than two miles, sightseeing, fossil hunting, beach team sports, body boarding, general swimming and snorkelling, coastal cycling, horse riding and dog walking.

Figure 6.30 Activity and most important activity undertaken in the last year (CMR respondents)

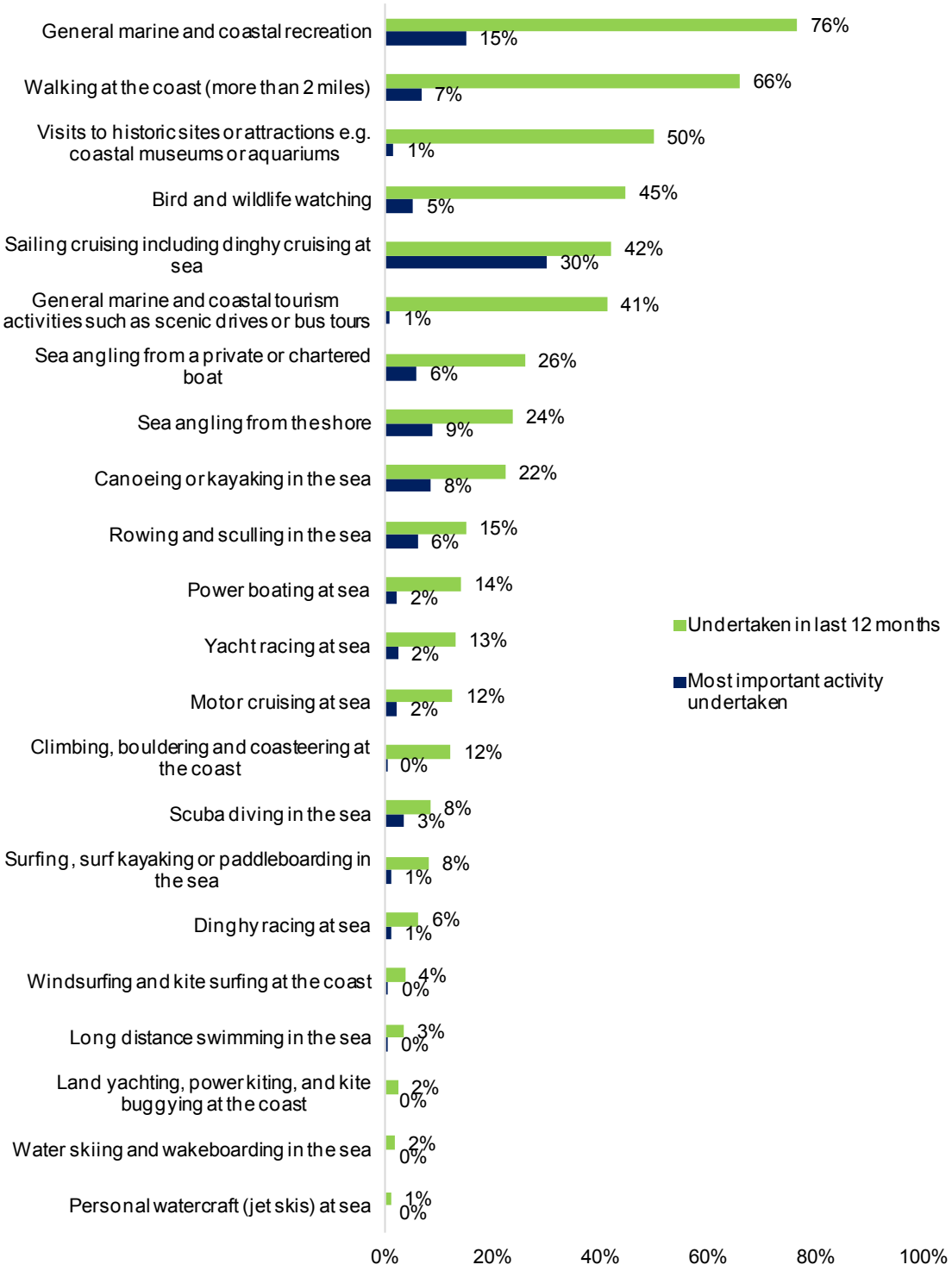
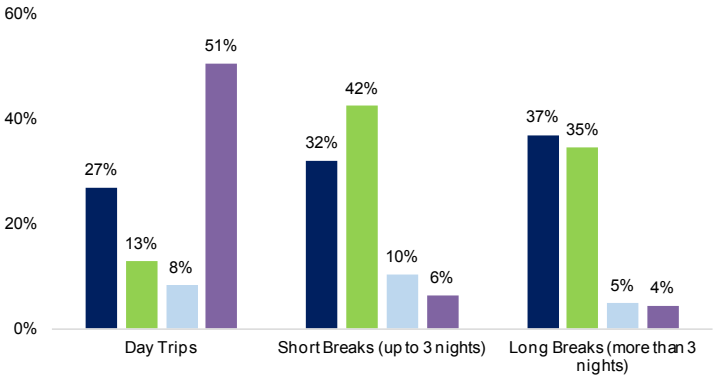


Figure 6.31 shows the frequency and duration of visits to the coast to participate in their most important coastal or marine tourism/recreation activity. More than half (51%) of those who use the CMR for tourism and recreation take at least 10 day trips to the coast each year.

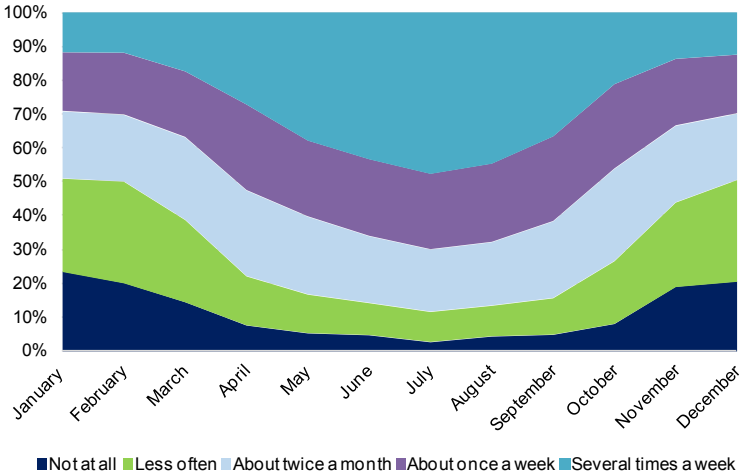
Figure 6.31 Frequency and Duration of Trips to Undertake Main Recreation Activity in the Clyde



N=625. Source: SMTRS

Tourism and recreation activity in the CMR peaks during the summer months. In July, 48% of people undertake their main activity several times a week, which reduces to 12% between December and February – see Figure 6.32.

Figure 6.32 Seasonality of Activity in the Clyde



N=599. Source: SMTRS

Figure 6.33 shows the typical spend per day while undertaking activities at the coast among recreation and tourism users of the CMR.

Table 6.12 Typical Spend per Day in the Clyde

ITEM	ALL ACTIVITIES	SAILING
Petrol/diesel/LPG	£22.3	£13.9
Bus/train fares	£9.3	£6.8
Car parking	£3.7	£5.0
Overnight accommodation	£48.7	£57.0
Eating out	£30.8	£38.2
Food and groceries	£20.3	£27.9
Entrance to local visitor attractions	£11.4	£11.7
Mooring or transit fees	£32.1	£43.8
Hire of equipment	£26.9	£54.1
Maps\guidebooks\ leaflets	£5.3	£5.5
Gifts\souvenirs	£11.6	£16.1
Other items	£30.3	£26.1

Source: SMTRS

Note on heat mapping

In addition, the following sections of this chapter contain 'heat maps' which identify the areas in the CMR where the most popular marine recreation activities take place.

Sport, Recreation and Tourism Activities

A wide variety of marine and coastal sport, recreation and tourism activities are undertaken in the CMR. These range from seaside walks and angling to sailing, diving and beach recreation and sports.

Having considered tourism numbers and visitors days within the Local Authority areas that can be considered 'coastal areas' and where the majority of marine related tourism takes place:

- Argyll and Bute typically get just over two million visitors a year, and around 4.5 million to 4.8 million visitor days;[496]
- Ayrshire, including Arran get around 3.5 million visitors a year and seven million visitor days;[497] and
- Inverclyde get 540,000 visitors each year.[498]

While these figures include all tourism activity, a significant proportion of these visits will include a marine or coastal element.

496. Global Tourism Solutions, 2015
497. Ayrshire Economic Partnership,2011
498. Inverclyde Council, 2015

Sailing

Sailing makes a notable contribution to attracting visitors and generating economic value in the region. Sailing in the CMR has grown in popularity over recent years, driven by both the 'natural competitive offering' (deep sheltered waters, good access, beautiful scenery and coastline) and also the growth in supporting infrastructure.

A study carried out in 2010 identified that around half of the economic activity (employment and GVA) generated through the recreational sailing sector in Scotland occurs in the CMR, which in this study also included the Solway Firth.[499] This helps to demonstrate the important role that the region provides to the marine tourism sector in Scotland. The same study estimated that visitor expenditure had the potential to grow by 8% in Scotland over the short term (2010–2015), however, due to the impact of the recession it is unclear whether this forecast was achieved.

The marine tourism strategy aims to increase visitor expenditure from sailing tourism in Scotland from £101m to £145m per annum by 2020.[500]

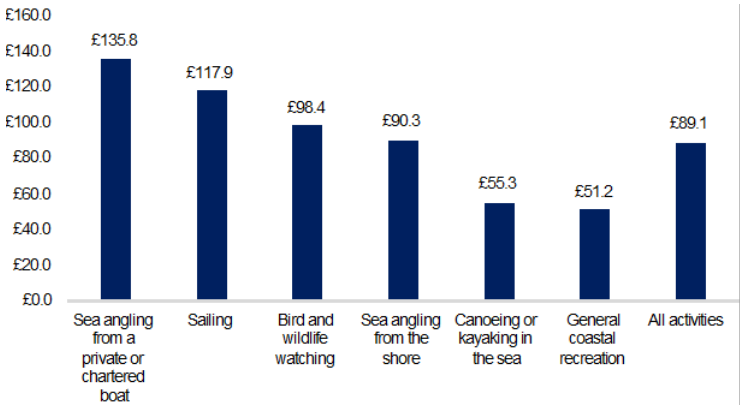
The majority of Scotland's sailing facilities and infrastructure are located on the west coast, with the highest concentration found in the Clyde and Solway Firth area. A 2010 study found that 43% of Scotland's 10,918 resident moorings are located within this area, as well as 38% of Scotland's 1,684 visitor moorings.[501]

Table 6.13 Overview of Sailing in the Clyde and Solway Firth

ITEM	ALL ACTIVITIES	SAILING
No. of pontoons	3,333	46.2%
No. of moorings	2,038	37.9%
Employment (FTEs)	1,273	46.6%
Resident berth expenditure	£34,037,443	52%
Visitor berth expenditure	£10,059,914	28%
GVA	£24,689,429	46.6%

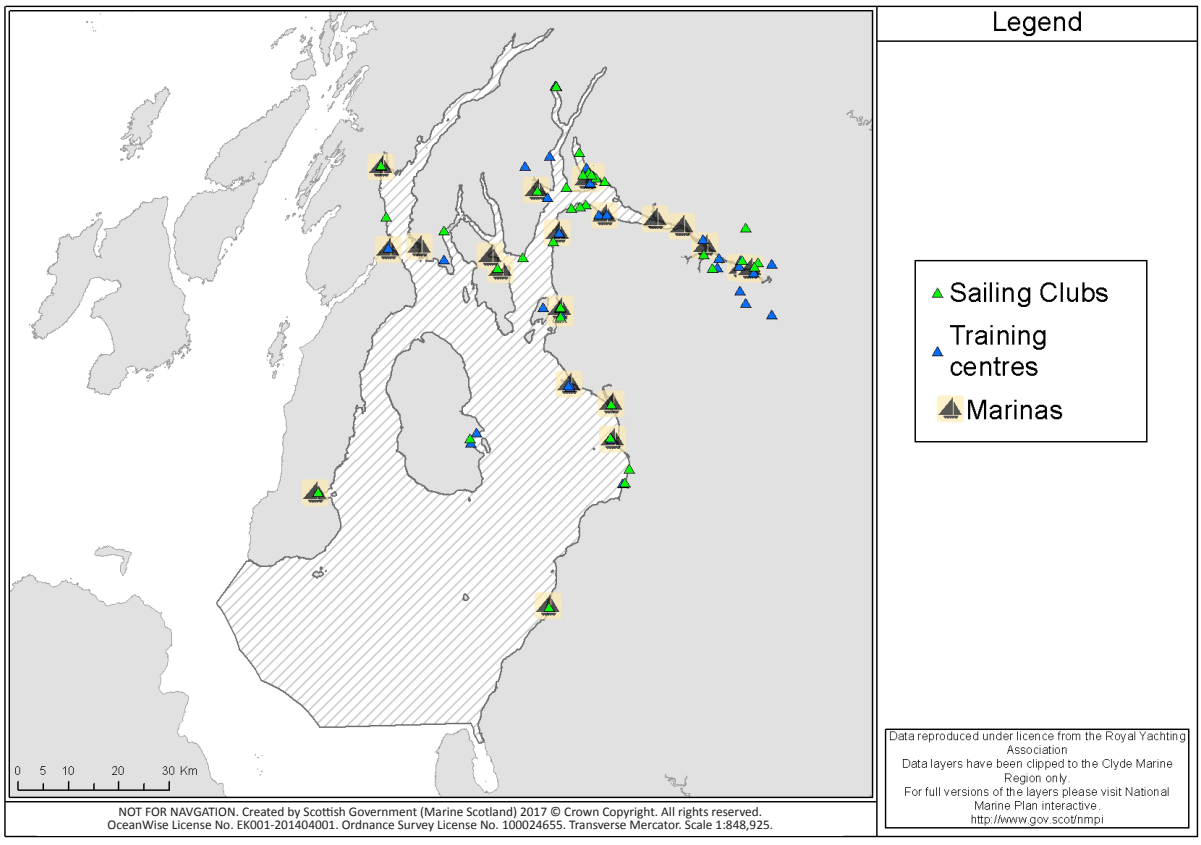
Source: Sailing Tourism in Scotland 2010

Figure 6.33 Typical Spend per Day, by Activity in the Clyde



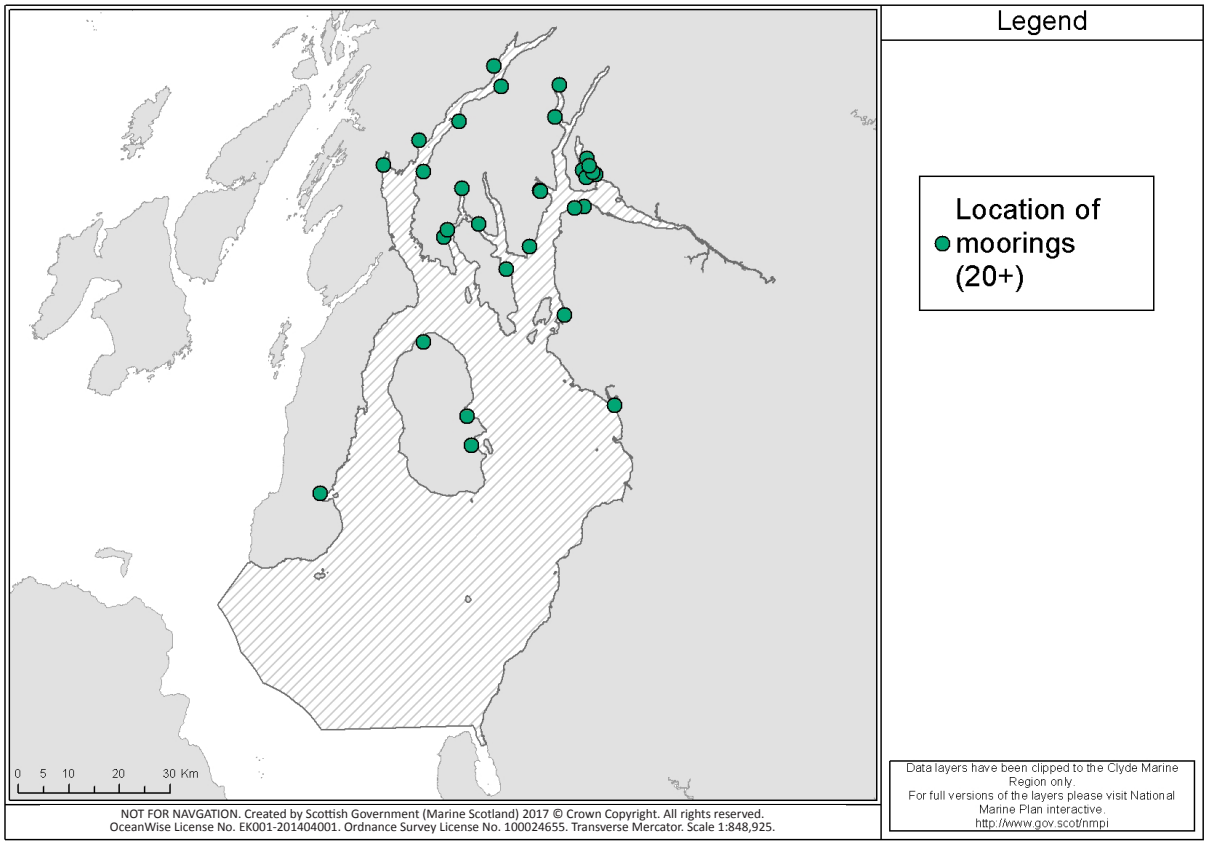
Source: SMTRS

Map 24. Sailing infrastructure in the Clyde Marine Region



499. Scottish Enterprise, 2010
500. British Marine Federation, 2015
501. Scottish Enterprise, 2010

Map 25. Location of sites with 20 or more moorings



Map 24 shows the marinas located in the CMR, with the larger marinas located near to major population centres and with good transport links. Two of Scotland's three 'Gold Anchor' marinas are located in the Clyde. Awarded by The Yacht Harbour Association for outstanding facilities and standards, Largs Yacht Haven and Portavadie Marina have both been awarded the highest certificate of 5 Gold Anchors. The Clyde also hosts 35 sailing clubs, 57 training centres and 24 marinas registered with the Royal Yachting Association.

There continues to be significant investment in sailing infrastructure in the CMR, which includes:

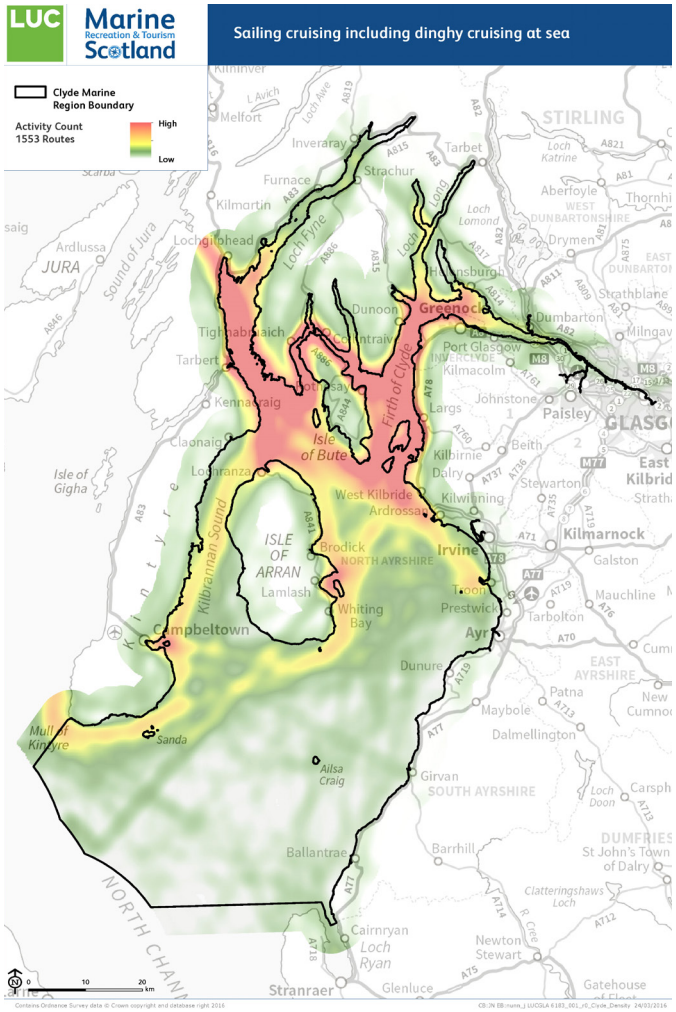
- extensive upgrade of the Campbeltown Berthing Facility (2015) funded by Argyll and Bute Council, together with contributions from Highlands & Islands Enterprise and other partners;
- extensive upgrade of Rhu Marina and investment by The Crown Estate that was completed in 2012, with 60 new berths, a new toilet and shower facility and floating breakwater;
- expansion of Ardrossan marina in recent years and increased capacity to 280 berths;
- upgrade of pontoons at Tarbert Harbour supported by an award of £500,000 from the Coastal Communities Fund in early 2015; and
- investment in Troon.

In addition to marinas and sailing clubs, there are numerous moorings and around 100 small vessel anchorages at various locations throughout the Clyde region[502] that further add to the infrastructure capacity within the Clyde. Map 25 shows the locations of sites with 20 or more moorings.

502. The Clyde Yacht Clubs' Association

Figure 6.34 Heat map of Sailing activity

N.B. These maps are available at the national scale on NMPi

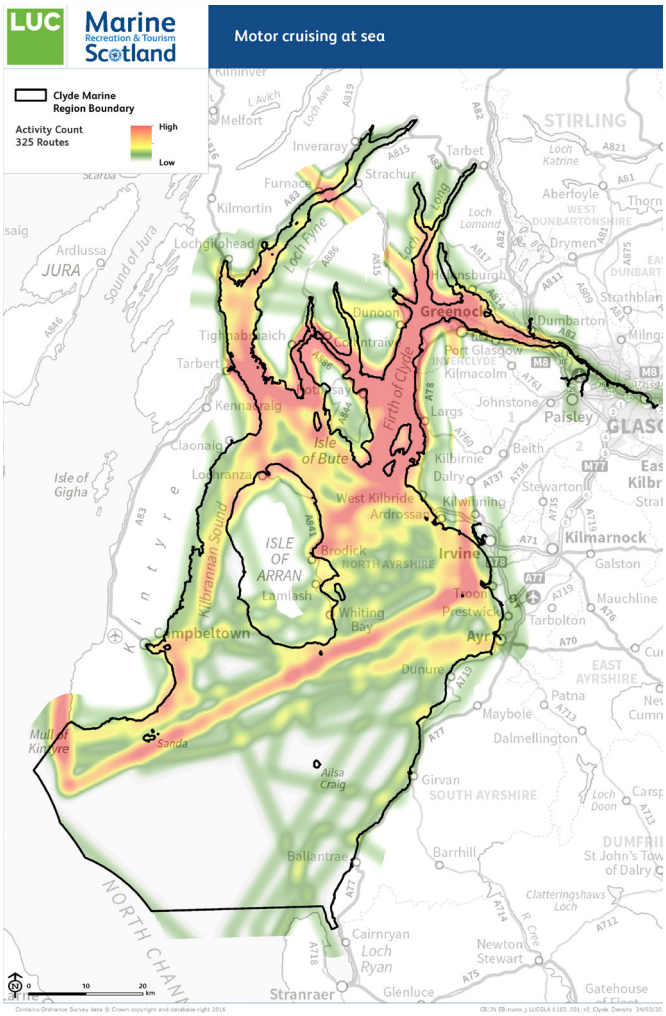


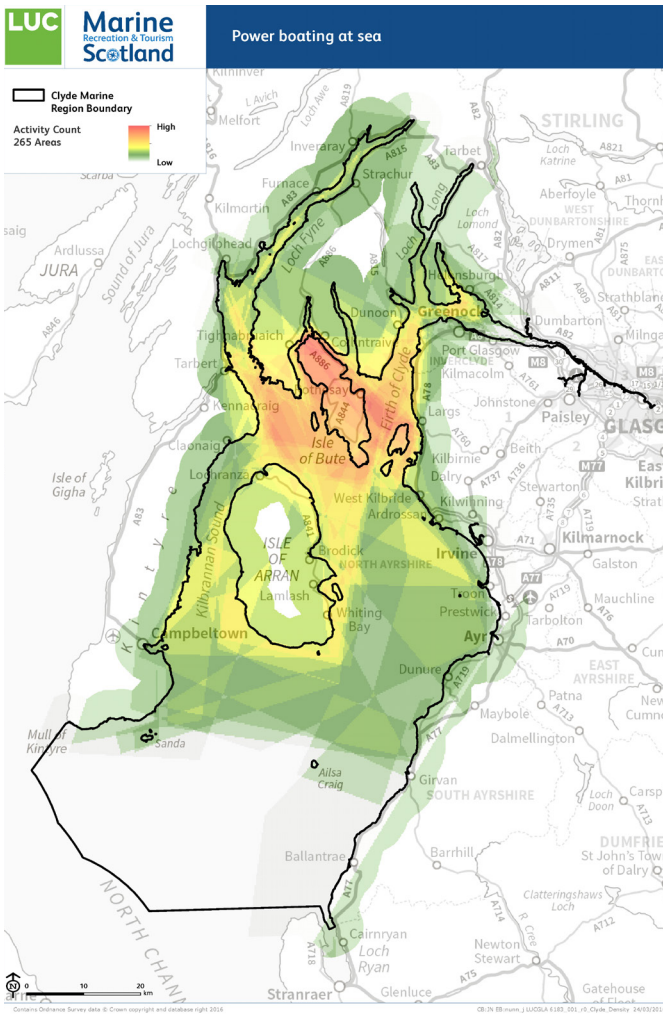
Source: SMTRS



Sailing © PETER SANDGROUND

Figure 6.35 Heat maps motor at sea and power at sea
N.B. These maps are available at the national scale on NMPi





Source: SMTRS

Other Water Sports and Diving

The Argyll Sea Kayak Trail runs for 150km between Helensburgh and Oban. A large portion of the trail is contained within the Clyde, going from Helensburgh around the Cowal Peninsula and the north of Bute to Loch Fyne, before going through the Crinan Canal.

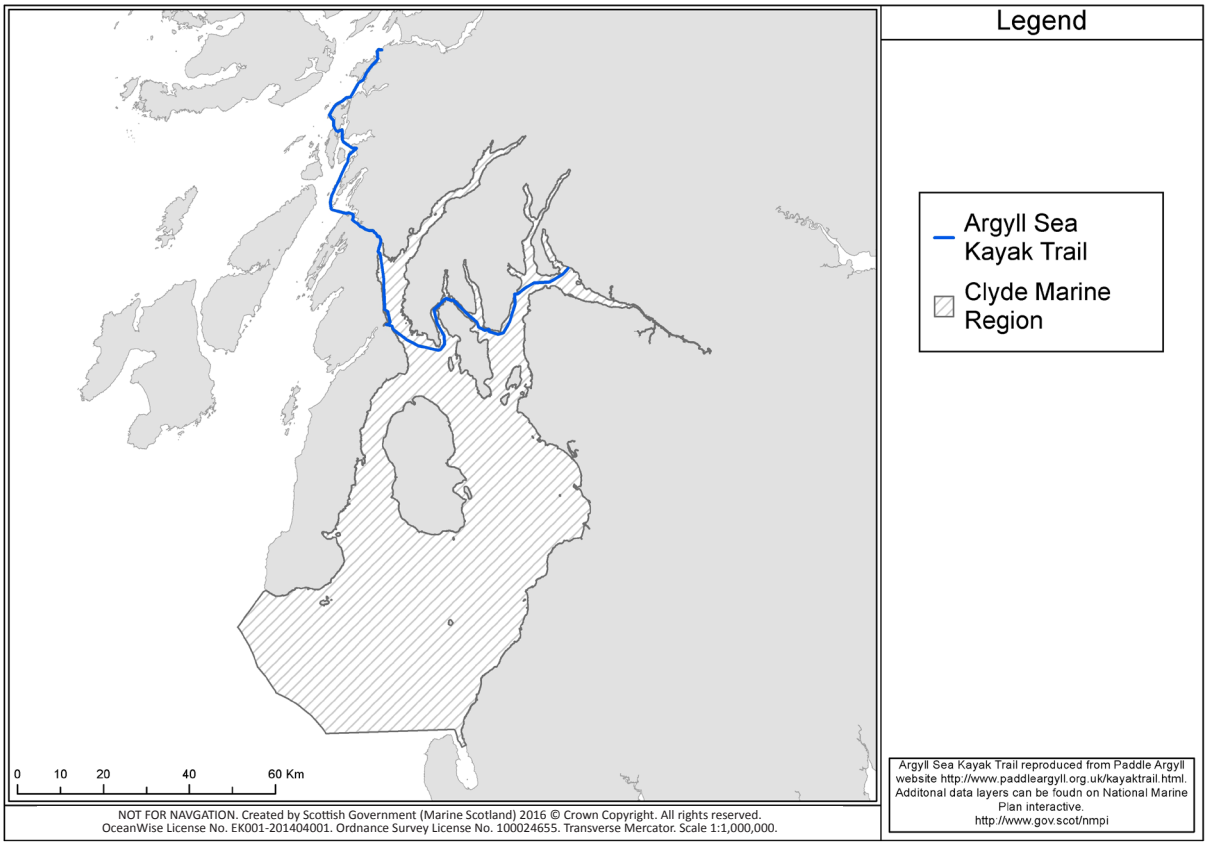
Coastal rowing is becoming more popular with 12 clubs located throughout the region. In 2010 the Scottish Coastal Rowing Association was formed to encourage boat building and rowing and racing of coastal rowing boats around the coastline, and there are regular events and regattas held throughout the year.

Sportscotland's National Watersports Centre in Cumbrae and the Arran Outdoor Education Centre offer a range of outdoor activities to schools and other groups. Along with sailing, they offer marine/coastal activities including: windsurfing, kayaking and abseiling.

A small number of diving charter operators are based in the Clyde and several businesses offer boat trips, although these are more seasonal activities. There are several dive clubs located within the CMR which dive both the local area and further afield. There is an opportunity to increase the use of the CMR by both local and other dive visitors in the future.

A canal-side Glasgow 2014 legacy project in the north of Glasgow offers a range of activities, including outdoor swimming, rafting, kayaking and canoeing within the canal basin. As well as providing a training centre for elite athletes, it aims to increase public participation in water sports and to attract 25,000 visitors a year.

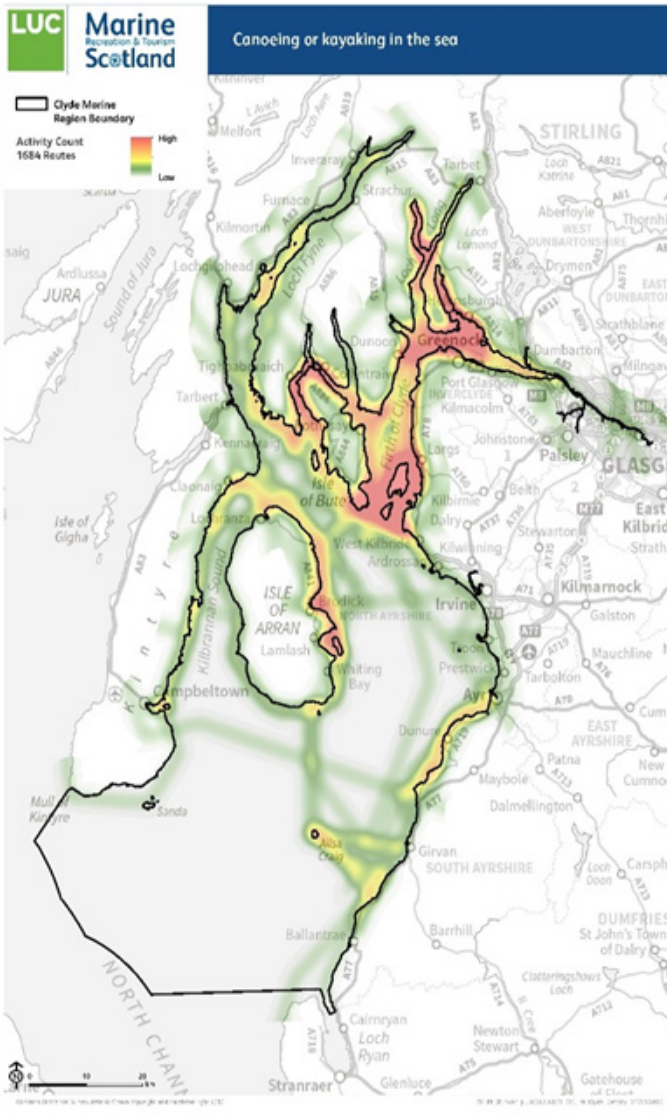
Map 26. Argyll Sea Kayak Trail

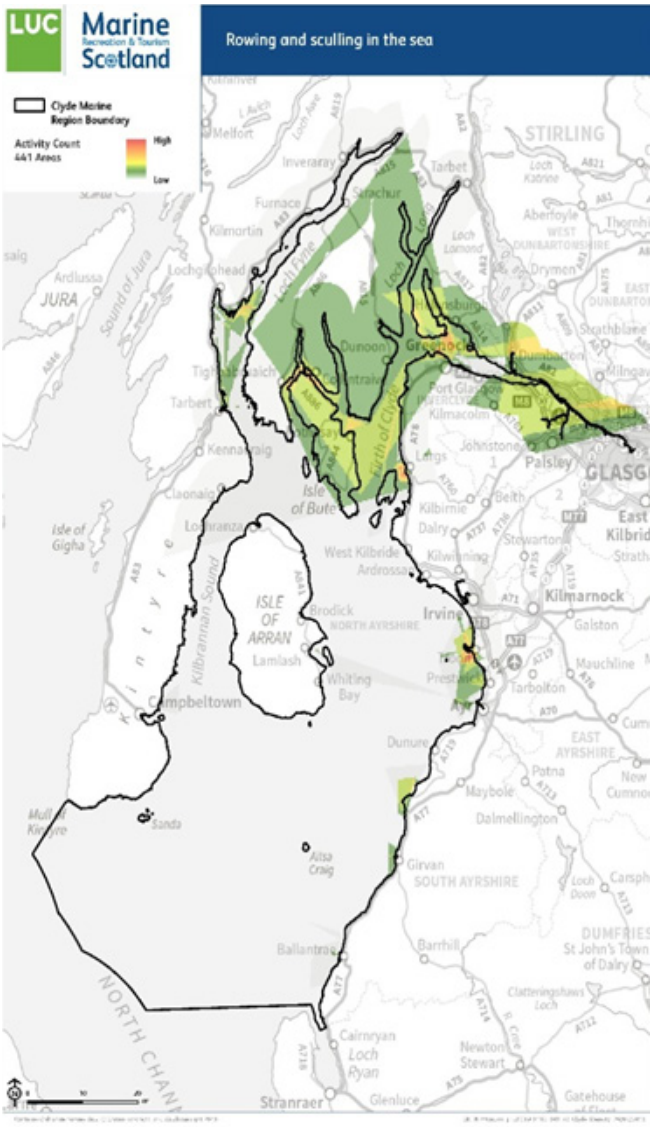




Racing boats © JIM BYRNE

Figure 6.36 Heat Maps of Canoeing, Kayaking and Rowing and Sculling at sea
N.B. These maps are available at the national scale on NMPi





Source: SMTRS

Beaches and Bathing Waters

Keep Scotland Beautiful co-ordinates two beach award schemes, the Blue Flag and the Seaside Award. Across the CMR, three beaches achieved the Seaside Award in 2015: Maidens and South Ayr, both on the South Ayrshire coast, and Newton Beach in Millport. To gain this recognition, beaches must demonstrate excellent management and environmental practice.

The Ayrshire coastline has a number of large sandy beaches, which, given their proximity to major population centres, are popular during the summer months. The Clyde islands also boast a number of beaches. These beaches are also popular for recreation activities such as kite and wind surfing, paddle boarding and surfing. For further information on bathing waters monitoring, see Chapter 4.4 Microbiological contamination – bathing waters.

Salmon and Sea Trout Fishing and Sea Angling

Scotland is a popular destination for salmon and sea trout fishing, as well as other types of open sea angling. Of the three methods of salmon and sea trout fishing in Scotland, only the rod and line method is used in the CMR and this generally takes place in rivers and above tidal limits and is therefore predominantly land based. Sea angling is the catching of sea fish for pleasure and/or 'for the pot' using a hook. A report from 2009 estimated that Glasgow and the West contributed a total annual sea angler expenditure of £24 m and has 23,548 resident sea anglers, the largest of any region in Scotland. It also estimated a contribution in terms of employment of 523 jobs and £12 m income in the region.[503]

503. Marine Scotland, 2009b

Salmon and Sea Trout Fishing

Salmon and sea trout fishing rights in Scotland are held privately, however, Marine Scotland collects catch statistics on an annual basis. As it is classed as a recreational activity, rod fishermen cannot sell their catch.

In 2014 a total of 8,750 kg of salmon and grilse, and sea trout and finnocks[504] were caught in the CMR, of which 70% was released, table 6.14.

Figures 6.37 and 6.38 show the change in retained and released stock. Across wild salmon and trout there has been a notable decline in the numbers retained, –71% since 2005.

Map 27. Salmon Fishing Rivers in the Clyde Marine Region

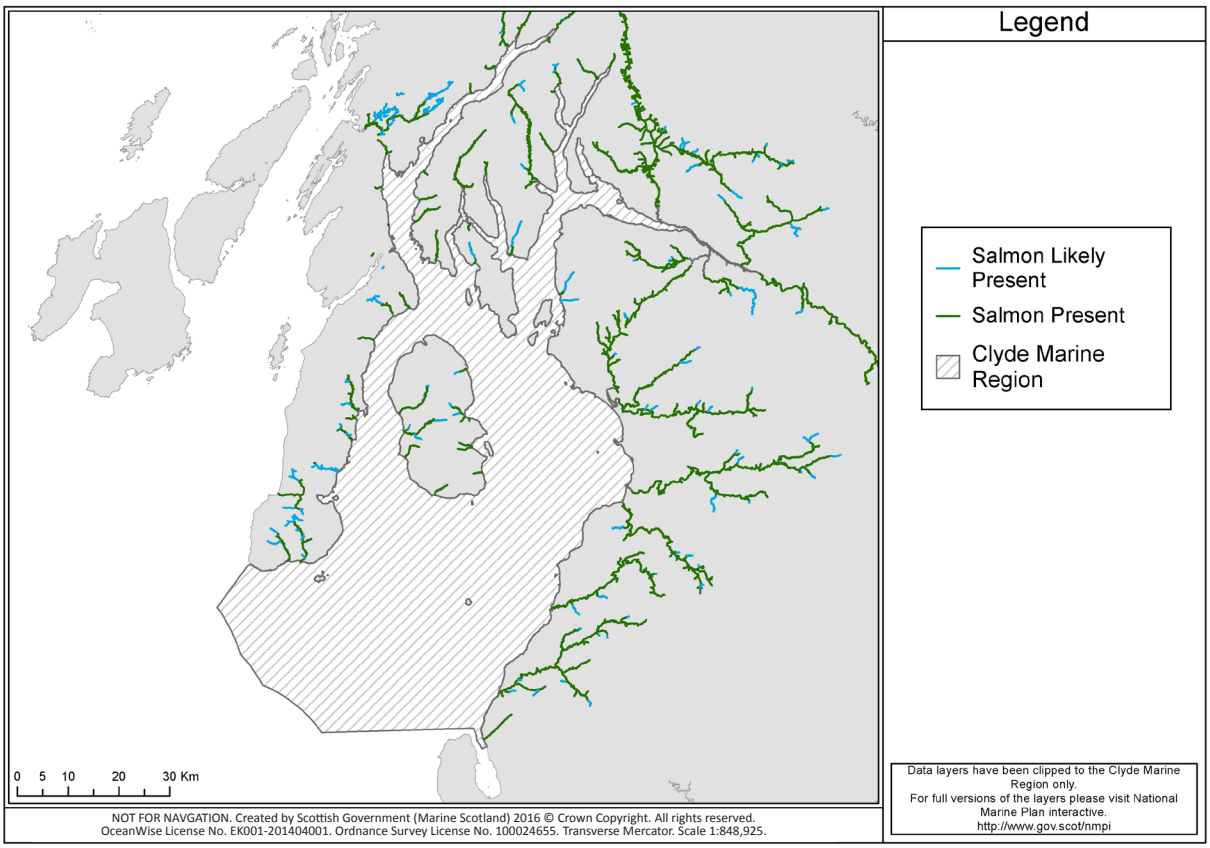
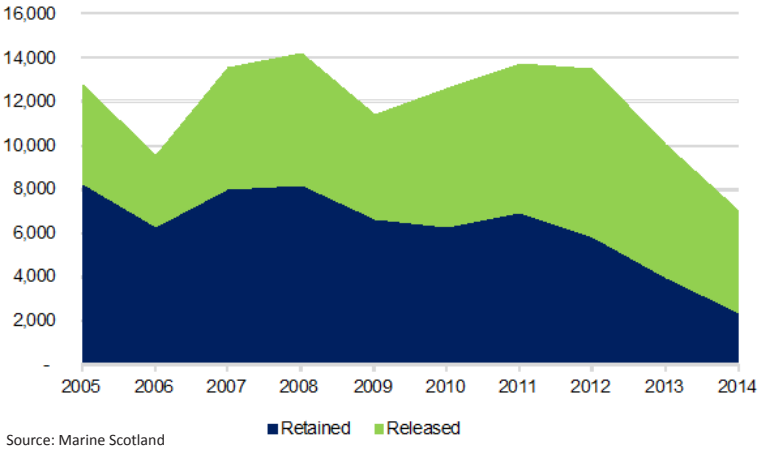


Table 6.14 Clyde Marine Region, Salmon and Sea Trout Catch 2014

	WILD SALMON AND GRILSE		SEA TROUT AND FINNOCK	
	NUMBER	WEIGHT (Kg)	NUMBER	WEIGHT (Kg)
Total	2,136	7,059	2,110	1,691
Caught	696	2,390	175	193
Released	1,440	4,669	1,935	1,498

Source: Marine Scotland

Figure 6.37 Clyde Marine Region: rod and line salmon and grilse Catch (Kg)



Source: Marine Scotland

504. Grilse and Finnock are young Salmon and Trout

Figure 6.38 Clyde Marine Region: rod and line sea trout and finnock catch (Kg)

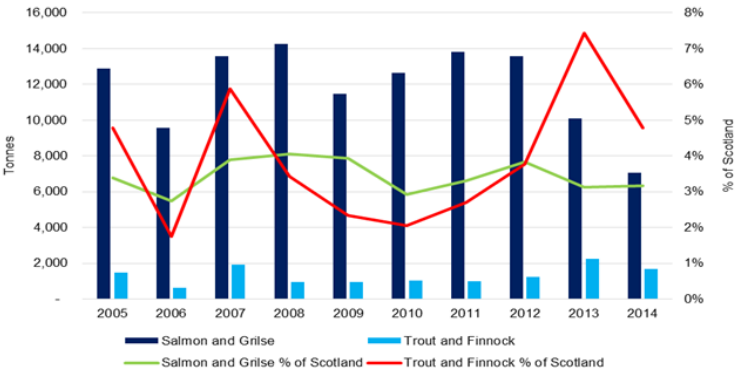


Source: Marine Scotland

In 2005, one in two trout was retained and in 2014 it dropped to one in ten. Similarly for the salmon catch, the numbers retained were two of every three caught (in 2005), this has now fallen to one in three. This is likely to be driven by the behaviour of anglers who are now more likely to release stock due to an improved understanding of the threat to stocks of these species.

However, it should be noted that the CMR has only marginal catches of wild salmon and sea trout, comprising only 3% of the total salmon and grilse and 5% of trout and finnock catch for Scotland, see Figure 6.39.

Figure 6.39 Wild Salmon and Trout



Source: Marine Scotland

Salmon fishing in the CMR is now regulated by 'Spring Conservation Measures' which ensure that no salmon is taken in Scotland before 1st April each year, and 'Conservation Status' regulations, the key aspects of which are as follows:

- killing beyond estuary limits will be prohibited for three years due to the mixed stock nature of the fishery and limited data on the composition of the catch;
- the killing of Atlantic salmon in inland waters will be managed on an annual basis by categorising fishery districts by their conservation status;
- a requirement to have a Conservation Plan irrespective of the conservation status; and
- the introduction of carcass tagging[505] for net-caught fish for areas in category 1 and 2. The costs for producing the tags will be, in the first instance, subsumed by Marine Scotland.

For further details see the Scottish Government website.[506]

Sea Angling

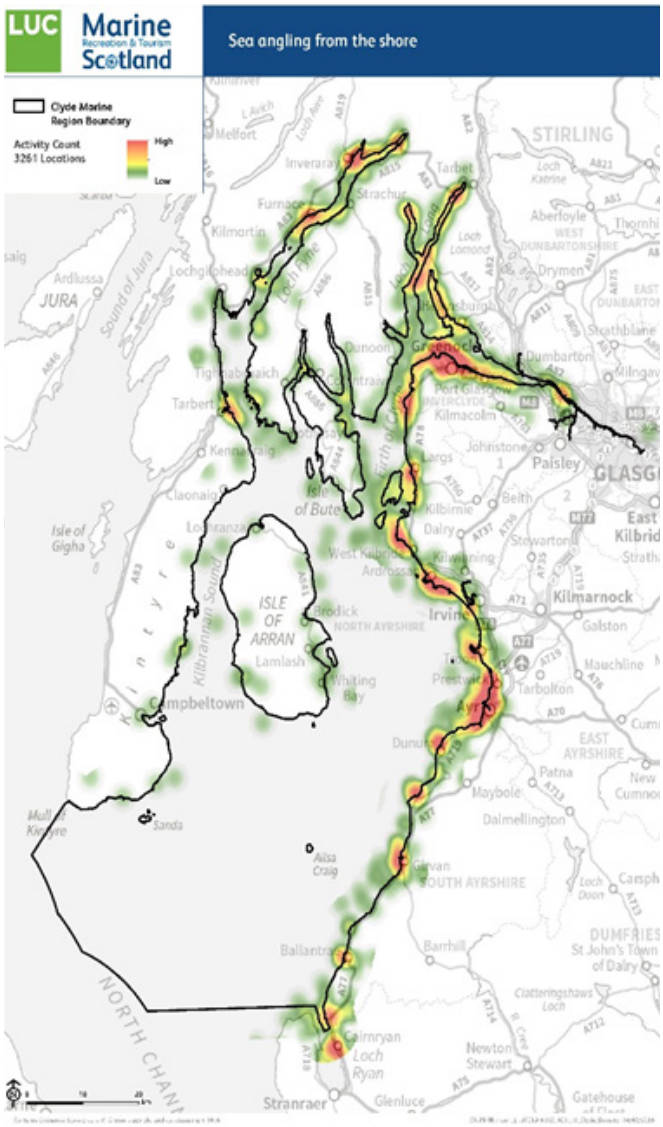
Sea angling can be done from land or sea through private or commercial fishing charters. A 2009 study[507] that considered the estimated economic impact of sea angling in Scotland identified the impact at the greater Glasgow and West of Scotland level:

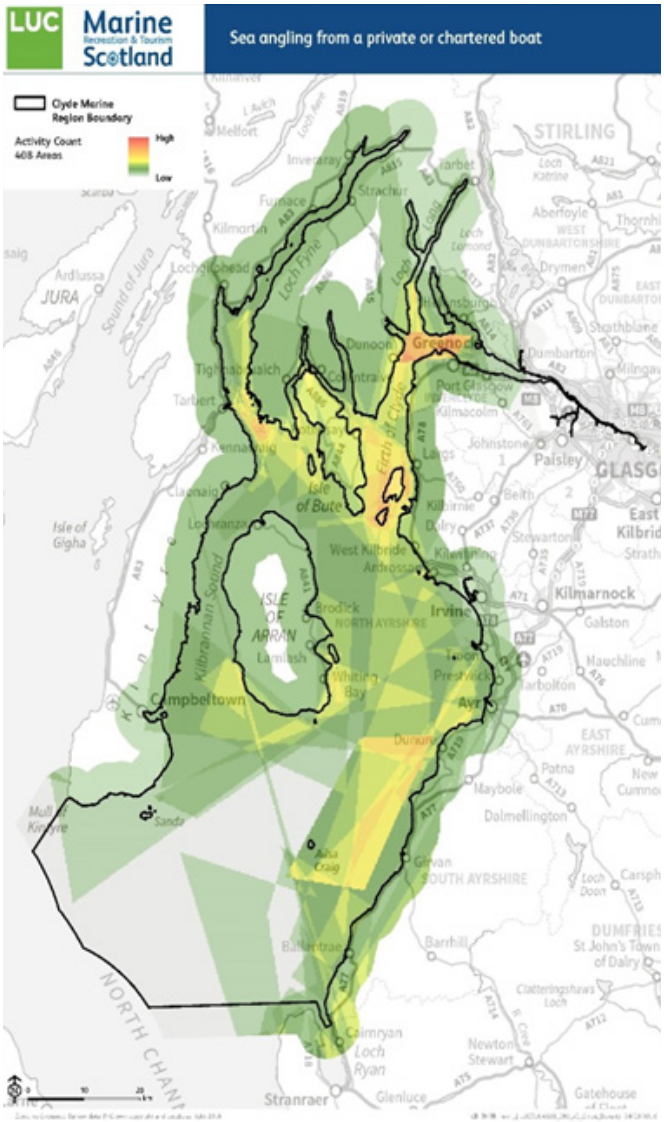
- 62% is undertaken by boat, and 38% land based;
- the top three target species in the region are mackerel, cod and pollack;
- there were 250,000 annual 'angler days' – primarily driven by the region's proximity to a large population base; and
- in 2009 sea angling generated and estimated £24.1m in gross expenditure, around 17% of total sea angling expenditure in Scotland.

While sea angling makes a notable contribution to the regional economy, the study identified that the quality and diversity of fish species has declined in the region and as a result it is no longer a popular destination with visiting angler, the SMRT survey shows a significant residual activity however which could be built on with good practice in catch and release and an improving ecosystem, in particular the availability of fish stocks. The majority of anglers in the 2009 study (95%) were from within the greater Glasgow and West of Scotland region.

505. The Salmon Carcass Tagging (Scotland) Regulations 2016
506. The Scottish Government, 2016b
507. The Scottish Government. 2009

Figure 6.40 Heat Maps of Sea Angling Activity
N.B. These maps are available at the national scale on NMPi





Source: SMTRS

Wildlife Tourism

Coastal and marine wildlife tourism attracts visitors to view, study and enjoy wildlife, including birds, sea and land mammals, fish, and coastal habitats. Within the CMR there are four RSPB reserves (all of which are in coastal locations and includes Ailsa Craig which is home to the third largest gannetry in the UK with 33,000 pairs – see Chapter 5.8 Seabirds and waterbirds) and 13 Scottish Wildlife Trust reserves (none of which are in coastal locations). These recognised reserves and other areas for watching wildlife will attract visitors to the region. Visitors should always use the Scottish Marine Wildlife Watching Code.

The area around the south of Arran and the tip of Kintyre is a particular hotspot for basking sharks each summer, while seals and seabirds also attract visitors across the CMR. There are also sightings of porpoises, dolphins and minke whales in the Clyde (see Chapters 5.5 – 5.8).

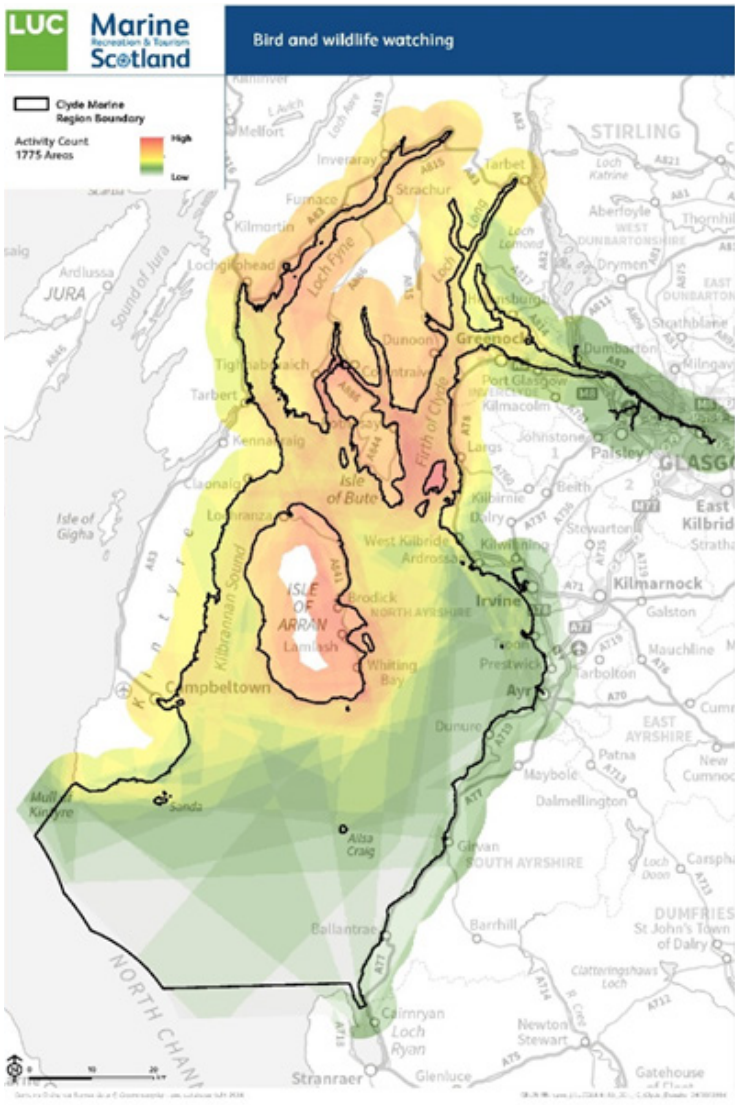
From the total impact of wildlife tourism in Scotland, around 30% of employment and income is generated in the Wider CMR and surrounding local authorities (including East Ayrshire and Dumfries and Galloway).

Table 6.15 Gross Impact of Wildlife Tourism in Scotland

	INCOME	EMPLOYMENT
Terrestrial wildlife tourism	£114m	3,061
Marine wildlife tourism	£63m	1,704
Coastal wildlife tourism	£100m	2,681

Source: The Scottish Government, 2012b. Generated using industry standard multipliers which attribute a proportion of other spend e.g. on accommodation.

Figure 6.41 Heat Map of Bird and Wildlife Watching
N.B. These maps are available at the national scale on NMPi



Source: SMTRS

Events

A variety of marine events are held in the region – a mix of annual and one-off events, and leisure and sport. This includes:

- **Scottish Series** – Bills itself as the premier yacht racing event in Scotland and is held each May in Tarbert, Loch Fyne which has hosted the event since 1977 and remains an important contributor to the local economy;
- **Glasgow River Festival** – This two day festival was held each summer between 2004 and 2009, and featured a variety of events on water and land. Scotland's marine tourism strategy (2015) includes an ambition to relaunch the river festival and Clyde fortnight, a historic yachting event.
- In 2014, the **Commonwealth Games** cultural programme featured a flotilla of 250 boats which sailed to the city centre;
- Launched in 2011, **The Tarbert Traditional Boating Festival** is held each July and attracts 30 to 40 traditional boats to the town;
- The international **Tall Ships Races** were held in Greenock in 1999 and 2011, drawing hundreds of thousands of visitors on each occasion - the 2011 race helped attract 700,000 visitors to Inverclyde and additional spend of £10.4m;[508]
- **The Fife Regatta** which stats at Largs Yacht Haven and sails along the west coast, and involves boats from all over the world. These wooden boats were designed and built by one of Scotland's most famous boat builders, William Fife, in the Clyde Estuary during the 19th century.
- **The Largs Viking Festival**, held to celebrate the Battle of Largs, which ended the Viking influence in Scotlan, takes place over one week in late August/early September and includes a Viking village and the burning of a longship. In 2012, the festival attracted 29,000 visitors and led to additional spend of £250,000 in the local economy.[509]
- **The World Laser Radial Championships** held at Largs Yacht Haven (the first Olympic class sailing event held in Scotland) in 2010 generated around £1 m for the Ayrshire economy.

Canals

Once important commercial routes, Scotland's canals are now primarily used for leisure and recreation. There are two canals in the CMR:

- **Crinan Canal**, which is nine miles long and intersects the north of the Kintyre peninsula between Ardrishaig and Crinan; and
- **Forth and Clyde Canal**, which is 35 miles long and meets the Clyde at Bowling, crosses north of Glasgow and eventually meets the River Forth at Falkirk.

Nationally, there are 22 million visits to canals each year, with 99.7% of these being to towpaths, involving activities such as running, walking or cycling.[510] Recreational use of canal towpaths has increased substantially in recent decades and is up from the 4.5 million visits in 1997.

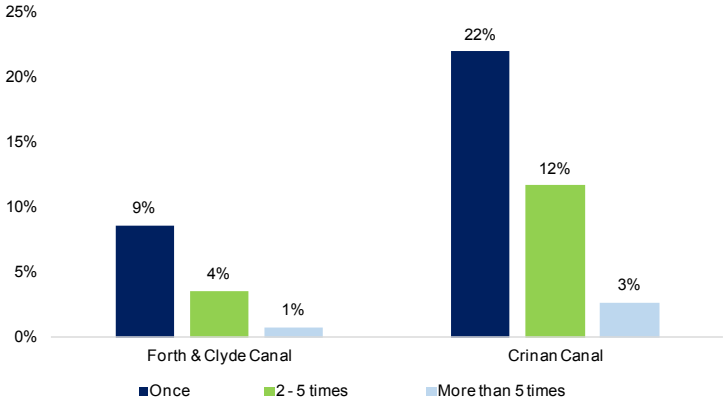
Canals in Scotland are operated by Scottish Canals, which is owned by the Scottish Government and employs around 280 staff (some seasonal), with revenue of £10.3m at a national level in 2014-15, supplemented by an £8m government grant.

Scottish Canals has also been involved in regeneration projects along the Forth and Clyde Canal, including the Lambhill Stables community hub and social enterprise project.

508. The Chartered Institute of Logistics and Transport, 2011
509. EKOS, 2012
510. Scottish Canals, 2015

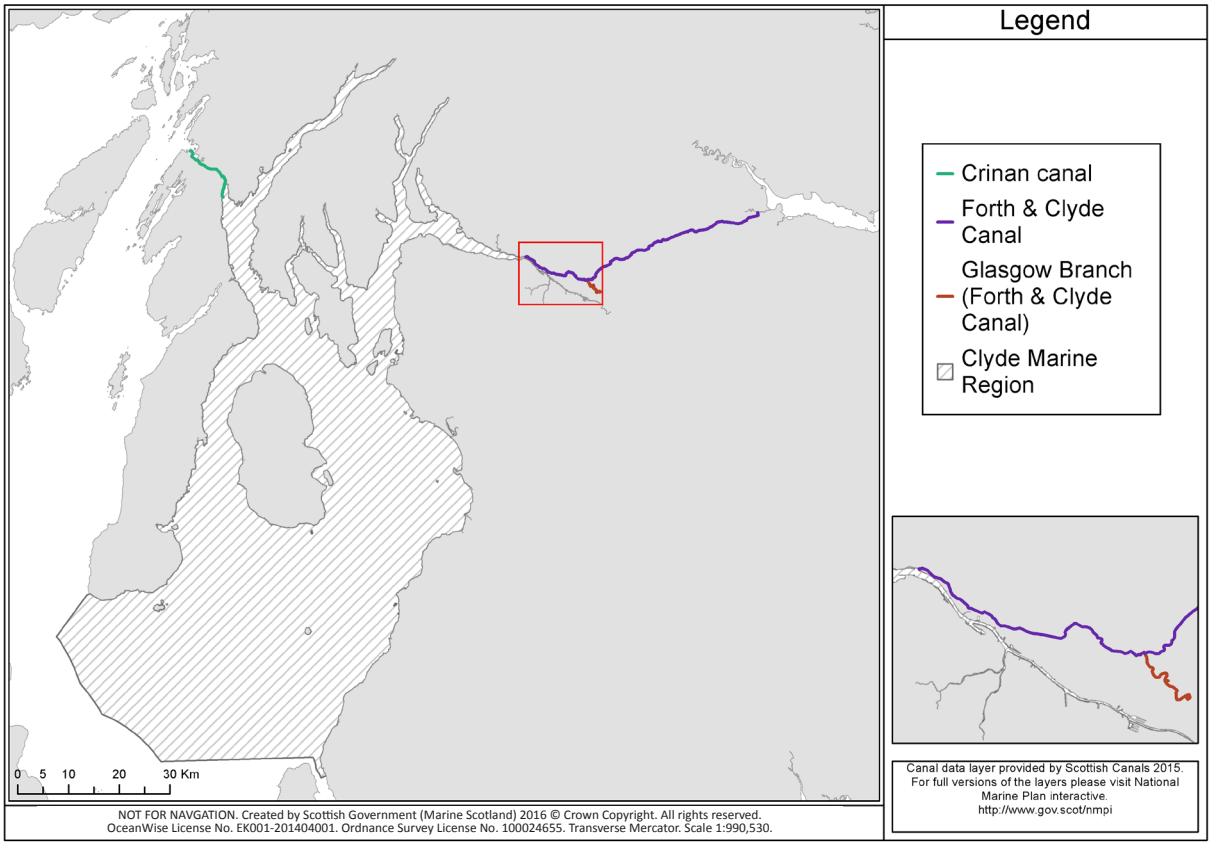
The SMRTS asked respondents who had been sailing or power boating in the last 12 months how many times they had used Scotland's canal system. In the CMR, a total of 14% had made use of the Forth and Clyde Canal at least once, while 37% had used the Crinan Canal. The Crinan Canal remains a crucial route for sailing and boating enthusiasts in the Clyde to access more northerly areas and vice versa. The SMTRS identified its increasing importance to other watersports participants, particularly kayakers as well as coastal walkers.

Figure 6.42 Canal Use by Recreational Boaters Over 12 Months



N=256 and 301 Source: SMTRS

Map 28. Canals in the Clyde Marine Region



Coastal Paths and Walks

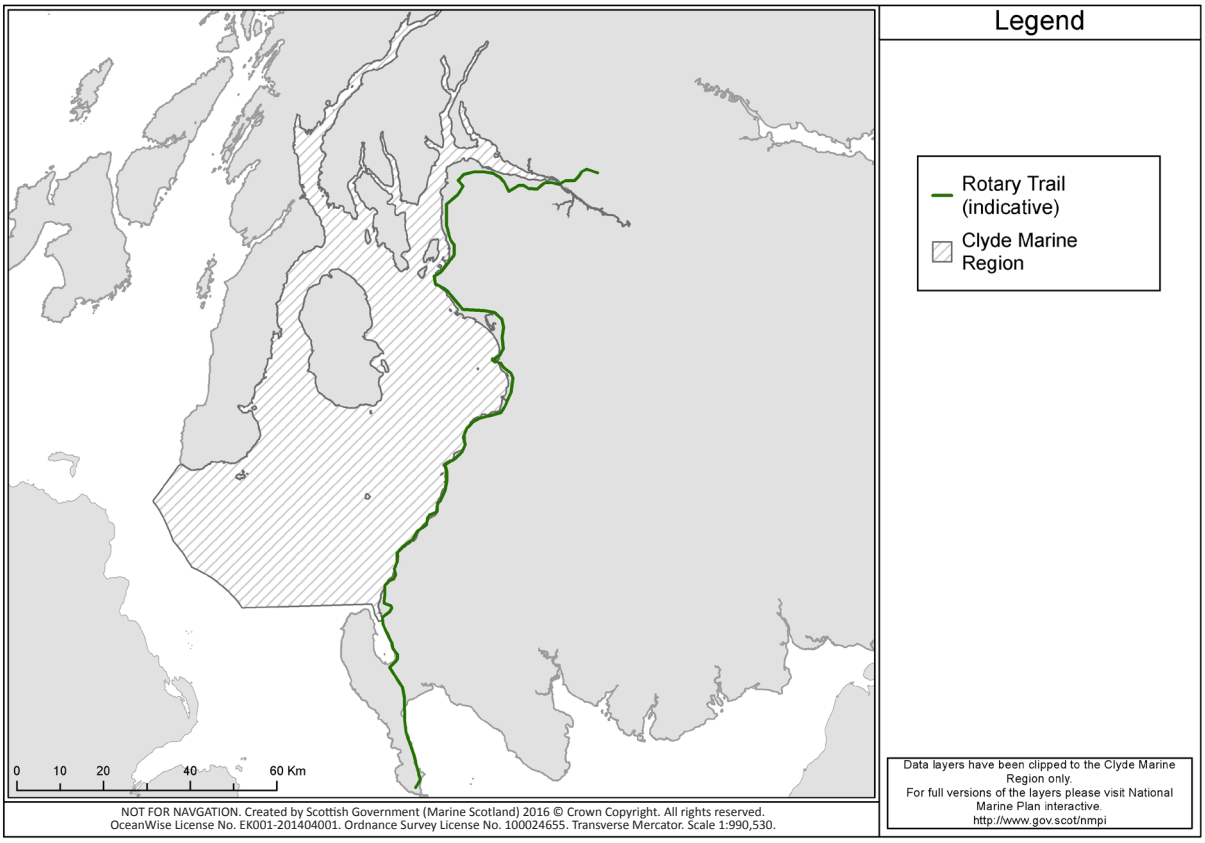
There are numerous recognised and more informal coastal paths and walks in the region. The more established coastal paths and long distance walks that are partly or wholly within the region include:

Coastal Paths:

- **Clyde Coastal Path** – 55km path that runs from the top of the Ayrshire Coast to the West Highland Way;
- **Ayrshire Coastal Path** – 160km from Glenapp in South Ayrshire to Skelmorlie in Inverclyde;
- **Cowal Way** – 92km from Portavadie in Argyll and Bute to Inveruglas at Loch Lomond;
- **Arran Coastal Way** – 105km circular route which follows the coast of Arran;
- **Kintyre Way** – 161km from Tarbert to Dunaverty in Argyll and Bute; and
- **West Island Way** – 40km across the length of Bute and is Scotland's first official island long distance footpath, opened in 2000 to celebrate the Millennium.

In July 2015 the Firth O' Clyde Rotary Trail was officially opened, which joins up three important coastal paths – the Mull of Galloway Trail (which runs from the Mull of Galloway to Glenapp via Stranraer) the Ayrshire Coastal Path and the Clyde Coastal Path. The new long distance path is 266km long and will be a boost to walking tourism in Scotland.

Map 29. Firth O' Clyde Rotary Trail



Long Distance Paths:

- **the Forth and Clyde Canal** – 56km from Grangemouth to Bowling;
- **the Three Lochs Way** – 55km runs from Balloch to Inveruglas and takes in Gare Loch, Loch Lomond, and Loch Long;
- **the John Muir Way** stretches 215 km coast to coast across central Scotland running from Helensburgh to Dunbar on the east coast and Muir's birthplace; and
- the **Firth O' Clyde Rotary Trail**

Cycle Routes

Many of the National Cycle Network (NCN) routes in the area take in stretches of coastline. The key routes with a coastal element are:

- **NCN Route 7** – runs between Sunderland and Inverness, taking in part of the Ayrshire coastline and the canal/riverside path between Glasgow and Loch Lomond;
- **NCN Route 73** – runs between Kilmarnock and Lochranza at the north end of the Isle of Arran;
- **NCN Route 75** – runs between Edinburgh and Portavadie on the Cowal peninsula, running along the Clyde coast where it meets the Gourock to Dunoon ferry.
- **NCN route 753** – continues along the Clyde coast to Ardrossan;
- **NCN Route 78** – runs between Campbeltown and Oban.

6.5.2 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of the sport, recreation and tourism sector is provided below.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Sustainable tourism is recognised as a key growth sector and the Scottish Government has outlined ambitious plans to grow the sector • Opportunity for sailing supply chain - boat rental and repair and chandlers, etc. • Marine and coastal events attract significant numbers of visitors every year • Availability and access to outdoor activities contributes to the healthy living agenda • Enhanced policy focus on the development and promotion of skills and training related to marine tourism	• Competition for coastal locations and routes – although numerous bodies are responsible for management and co-ordination of activities at discreet geographical routes, there is nocoordination across routes. • Seasonal employment that is often considered 'lower value' • Increased activity and usage could lead to an increase in litter from recreational activity, potentially damaging the perception of the area and attractiveness as a tourism destination • There is an identified skills gap in marine tourism that is being addressed via the Marine Tourism Strategy

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Pollution	Introduction of hazardous substances	Recreational boats and commercial charters that use the marinas and harbours are likely to be treated with antifoulant to protect the bottom of the boat from fouling. The Green-Blue provide guidance for recreational boaters on the use of antifoulants. There is also the potential for sewage discharge from marine toilets.
Habitat change	Habitat damage	The development and expansion of breakwaters, jetties and marinas (including land reclamation) lead to disturbance of the seabed and coastline and may lead to changes in erosion and accretion patterns; there is regulatory guidance in place to help minimise and mitigate against these potential impacts. Growth in recreational use of the CMR may lead to environmental damage from erosion, disturbance to wildlife and other damage to sensitive habitats such as salt marshes and dune systems.
Other physical	Litter	The increased use of the water and coastal areas for recreation and leisure could lead to an increase of littering. Not only does this impact on the visual amenity, there is a risk to marine wildlife for example through entanglement or suffocation, as well as to people using the water for recreation. Marine Litter is a Descriptor under the EU Marine Strategy Framework Directive and has the objective of decreasing overall levels of shoreline litter. There are a number of schemes targeted to raise awareness and address the issue of littering/dumping waste, including; Keep Scotland Beautiful, the Green Blue; MCS Adopt a Beach and Beachwatch; Bag it and Bin it; Surfers Against Sewage and the GRAB Trust, see Chapter 4.8 Marine Litter.
	Underwater noise and disturbance	No Clyde specific studies have been undertaken, however, anecdotal evidence suggests that birds and water fowl will usually adapt to the noise and vibration of marina/harbour activity, but there may be an adverse impact on some fish and cetacean species. See Chapter 4.9 Noise. When observing marine mammals always follow the Scottish Marine Wildlife Watching Code.[511]
Biological	Introduction of INNS	Within the CMR there are 11 Non-Native Species (NNS) identified in the biosecurity plan that are of 'concern'. Organisms living on vessel hulls and equipment used in the water are just two 'pathways' by which NNS can be introduced. The GB non-native species secretariats 'Check, Clean, Dry' campaign, is supported by The Green Blue and aims educate water users and promote biosecurity.[512]

511. Scottish Marine Wildlife Watching Code, 2017
512. Great Britain Non-native species secretariat, b



Squinty bridge © JED

6.5.3 Regional Look Forward

The Marine Tourism Plan for Scotland has outlined its visions as follows: 'By 2020 Scotland is a marine tourism destination of first choice for high quality, value for money and memorable customer experience delivered by skilled and passionate people.' Economic growth in marine tourism looks likely to continue to be driven by the sailing/boating sector which offers significant potential as the sector looks to build on recent success, including being voted the 'World's Best Cruising Ground' in the Sailing Today Awards.

While it is recognised that the greatest level of economic growth will come from sailing, anecdotal evidence suggests that watersports such as kayaking and coastal rowing are also growing in popularity. There could also be potential to increase the number of divers visiting the area.

One of the potential challenges for the sailing sector is that there is no central point of data available on the current capacity of marinas, or the likely levels of demand for berths/moorings in the future. This could potentially impact upon the sector's ability to meet future demand. The sailing sub-sector is a key economic driver that will contribute towards the ambitious targets of the Marine Tourism Plan and it is therefore crucial that up-to-date and robust data are available to inform the planning and development process.

There are a number of ambitious proposals for tourism developments around the region, for example, the proposed Ben Arthur resort at the head of Loch Long, which includes a 130-bed five star hotel, lodges and a 250 berth marina.[513] The proposals have been granted planning permission but are currently on hold.

As part of the Clyde Waterfront regeneration project there are proposals for the world's first 'floating leisure village' at the Canting Basin at Pacific Quay. The development could create up to 450 local jobs and transform the Canting Basin into a spectacular floating community comprising shops, offices, houses, restaurants, a marina and a roof-top concert arena.[514] Bowling Harbour is also going through significant development planning with the master plan for the area showing ambitious plans for not only harbour facility improvements but housing and other types of recreation as well.

As shown in the SMRTS there are a number of recreational activities that take place by the coast including general recreation activities, walking, bird/wildlife watching and visiting historic sites. It is therefore important that spatial planning takes account of the different needs and competing coastal uses. In years to come, economic and social benefits are likely to be seen from the newly established MPAs in the CMR. There are plans to develop a new marine discovery centre for the Isle of Arran to interpret the South Arran Marine Protected Area (MPA) and help to realise the full economic, social and environmental benefits of the MPA.

In terms of recreational fishing, the attitudes of salmon and trout anglers has changed in recent years with a greater focus on conservation i.e. much of the catch is released. In addition, the Spring Conservation Measures (introduced in 2016) includes a number of measures to safeguard salmon stocks in Scotland.

Sea angling activity has experienced a decline in the region, mainly due to a decrease in the number and diversity of fish stocks/species. In fact the CMR has the highest negative net flow of angler days (-140,000) i.e. more people leave the region to participate in sea angling than come into the region. An improvement in the availability of large individuals, in particular whitefish species may be an opportunity to grow this activity.

513. Urban Realm, 2012
514. Clyde Waterfront

6.6 Defence

Summary

Ministry of Defence (MoD) activities in the Clyde Marine Region (CMR) are concentrated at Her Majesty's Naval Base (HMNB) Clyde. The base, known as Faslane, sits on the eastern shores of Gare Loch and is home to the core of the Submarine Service, including the UK nuclear deterrent Trident, and the new generation of hunter-killer submarines; specifically designed for the purpose of locating and destroying other submarines.

There is also a Naval Armaments Depot located nearby at Coulport which is responsible for the storage, processing, maintenance and issue of key elements of the UK's Trident Deterrent Missile System. In addition to the naval base and storage facilities, the waters in the CMR are used for training and conducting naval exercises and by military vessels including the submarines.

Faslane is the largest single site employer in Scotland with around 4,900 jobs. Activities include on-site naval personnel as well as civilian population working at the base.

Defining the Sector

The economic contribution of the Defence sector is measured from official MoD statistics for MoD personnel.

6.6.1 Contribution to the Economy

Employment

The bulk of defence employment in the CMR is at Faslane and Coulport. Direct MoD employment by local authority is presented in table 6.16.

Defence employment has fallen by -9% since 2011, with the largest fall amongst MoD civilian staff at -14%, whilst military staff has fallen by -7%, figure 6.43.

Table 6.16 MoD Employment, 2015

	INCOME	MILITARY	MOD CIVILIAN STAFF
Argyll & Bute	4,690	3,300	1,390
North Ayrshire	260	0	260
South Ayrshire	20	20	-
Clyde Marine Region	**4,970**	**3,320**	**1,650**

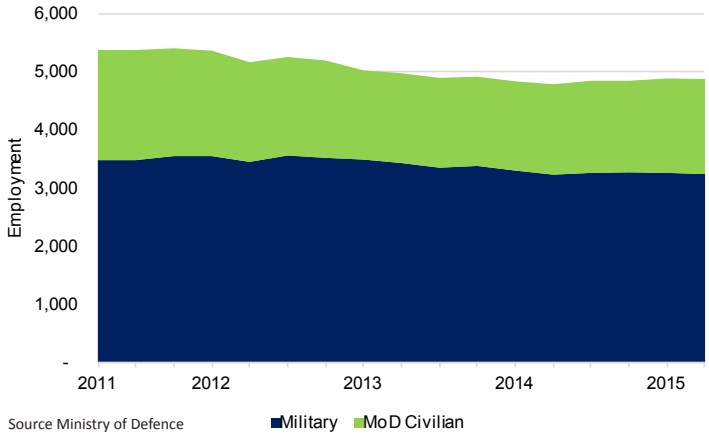
Source Ministry of Defence,[515] BRES (2014)



Submarine in the Clyde © J. E. DONNELLY

515. Ministry of Defence, 2014 & 2016

Figure 6.43 Clyde Marine Region: MoD Employment 2011–2015[516]



Source Ministry of Defence

In addition to direct MoD employment indicated above, there is also considerable civilian contractor employment on the site at Faslane. Evidence submitted to the UK parliament Scottish Affairs Committee in 2012 states that there are 1,650 civilian contractors working at the base, including 1,470 employed by Babcock. They are employed in a variety of roles from submarine engineering to facilities management.[517]

Economic Output – Turnover and GVA

Turnover and GVA statistics are unavailable for the defence sector due to reasons of security and are not collected by either the Annual Business Survey or the Scottish Annual Business Statistics.

There have, however, been studies that have estimated the economic impact of activity at Faslane in the local economy, with a 2013 study[518] estimating that it contributes around £90m per annum to the Helensburgh and Lomond economy; however there are no estimates of the impact on GVA or local salaries.

When considering the economic effects at the CMR level, the knock-on impacts provided by a strong supply chain add further value to activity at Faslane. For example, Babcock International is one of the primary civilian contractors that provide services to Faslane and 80% of employees live within the wider CMR.[519] This retains economic activity in the region and the economic contribution at the CMR level is likely to be greater due to these supply chain linkages.

Defence Activity

The MoD uses various locations throughout the west coast of Scotland for stationing Royal Navy vessels, armament and fuel depots, and conducting training exercises. Details about these facilities are often secret or not publicised, making an assessment of defence activity in the region challenging.

Naval assets based at HMNB Clyde include:[520]

- four vanguard class ballistic submarines, which when at sea are armed with eight trident nuclear ballistic missiles containing a total of 40 nuclear warheads. A single submarine is always at sea maintaining a continuous deterrent whilst the remainder are at various stages of maintenance, refit or engaged in training exercises;
- Royal Naval Armaments Depot, Coulport acts as a munition storage and loading facility for the submarine fleet, and includes a stockpile of nuclear warheads, although it is unclear how many. Warheads are regularly transferred by road between Coulport and the Atomic Weapons Establishment at Aldermaston in the south of England;
- three astute class hunter-killer attack submarines. A further four of these submarines are under construction and will also be based at Faslane, following the phased relocation of the Royal Navy's attack submarine base from Devonport to Faslane, whilst two of the remaining Trafalgar class submarines will soon be transferred until their decommissioning;
- seven Sandown class mine counter-measure vessels;
- the Faslane Patrol Boat Squadron consisting of two Archer class offshore patrol vessels;
- 43 Commando Fleet Protection Group, tasked with providing security for the UK's nuclear weapons; and
- the Northern Diving Group which provides diving, bomb disposal and underwater engineering to the fleet in all UK coastal waters north of Liverpool in the west and Hull in the east.

Other marine related defence sites include:

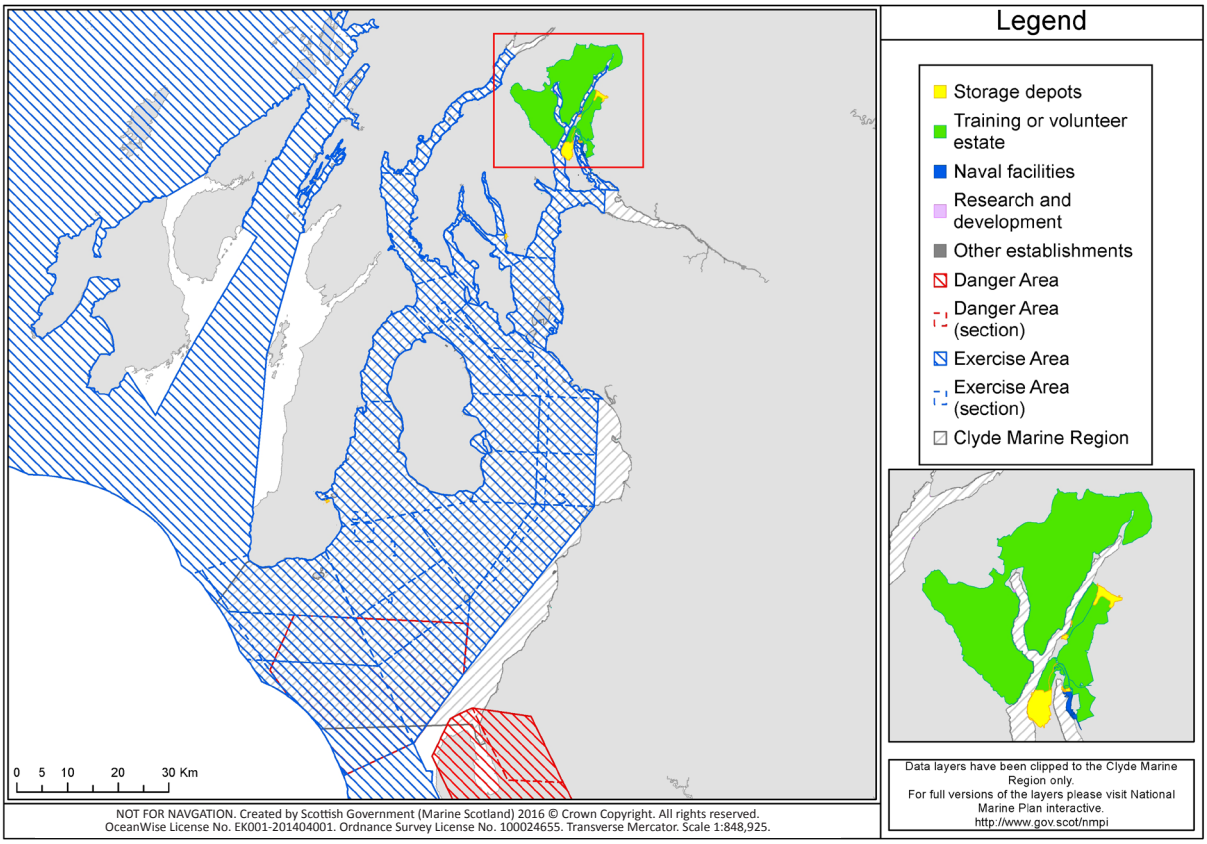
- Defence Munitions (DM) Douglas armaments depot located to the north of Coulport on Loch Long and used to store relatively low-tech conventional weaponry, with an associated jetty at Glenmallan and connected to the rail network;
- DM Beith armaments depot in North Ayrshire used to store complex weaponry, including a number of armaments used by the Royal Navy;[521]

516. Statistics unavailable prior to 2011
517. House of Commons Scottish Affairs Committee, 2013b
518. Built Environment Forum Scotland,2013
519. House of Commons Scottish Affairs Committee, 2013a
520. Royal Navy
521. Ardrossan and Saltcoats Herald, 2014

- Loch Goil and Loch Fyne Noise Ranges, operated by QinetiQ, used to test the acoustic signature of Royal Navy vessels, with Loch Fyne used to test surface vessels and Loch Goil both surface vessels and submarines;
- Loch Striven and Campbeltown Petroleum, Oil and Lubricant depots, which store fuel for NATO naval vessels; and
- Garelochhead training camp, used for training purposes by the territorial and regular army accommodating up to 500 people at any one time.

Map 30 identifies the location of defence facilities and also shows the region's importance as a naval training exercise area.

Map 30. Defence Mapping with Faslane and Garelochhead inset





Faslane © PETER SANDGROUND

6.6.2 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of the defence sector is provided below.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Significant regional employer – both direct and on-site activity (largest single site employer in Scotland) • The operations at Faslane support numerous supply chain jobs in the local area	• The Faslane base is relatively self-contained offering a wide range of amenities and services, potentially limiting spend in the local economy. Fishing and aquaculture activities are restricted in the MoD exclusion areas in Loch Long and Gare Loch. • Competition for coastal locations and routes – activity near MoD sites is controlled. • Whilst there could be conflicts with other marine users, an agreement has been reached whereby submarines move about above water whilst in the Clyde to avoid collision with other users.

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Pollution	Introduction of hazardous substances	There is a risk of contamination due to spillages from the discharge of fuel, munitions or other contaminants including radionuclide contamination. In addition, the MoD has Crown immunity from regulation on radioactive pollution and therefore does not have to disclose details on sites or activity. Navy vessels that use the ports and harbours are likely be treated with antifoulant to protect the bottom of the boat from fouling. The International Maritime Organisation provides regulatory guidance on the types of chemicals that can be used as part of these antifouling treatments.
	Release/ reintroduction of hazardous substances	There is a risk that dredged materials from ports and harbours could be contaminated (oil, heavy metals, pesticides, etc.), and when they are disposed at licenced sites, the activity disturbs the seabed sediments, effectively 'unlocking' this contamination. Relatively few substances become bioavailable and this is taken into account when setting thresholds and when issuing a licence. The Crown immunity order means that the MoD is exempt from disclosing their disposal sites.
Other physical	Litter: discarded munitions and explosives	There are (historical and current) munition dumping sites in the area surrounding the Clyde, for example the Beaufort Dyke between Scotland and Northern Ireland and Holy Loch which is used as a dumping site for the US Navy, although these sites are often not well documented. Despite this, there is little evidence of the impact of pollution on either the seabed or marine wildlife. [522]
	Underwater noise	No specific studies have been undertaken of the impact on the noise disturbance of MoD sites on the Clyde. Noise impacts will come from harbour activity, sonar, and explosions and there may be an adverse impact upon marine wildlife. See Chapter 4.9 Noise.
Biological	Introduction of INNS	Within the Clyde region there are 11 Non-Native Species identified in the biosecurity plan that are of 'concern'. Organisms present in ballast water and living on ship hulls are just two 'pathways' by which NNS can be introduced. To limit the potential impact of this, the MoD has policy and guidance in place. See Chapter 5.10 on Non-Native Species for more information on this.
Habitat change	Habitat damage	Military infrastructure and man-made structures such as ports/harbours, slipways, jetties and breakwaters have the potential to lead to erosion and disturbance of the seabed and coastline.

522. Fisheries Research Services, 2004

It should be noted that the MoD has a number of policy statements and guidance documents that outlines their approach to the management of environmental protection to help minimise any adverse environmental impacts from their operations.[523]

6.6.3 Regional Look Forward

A recent announcement by the UK Chancellor (August 2015) pledged an additional £500m for infrastructure improvements at Faslane and will include ship lifts, sea walls, jetties and other major projects. The work is anticipated to start in 2017 with a delivery period of around 10 years.[524]

From 2020, Faslane will become the 'Submarine Centre of Specialisation' whereby all of the UK's underwater capability will be based there, including the hunter-killer attack submarine fleet which will be transferred from Devonport. Employment is likely to increase by around 1,500 by 2022.[525]

This, along with operational changes (transfer of the hunter killer submarines from Devon) is expected to increase total employment at the Faslane site to 8,200 by 2022 and demonstrates that Faslane remains a strategically important site for the MoD.

The main issue that will impact upon the defence activities in the Clyde is the renewal of the Trident nuclear deterrent at an estimated cost of £31 bn.[526] At present, the renewal of Trident has been approved by the UK Government and the first new submarine is anticipated to be delivered by the early 2030's. That being said, given the long-term nature of the Trident renewal project, there are both economic and political factors that could influence future activity at Faslane.

523. Ministry of Defence and Defence Safety Authority, 2010 & 2016
524. HM Treasury and The Rt Hon George Osbourne MP, 2015
525. Perraudin, F., 2015
526. Johnstone, R., 2015

6.7 Historic environment and cultural heritage

Summary

The Clyde Marine Region (CMR) has a rich maritime history linked to its industrial past and destination as a key shipping port – 'Glasgow made the Clyde, and the Clyde made Glasgow'. The cultural and historical heritage includes both sea and land based activity and the built environment.

Much of the cultural heritage and built environment has been shaped by the Clyde and surrounding seas in one way or another – coastal towns and villages have relied on the fishing sector and its supply chain for employment, and ship building has been synonymous with the River Clyde for centuries. The region has an intrinsic link with the maritime environment and heritage, including; maritime wrecks; historic buildings and sites; maritime and heritage museums; historic ports, docks, quays, warehouses and cranes. These all provide a historical record of the important role the Clyde played in the growth of the region.

The historical and cultural assets in the region also make a notable contribution to the region's visitor and tourism provision, as well as providing an educational resource and contributing to the sense of place. The preservation of these assets helps to foster the emotional and cultural identity of the CMR.

In addition, the sector provides employment opportunities for both those within the operational side, and the conservation and preservation of sites, buildings and monuments.

Defining the Sector

Given the diverse nature of the sector, it has not been possible to gather data on the economic activity and value it supports. Where data are available we have identified visitor numbers and visitor expenditure figures for heritage/cultural sites and attractions.

6.7.1 Contribution to the Economy

The economic contribution of the sector is not accurately captured through official data sources as the majority of activity is driven by visitors to historic sites and attractions and is captured and reported as part of Chapter 6.5: Sport, Recreation and Tourism.



Culzean Castle © PETER SANDGROUND

However, in order to provide some context for the important role the historic and heritage environment plays in Scotland's tourism offering, the Historic Environment Strategy for Scotland[527] highlights that:

- 28% of adults had visited a historic or archaeological site in the 12 months prior to 2012;
- 43% of first time visitors to Scotland and 28% of all visitors to Scotland cite *'to learn more about the history/culture of Scotland*' as the key motivator for their trip to our country (2011/12);
- the historic environment is estimated to contribute in excess of £2.3bn (2.6%) to Scotland's national gross value added (GVA) and to account for 2.5% of Scotland's total employment, supporting 60,000 FTE employees, which includes seasonal employment.

Historic Environment and Cultural Heritage Activity

Maritime Wrecks

The historic importance of shipping for transport, defence and trade purposes in the Clyde means that it is home to a large number of maritime wrecks and losses. Some of these wrecks are popular with divers, including several puffers in the waters around Tarbert. Other popular wreck diving sites are located near the Cumbraes and are accessible via diving charters from Largs.

Two wrecks within the Clyde are protected under the Protection of Military Remains Act (1986), both of which were lost during the Second World War:

- HMS Vandal: a Royal Navy submarine which sank 4km north of Arran shortly after launching in 1943, with 37 crew members on board. The site is now designated a 'protected place' which allows diving but prohibits interference with the wreck;[528] and
- HMS Dasher: a Royal Navy aircraft carrier which sank half way between Brodick and Ardrossan in 1943, with the loss of 379 of its 528 crew members. It is designated a 'controlled site', meaning dives at the site are restricted.[529]

The Iona I Historic Marine Protected Area (HMPA) was designated in November 2016 to: minimise the loss or damage to the wreck; minimise deterioration of the site; prevent removal of any parts of the wreck and to prevent the commercial exploitation of the wreck.[530] The Iona I is a 19th Century Clydebuilt passenger paddle steamer, purchased during the American civil war as a blockade runner by the confederates to gain access to Southern ports. Historic Environment Scotland, who put forward the proposal to designate the wreck, described the site as *'in a relatively undisturbed state on the seabed and has the potential to help us understand much about the Clydebuilt paddle steamers and Scotland's role in the American Civil War'*.[531] The wreck is submerged under almost 30 metres of water off Gourock.

Coastal Historic Properties and Sites

The Clyde coastline is dotted with sites of historical significance, including castles, churches and other sites, such as standing stones and cairns. A number of these are managed by heritage agencies or charities, notably Historic Environment Scotland[531] and the National Trust for Scotland (NTS).

Historic Environment Scotland is responsible for 13 coastal sites or properties in the CMR, three of these are staffed: Rothesay Castle on Bute (9,200 visitors in 2013/14), Newark Castle near Port Glasgow (4,200 visitors in 2013/14) and Dumbarton Castle (17,200 visitors in 2013/14). The other sites are St Mary's Chapel and St Blane's Church on Bute, Skipness Castle and Chapel in Kintyre, Skelmorlie Aisle and Largs Old Parish church, and Lochranza Castle and a number of cairns/standing stones on Arran.

NTS manage five sites:

- Culzean Castle and Country Park, South Ayrshire – 219,000 visitors per annum (2013);
- Brodick Castle and Country Park, Arran – 26,000 visitors per annum (2012). NTS also own the nearby mountain of Goatfell which receives 38,000 visitors per annum. The castle it set to close for 18 months from October 2016 for a £5m refurbishment;
- Geilston Gardens near Cardross;
- Crarae Garden next to Loch Fyne in Argyll;

Also of note is Kelburn Castle and gardens on the North Ayrshire coast, which is owned privately but open to the public, and recorded 60,000 visitors in 2009. Inveraray Castle on Loch Fyne attracts around 85,000 visitors a year. Mount Stuart is located near Rothesay on the Isle of Bute and attracted 45,000 visitors in 2016. The smallest cathedral in Great Britain on the Isle of Cumbrae, the Cathedral of the Isles is open everyday to visitors.

The heritage tourism sector is an important contributor to the regional economy, with 'visiting a historic house or castle' the joint most popular activity (52% of respondents) for visitors in Ayrshire including Arran.[532]

527. The Scottish Government, 2014b
528. Canmore, b
529. Canmore, a
530. Marine Scotland, 2016c
531. Historic Environment Scotland. Historic Environment Scotland is the public body (constituted in October 2015) responsible for Scotland's historic environment and brings together Historic Scotland and the Royal Commission on the Ancient and Historic Monuments of Scotland.
532. Visit Scotland, 2012

Maritime and Coastal Heritage Museums

The historical significance of marine activity in the region is recognised at several museums and visitor centres located along the Clyde coast. The number of sites, attractions and museums dedicated to the maritime past helps to demonstrate how vital the Clyde Estuary in particular, has been for shaping both the physical infrastructure but also cultural identity of the region. Both the Mitchell Library and University of Glasgow archives hold shipbuilding records, including photographs, plans, technical data and cost books. The importance of the shipbuilding industry in relation to social history in Glasgow is captured in The People's Palace, which shows the history of people living in Glasgow from the 18th - 20th century.

A dedicated Scottish Maritime Museum has two sites, in Dumbarton and Irvine, with the Irvine site undergoing a £1.25m restoration in 2013 with funding from the Scottish Government. The Scottish Maritime Museum in Irvine is host to a nationally important collection of historic ships, artefacts, shipbuilding machinery and other items. The museum site in Dumbarton is home to the Denny Ship Model Experiment Tank. Other maritime heritage attractions around the Clyde coast include:

- Riverside Museum, Glasgow: opened in 2011 on the northern bank of the Clyde, as a replacement for the former Transport Museum. It was awarded the European Museum of the Year in 2013, and in 2014 recorded 1.05 million visitors;
- The Tall Ship, Glasgow: museum ship adjacent to the Riverside museum. Previously charged an entry fee and recorded around 50,000 visits annually, however fees were scrapped in 2013 so this is likely to have increased visitor numbers;
- Titan Crane, Clydebank: shipyard crane from the early 19th century, restored and opened as a museum in 2007;
- Scottish Submarine Centre: under construction in a former church building in Helensburgh, having secured funding from the UK Government Coastal Communities Fund and the Armed Forces Covenant. Exhibits will include a Second World War X-class midget submarine, and it is expected to attract over 10,000 visitors a year;
- Vikingar, Largs: museum/exhibits focused on the area's Viking heritage. The museum attracts around 20,000 visits annually
- local heritage museums in Clydebank (next to a former shipyard), Arran, Bute, Cumbrae and Saltcoats also have some focus on maritime heritage ; and
- Fairfield Heritage Centre located in the historic Fairfield shipyard offices in Govan, Glasgow.

Additionally, the Clyde Docks Preservation Initiative is campaigning to have the now derelict Graving Docks in Govan transformed into a shipbuilding heritage park.

The Turbine Steamer (TS) Queen Mary, the last remaining steamer built on the Clyde, was purchased by the Friends of TS Queen Mary charity in 2015, with the intention to restore the ship and return it from the south of England to a permanent berth on the Clyde. The ship has undergone repair work in Greenock and is seeking a permanent berth.

GalGael is a charitable organisation and social enterprise which seeks to preserve Scotland's shipbuilding skills and community traditions through training people in traditional boat making skills. Galgael's latest project 'Anchor and Sail' will offer skills development opportunities to over 200 local people with multiple barriers to progression, train eight 'apprentices' as boat builders, restore two boats and build three new boats in partnership with The Tall Ship and the Clyde Maritime Trust.

Listed Buildings and Scheduled Monuments

Hundreds of listed buildings are spread along the coastline of the CMR. Listed status is awarded to buildings with special historical or architectural interest, with the scheme administered by Historic Environment Scotland. While not all of these buildings and monuments will have a strong connection with the maritime past, many do.

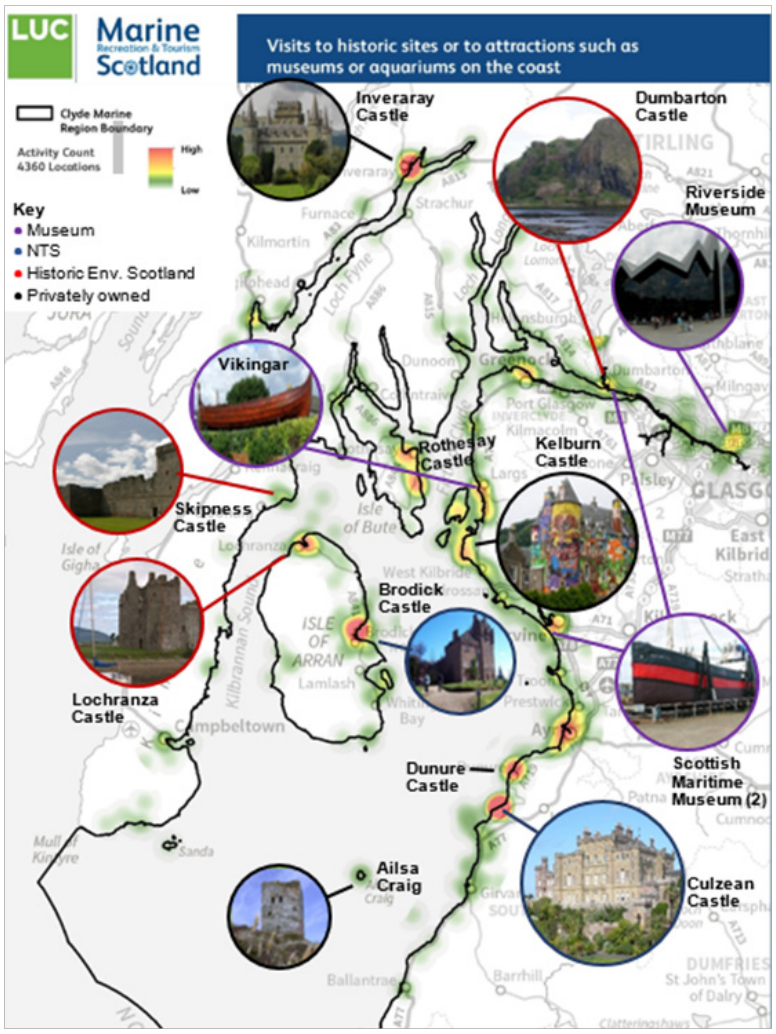
Scheduled monuments are also spread throughout the region, a designation reserved for archaeological sites and monuments deemed to be of national importance (around 3% of sites). These are often defensive installations or religious sites, and can date from prehistoric times to as recently as the Second World War.

Funding

A variety of funding mechanisms are available to support the preservation of coastal historic environment and cultural heritage. This includes the UK Government's Coastal Communities Fund, which aims to stimulate economic development in coastal towns, and the Heritage Lottery Fund which provides grant funding to support a wide range of heritage projects.

Argyll and Bute Council's Campbeltown, Helensburgh, Oban, Rothesay, and Dunoon (CHORD) Town Centre Regeneration project has focused on the regeneration of five of the area's coastal towns. As part of this, both Rothesay and Campbeltown have seen Townscape Heritage Initiatives launched, which are projects that aim to conserve the fabric of historic town centres, for example, Rothesay Pavilion. In 2016 major structural repairs and works to redevelop the buildings on Dunoon's wooden pier, a category A listed structure, were completed. A flagship project by the Council, the work cost over £2.3m and long term ambitions hope to see all the pier buildings back in use.

Figure 6.44 Heat Map of Visits to Coastal Historic Sites or Visitor Attractions



Source: SMRTS. Images reproduced under Creative Commons licence: Phil Sangwell (Inveraray); Stephen Sweeney (Dumbarton); Mark Harkin (Titan Crane); Bjmullan (Riverside Museum); Chris Townsend (Kelburn); amesx12345 (Culzean); Tony Page (Ailsa Craig); Martin (Brodick); Ultra7 (Lochranza); Hamish Kirkpatrick (Skipness); Thomas Nugent (Vikingar) – all via Wikimedia Commons.

6.7.2 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of the Historic Environment and Cultural Heritage sector is provided below.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Contributes to the region's tourism offering – attracting significant visitors annually (both national and international) • The historic and heritage environment also offers an educational asset for the region • Safeguarding and promoting the cultural and heritage offering helps to define the region's 'sense of place' • There is a broad network of historical/archaeological/heritage societies that help promote the region, educate, and deliver training opportunities	• Potential conflict of uses with other sectors e.g. restricted activity near sites with conservation status e.g. fishing or recreation activities • Potential restriction of new development

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Pollution	Introduction of hazardous substances	There is the potential of pollution e.g. fuel, oil and other chemical leakages from historic maritime wrecks and metal corrosion over time.
Other physical	Litter	The growth in tourism and the number of people visiting heritage and cultural sites/attractions could lead to an increase in littering. Not only does this impact on the visual amenity, there is a risk to both marine wildlife, for example entanglement or smothering, and also to people using the water for recreation.
Habitat change	Habitat damage	There is a risk that visitors to heritage and cultural attractions can damage or disturb surrounding habitats, for example, those visiting maritime wrecks could damage the site or seabed. There is also a risk of visitors removing flora or fauna from the natural environment.



Waverley © PETER SANDGROUND

6.7.3 Regional Look Forward

There are numerous naturally occurring and man-made factors that will impact upon the longer-term sustainability of the historic and heritage environment, for example, coastal erosion, sea-level rise and expanding development activity.

Historic Environment Scotland strategy, Our Place in Time – The Historic Environment Strategy for Scotland (2014) outlines its approach to support the protection, management and promotion of the historic and heritage environment. The three overarching strategic aims are considered as:[533]

- Understanding – by investigating and recording our historic environment to continually develop our knowledge, understanding and interpretation of our past and how best to conserve, sustain and present it.
- Protecting – by caring for and protecting the historic environment, ensuring that we can both enjoy and benefit from it and conserve and enhance it for the enjoyment and benefit of future generations.
- Valuing – by sharing and celebrating the richness and significance of our historic environment, enabling us to enjoy the fascinating and inspirational diversity of our heritage.

533. The Scottish Government, 2014b

The Argyll and Bute Historic Environment Strategy[534] aims to provide an overarching framework through which heritage projects, decisions and impacts can be positively managed. This strategy has 8 key objectives which overlap with those of Historic Environment Scotland listed above.

One of the main challenges for the management and the preservation of the cultural and heritage environment (particularly land based) across the region is access to funding sources. Many of the sites, buildings, facilities, etc. are wholly (or at least partially) reliant on grant funding and in-kind donations (financial and volunteer time) and there is increased competition for limited grant funding support – this is a challenge across Scotland and is not unique to the CMR.

Promotion and educating the public is an important approach to secure the heritage/cultural environment; for example, the Doors Open Day[535] scheme is promoted every September and allows members of the public to access historic/heritage buildings across Scotland that are normally closed to the public. Other successful projects have focused on promoting community engagement and empowerment, for example, Heritage Lottery Funded projects on the Isle of Bute, including the Rothesay Townscape Heritage Initiative. The holistic approach sought to engage and work with the local community to record, repair, understand, archive and celebrate the historic environment of the island.[536]



Kintyre Sadell beach © PETER SANDGROUND

534. Argyll and Bute Council, 2015
535. Scottish Civic Trust, 2016
536. Brandanii Archaeology and Heritage

6.8 Energy, subsea cables and pipelines

Summary

The energy, subsea cables and pipelines sector includes; energy generation (offshore renewables), transporting oil via pipeline, and power and telecommunication infrastructure/cables.

Development proposals for a new coal powered power station using carbon capture and storage technology at Hunterston in North Ayrshire have been dropped, due to uncertainties around funding. Details of the decommissioning of Hunterston B nuclear power station can be found in Chapter 6.11 – Water abstraction.

Renewable energy continues to be a big policy driver for the Scottish Government which has set a target for renewables to supply the equivalent of 100%[537] of gross annual electricity consumption and 11% of heat consumption by 2020. However, there has recently been a slowing down in the market due to the significant costs of developing the supporting infrastructure, including expanding the grid capacity and connections, and uncertainties surrounding subsidies that may be required to support investment.

While there are no live offshore renewable schemes in the Clyde Marine Region (CMR), there are two sites, at Hunterston and Campbeltown/ Machrihanish that have been identified in the National Renewables Infrastructure Plan (NRIP) as locations for manufacturing, and operation and maintenance. In addition there is an area identified at the south of the Mull of Kintyre as a potential development site for tidal energy.

Submarine power, transmission and telecommunications cables are a key component of the CMR's enabling infrastructure and are of recognised national and international economic importance, providing power and broadband connectivity to businesses and households on the mainland and to the islands. In addition, this infrastructure will support the development of the renewable sector.

Scotland has notable oil and gas reserves, with the majority of activity in the North Sea, although there have been discussions about the potential to exploit oil and gas reserves of other coastal areas in Scotland, including the CMR.[538] Finnart Oil Terminal on the eastern shore of Loch Long is the centre of existing oil industry activity on the Clyde. The terminal has capacity to dock large oil tankers. There are two pipelines that transport crude oil across Scotland to the Grangemouth refinery and transport the refined products back for exporting. Other oil terminals support domestic activities at Rothesay Dock and defence, such as the Oil and Pipelines Agency site at Loch Striven.



Hunterston © PETER SANDGROUND

537. This target was increased from 80% to 100%.
538. Scottish Energy News

Defining the Sector

It is challenging to define and identify the economic value of the sector, due to a lack of significant energy sites in the CMR. Employment at the Finnart oil terminal is not disclosed within official data sources. There are undoubtedly wider economic benefits of subsea cables, particularly to island economies (connectivity and operational and maintenance employment), however, these are relatively diffuse in the context of this assessment. Therefore this section only considers the activities related to Energy, Subsea Cables and Pipelines and it does not quantify the economic contribution or social benefits of the sector.

Renewable Energy Activity

There are currently no active renewable energy sites in the CMR, however, there are a number of sites identified for the manufacture and maintenance of renewable energy equipment, see Map 31. It should be noted, however, that terrestrial renewable sites can have an impact on the landscape-seascape as viewed from the sea.

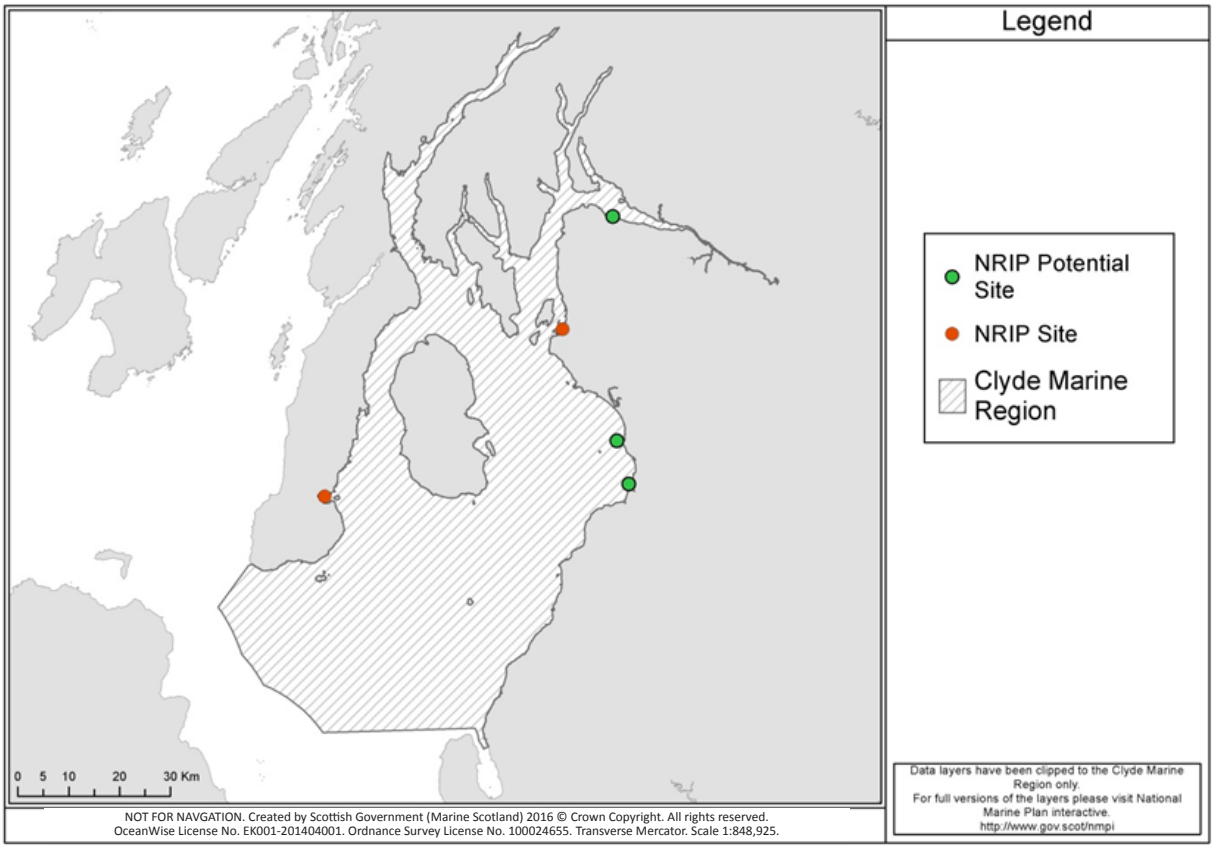
In addition to these sites, there are research and testing centres such as the Advanced Forming Research Centre and Offshore Renewable Energy (ORE) Catapult at Strathclyde University, and a Power Networks Demonstration Centre at Cumbernauld.

There is also a tidal option site at the south of the Mull of Kintyre, although, there are two issues that are likely to restrict development. Firstly, tidal devices may impede navigation for the Ministry of Defence and commercial shipping, and secondly there is insufficient grid capacity (local infrastructure) to support additional power sources.[539]

Hunterston and Campbeltown/Machrihanish have been identified as key development sites for the marine renewables sector in both the National Renewables Infrastructure Plan (N-RIP)[540] and the Third National Planning Framework (NPF3).

Hunterston has been designated as a potential site for integrated manufacturing of off-shore wind infrastructure, and the owners of Hunterston, Peel Ports Clydeport, have developed a master plan, which includes provision for the following; 53 hectares of marine/renewables manufacturing, 300m of new quayside, a 34 hectare container shipment hub, and retention of the marine construction yard with potential to upgrade the dry dock.[541] Hunterston is currently a testing site for turbines. Plans for a proposed new clean coal power station using carbon capture and storage technology have been dropped due to a lack of funding.[542]

Map 31. National Renewables Infrastructure Plan sites



539. The Scottish Government, 2010a
540. Highlands and Islands Enterprise
541. Scottish Development International , 2011
542. BBC News, 2012b

The Campbeltown/Machrihanish site has been identified as a site for large-scale manufacturing, fabrication and construction, with Wind Towers Scotland Ltd, a manufacturer of components for both onshore and offshore wind already located at the quayside. Campbeltown harbour has been identified as a potential base for activity and there have been two recent developments that will support the area as a hub for renewables:

- Kinloch Road Regeneration Project – realignment of Kinloch Road to allow for increased traffic flow from Heavy Goods Vehicles (HGVs) associated with transporting wind towers and turbines for export. The project was funded through Argyll and Bute Council's £30m Campbeltown, Helensburgh, Oban, Rothesay, and Dunoon Town Centre Regeneration project;[543] and
- Construction of a new deep water quay/new open piled pier (North side), and increase in the dredge level from 5m to 9m.

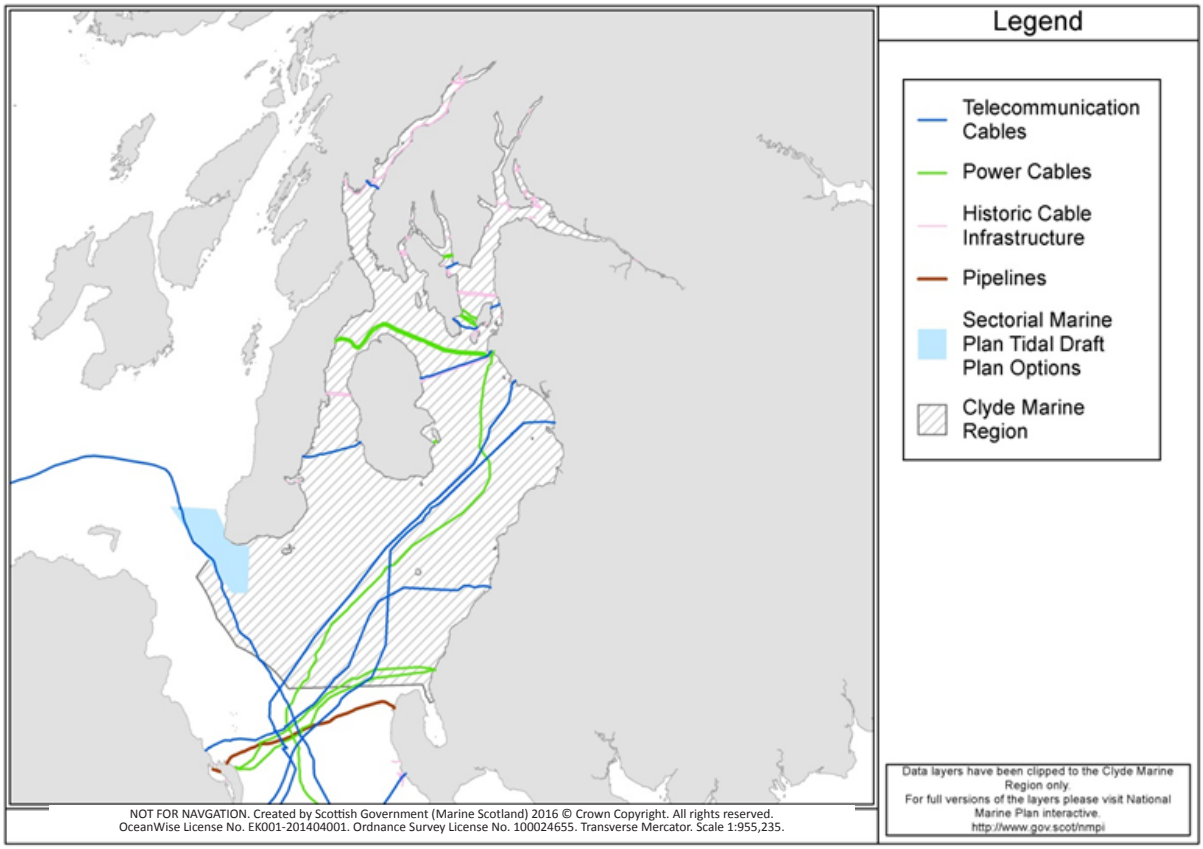
In addition, Troon, Ayr and Inchgreen in Inverclyde have been identified as potential support sites, providing operations and maintenance, logistical support services and supply chain manufacturing.

The region has a strong renewables supply chain and a number of Clyde based companies have been identified in the N-RIP as part of this:[544]

- Ferguson group (Port Glasgow) – delivery of a range of engineering services and the fit-out of cable laying barges for offshore wind;
- Lafarge Cement (Glasgow, Clydebank and Greenock) – suppliers of cement for manufacture of concrete structures;
- Maritime Craft Services (Largs) – operator of a fleet of tugs, workboats and offshore wind support vessels as well as diving services;
- Argyll Workboats (Bute) – operator of workboats and diving services; and
- Windhoist (Irvine) – supplier of heavy cranage to the offshore wind industry.

Map 32. Telecommunication and power cables, pipelines and historic cable infrastructure in the Clyde Marine Region

N.B. The Western Link Project is ongoing, and so the power cable running from Hunterston to Deeside is not operational yet. More information can be found in the Regional Look Forward section of this chapter.



543. Argyll and Bute Council
544. Scottish Development International, 2011

Telecoms Cables

There are a number of subsea telephone lines in the CMR, mainly linking the islands of Cumbrae, Bute and Arran to the mainland, but also three connecting Scotland with Northern Ireland, see map 32.

INTRA SCOTLAND CONNECTIONS	SCOTLAND TO NORTHERN IRELAND CONNECTIONS
• Knockdow to Port Bannatyne (Bute) • Kingarth (Bute) to Millport (Cumbrae) • Largs to Cumbrae • West Kilbride to Arran • Achnaba (Lochgilphead) to Otter Ferry	• Stevenston to Newtonabbey (Northern Ireland) • Troon to Whitehead (Northern Ireland) • Girvan to Larne (Northern Ireland)

Power Cables

As with subsea telecoms cables, power cables in the CMR link the islands and Northern Ireland with mainland Scotland, see map 32.

INTRA SCOTLAND CONNECTIONS	SCOTLAND TO NORTHERN IRELAND CONNECTIONS
• Ardyne to Port Bannatyne (Bute) x2 • Bute to Cumbrae x3 • Carradale to Arran x2 • Arran to Holy Isle x1 • Campbeltown to Davaar x1 • Bute to Kames x2	• Ballantrae to Islandmagee (Northern Ireland) x2

There has been a recent upgrade of the power connection to Kintyre by Scottish and Southern Energy Power Distribution, with a new substation constructed at Crossaig Forest, approximately 15 miles south of Tarbert.

This new substation will be linked by both underground and undersea cables with Hunterston, and the connection will provide a more secure electricity supply to the area and facilitate the connection of renewable energy developments.[545]

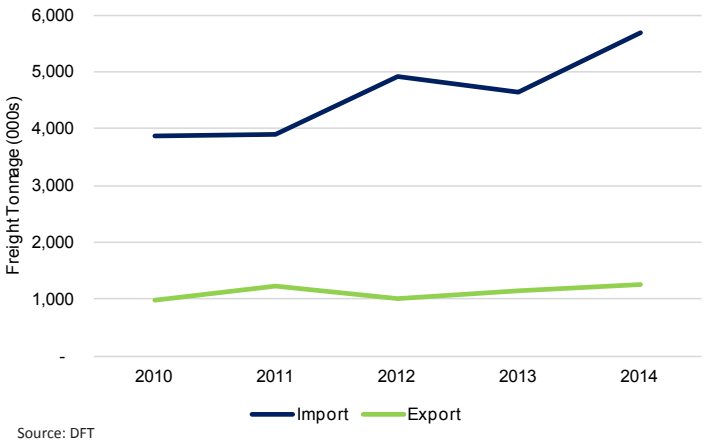
Finnart Oil Terminal

The Finnart Oil Terminal is a petrochemical transfer facility owned and operated by INEOS,[546] used for the loading and unloading of oil and petrochemical tankers. It is located on the eastern shore of Loch Long, approximately two and a half miles north of Garelochhead.

The terminal is capable of receiving Very Large Crude Carriers and Ultra Large Crude Carriers and is connected to Grangemouth oil refinery and petrochemical plant via two pipelines. Crude oil is unloaded at Finnart and transferred to Grangemouth, whilst refined products are transported back to Finnart for exporting.

Exact figures for the tonnage of liquid freight handled at Finnart are unavailable as the Department for Transport only collect data at the wider Clyde level. Rothesay Dock at Clydebank is the only other port in the region where significant volumes of liquid freight are handled, importing approximately one million tonnes of petroleum and diesel per annum.[547] Figure 6.45 outlines the amount of Liquid freight handled in the CMR, of which the majority of imports and exports are handled at Finnart.

Figure 6.45 Liquid Freight Handled in the Clyde Marine Region



Source: DFT

545. Scottish and Southern Energy, 2016
546. INEOS is a global manufacturing, distribution, sales and marketing company of chemicals including petrochemicals. INEOS also owns Grangemouth which is Scotland's largest crude oil refinery and NEOS' largest manufacturing site by volume of products.
547. House of Commons Scottish Affairs Committee, 2012

The terminal is in regular usage, with a total of seven tankers docking during December 2015,[548] the largest of which was in excess of 85,000 Gross Register Tonnage (GRT).

6.8.1 Pressures and Impacts

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Potential to support rural economies through the creation of higher value manufacturing and maintenance jobs. • Access to reliable power and electricity supply is important for supporting both households and economic activity. • Development of renewable energy activity contributes to Scottish Government green energy targets. • Connectivity to broadband, particularly in the more rural areas and islands, is critical for supporting economic activity. • Scotland has developed a world class research base in renewables with a growing reputation for innovation and research and engineering expertise, an example of such innovation within the CMR include the Offshore Renewable Energy (ORE) Catapult in Glasgow city centre which drives employment and investment into the region.	• There is potential for conflict with other marine users, for example, defence activities at HMNB Faslane and tourism – there is ongoing research looking at the opportunities for co-location between sectors and off-shore/marine renewables. • Landscape/seascape impacts, including terrestrial sights that impact the landscape-seascape as viewed from the sea • There is potential conflict between new or replacement subsea cables and marine users, in particular the fishing industry

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Habitat change	Habitat damage	There are no Clyde specific studies, however, the subsea infrastructure has the potential to damage the seabed (for e.g. sediment disruption that leads to smothering of organisms), particularly during installation, maintenance and upgrade construction works.
	Habitat loss	There will be a loss of habitat in the footprint of any subsea infrastructure, however, the infrastructure may provide new habitat.
Other physical	Electromagnetic changes	There are no Clyde specific studies, however, wider evidence suggests that the electromagnetic fields generated by power and telecoms cables have the potential to change the behaviour of marine wildlife, for example migratory patterns of fish. A cost-benefit analysis undertaken by Scottish and Southern Energy Power Distribution included a literature review and consultation with stakeholders to consider the environmental impact of subsea cabling – the analysis did not identify any 'conclusive evidence'.[549]
	Underwater noise	There are no Clyde specific studies, however, there is potential for underwater noise generated by subsea cabling installation and pile driving to impact upon marine wildlife, see Chapter 4.9 - Noise.
Pollution and chemical	Introduction of hazardous substances	Finnart is used for importing crude oil and petrochemicals, so there is potential for leaks and spillages. There are guidance documents with regards the safe transfer of crude oil, including the Clyde Clean Oil Spill Response Plan which was updated in mid-2016. Vessels that use the ports and harbours are likely to be treated with antifoulant to protect the bottom of the boat from fouling. The International Maritime Organization provides regulatory guidance on the types of chemicals that can be used as part of these antifouling treatments.
Biological	Other	There is potential for marine mammals or seabirds to collide with tidal stream renewables (eg at Mull of Kintyre).

Note: Information on the potential environmental impact of subsea cables taken from the OSPAR Commission: http://qsr2010.ospar.org/media/assessments/p00437_Cables.pdf.

548. Marine Traffic, 2016
549. Scottish and Southern Energy Power Distribution

6.8.2 Regional Look Forward

While there are no live offshore renewables sites in the CMR, the development of a strong supply chain is a key policy driver for the Scottish Government to create employment and economic wealth, and attract investment. Hunterston is currently testing turbines.

As part of the Glasgow and Clyde Valley City Deal investment, Inverclyde Council and Riverside Inverclyde are working up proposals for a £9.4m renewables hub at Inchgreen dry-dock. The site covers 31 acres with potential to expand to 50 acres and is identified as a location that could serve the offshore renewables industry (supply chain development activity). The Outline and Full Business Case for the Inchgreen proposal is not expected to come forward until 2020.

The Western Link Project will connect Hunterston to The Wirral Peninsula in a £1bn project to transfer renewable power generated in Scotland to England and Wales. It is split into five main sections; two convertor stations at each end, a 4km underground cable at Hunterston, a 33km underground cable through the Wirral Peninsula and a 385km long undersea cable linking the two. The work began in 2013 and it is expected to be operational in 2017.[550]

The Irish-Scottish Links on Energy Study *'is a major initiative designed to enable the development of interconnected grid networks to enhance the integration of marine renewable energy between Scotland, Northern Ireland and Ireland.'*[551]
The project takes a coordinated approach designed to simplify planning and licensing, market and regulatory issues between the governments of Scotland, the Republic of Ireland and Northern Ireland to catalyse offshore renewable energy developments.

550. Western Link Project
551. Irish Scottish Links on Energy Study

6.9 Shipping and transport

Summary

Shipping and transport includes vehicle/passenger ferries, ships, cruise vessels and commercial freight operations, ship building (commercial and leisure), as well as dredging and the disposal of dredged materials.

Ports in the Clyde Marine Region (CMR) have played a significant role in growing the heavy industry and exporting base of Scotland's economy. Many of the coastal towns in the CMR were established and grew on the back of activity at the ports, for example sugar and tobacco imports at Greenock and latterly exporting computer components and chemicals.

The ports remain vital for supporting the UK's import and export markets with some 95% of UK imports and exports transported by sea. Peel Ports Clydeport is the third largest port (comprising four individual ports) in Scotland and the 11th largest in the UK by volume of freight, with almost 16 million tonnes of cargo passing through the port in 2014. The other significant ports in the region, Troon and Ayr, are managed/operated by Associated British Ports (ABP).

Shipping and port infrastructure are also important for supporting rural and primary industries, through the transfer of bulk cargo such as coal, timber, aggregates, grain, etc. The deep water port at Hunterston is able to handle modern ships of any size and Finnart oil terminal in Loch Long can accommodate Very Large Crude Carriers and Ultra Large Crude Carriers. There are coastal timber transport sites located across the CMR.

The Clyde was once world renowned for its ship building industry, and at its peak employed tens of thousands of people. Shipbuilding now employs around 3,500, across three yards – BAE systems in Govan and Scotstoun; and Ferguson Marine Engineers at Port Glasgow. While all three yards have recently won new contracts (MoD contracts worth £350m at Govan and Scotstoun and two passenger ferry contracts at Port Glasgow worth £110m), conditions in the sector remain challenging.

There are numerous (circa 13) 'lifeline' ferry services connecting communities in the Clyde and providing links to the islands of Arran, Bute and Cumbrae. Over 4.1 million foot passengers used ferry services in the Clyde, although the number of passengers has declined annually for the past 10 years. However, the introduction of Road Equivalent Tariff (RET) - which considerably lowers the costs of passenger and non-commercial vehicle fares - has the potential to reverse this decline.



Shipping © PETER SANDGROUND

Defining the sector

The direct economic activity within the shipping and transport sector is measured through the following SIC codes:

30.11: building of ships and floating structures, **30.12**: building of pleasure and sporting boats, **33.15**: repair and maintenance of ships and boats, **42.91**: construction of water projects, **50.10**: sea and coastal passenger water transport, **50.20**: sea and coastal freight water transport, **52.22**: service activities incidental to water transportation, **50.30**: inland passenger water transport, **50.40**: inland freight water transport, **52.101**: operation of warehousing and storage facilities for water transport activities of division **50**, **52.241**: cargo handling for water transport activities of division **50**, **77.341**: renting and leasing of passenger water transport equipment, and **77.342**: renting and leasing of freight water transport equipment.

A summary of the changes across economic indicators (2010 to 2014) is presented in table 6.16.

Table 6.16 Transport and shipping change in activity, 2010–2014

INDICATOR	CHANGE
WIDER CLYDE MARINE REGION	
Turnover (2009 to 2013, adjusted to 2013 prices)	-17%
GVA (2004 to 2013, adjusted to 2013 prices)	-23%
CLYDE MARINE REGION	
Employment	-10%
Freight tonnage	+23%
Freight ship calls	+41%
Cruise ship passengers (2012 to 2015)	+66%
Ferry passengers (2009 to 2013)*	-12%
Ferry cars (2009 to 2013)*	-11%

*Decline in passenger numbers driven by significant decline and change of service on subsidised Gourock to Dunoon route

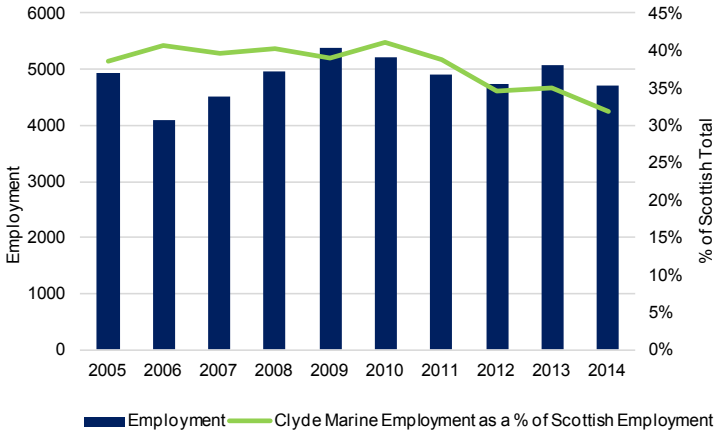
6.9.1 Contribution to the Economy

Employment

Employment in shipping and transport is around 4,700 jobs and since 2005 the sector has experienced some fluctuations, but generally post 2009 has seen an annual decline (with 2013 being an exception).

Notably, in 2005 the CMR accounted for 39% of all employment in transport and shipping in Scotland, this has now dropped to 32%. This is likely to be due to growth on the east coast in ship building/repair at Rosyth and BiFab at Burntisland,

Figure 6.46 Clyde Marine Region: Shipping and Transport Employment, 2005–2014



Source: Business Register and Employment Survey and Annual Business Survey

(which delivers fabrication works for the oil and gas, renewable and infrastructure industries) and activity associated with the oil and gas sector in Aberdeen and Aberdeenshire, for example, building oil platforms and the operation of oil terminals.

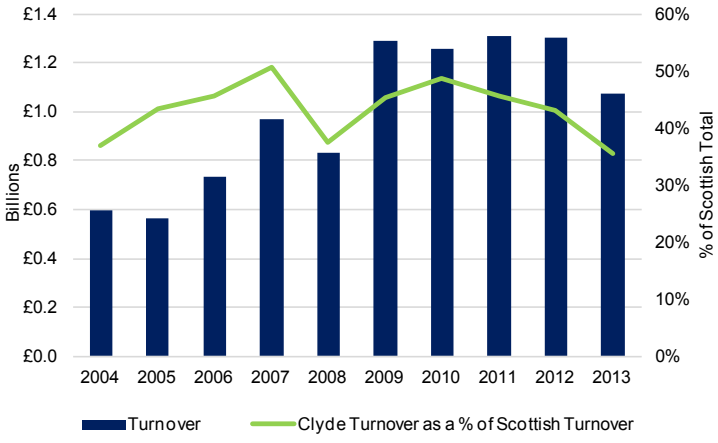
Between shipbuilding and transport, shipbuilding is the biggest employer, accounting for three quarters of jobs (3,600 jobs). In May 2015, BAE Systems confirmed that both their Govan and Scotstoun shipyards would remain open, pledging a £100m investment.

Ferguson Marine Engineering in Port Glasgow is the last remaining commercial shipyard in the outer Clyde estuary. After going into administration in August 2014, the company was bought over and has since won two significant contracts to build passenger ferries, worth £110m.

Economic output – turnover and GVA

Nationally, total turnover from the shipping and transport sector increased steadily in the decade to 2013, although this was less pronounced in the CMR. Since 2009, turnover has consistently been over £1bn per annum, totalling £1.076bn in 2013.

Figure 6.47 Wider Clyde Marine Region: Shipping and transport turnover, 2004–2013



Source: ABS (most recent available data). Adjusted to 2013 prices.
Note: these figures include all of Argyll and Bute local authority area

GVA from the shipping and transport sector has been prone to fluctuation, although generally has levelled out from 2009 onwards, totalling £314m in 2013, figure 6.48.

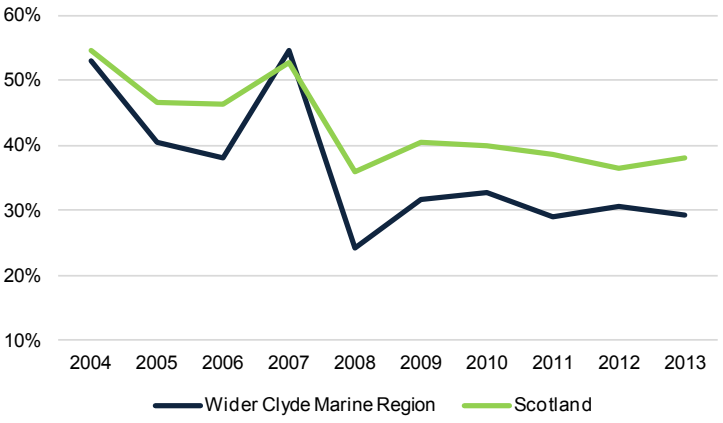
Figure 6.48 Wider Clyde Marine Region: Shipping and transport GVA, 2004–2013



Source: ABS (most recent available data). Adjusted to 2013 prices.
Note: these figures include all of Argyll and Bute local authority area.

The GVA to turnover ratio has declined over time indicating a decline in productivity with input costs such as fuel and equipment rising at a greater rate than the growth in turnover/sales. This would explain an increase in turnover and a corresponding decrease in GVA, figure 6.49.

Figure 6.49 Wider Clyde Marine Region: Shipping and transport GVA to turnover ratio, 2004–2013



Source: ABS (most recent available data). Adjusted to 2013 prices.

Figure 6.50 CalMac Ferry, Gourock



Source: Dave Souza via WikiCommons, under Creative Commons license

6.9.2 Passenger and vehicle transport

Passenger and vehicle ferry services are primarily operated/subsidised by the public sector, however, there are two privately run routes: the Dunoon to Gourock RO-RO (roll on – roll off) vehicle service (Western Ferries) and the Renfrew to Yoker passenger service (Clydelink). The Gourock to Kilcreggan service is operated by Clydelink, but with a public subsidy from Strathclyde Partnership for Transport (SPT). P&O previously operated a seasonal RO-RO service between Troon and Larne in Northern Ireland. In January 2016, the operator terminated this service. All other ferry routes are regulated by Transport Scotland and their operation is subject to tender. Most are bundled in the Clyde and Hebrides Ferry Services (CHFS) contract, while the Gourock to Dunoon passenger service, currently operated by Argyll Ferries (a sister company of CalMac) is tendered separately. The ferries and port infrastructure is, for the most part, owned by the Port Glasgow based Caledonian Maritime Assets Ltd (CMAL), which is owned by the Scottish Government, and then leased to the ferry operator. The current operator is the publicly owned CalMac Ferries Ltd.

Map 33 shows the ferry routes and also provides statistics on passenger and car journeys across the top six most popular routes (routes where foot passengers are 50,000+ per annum).

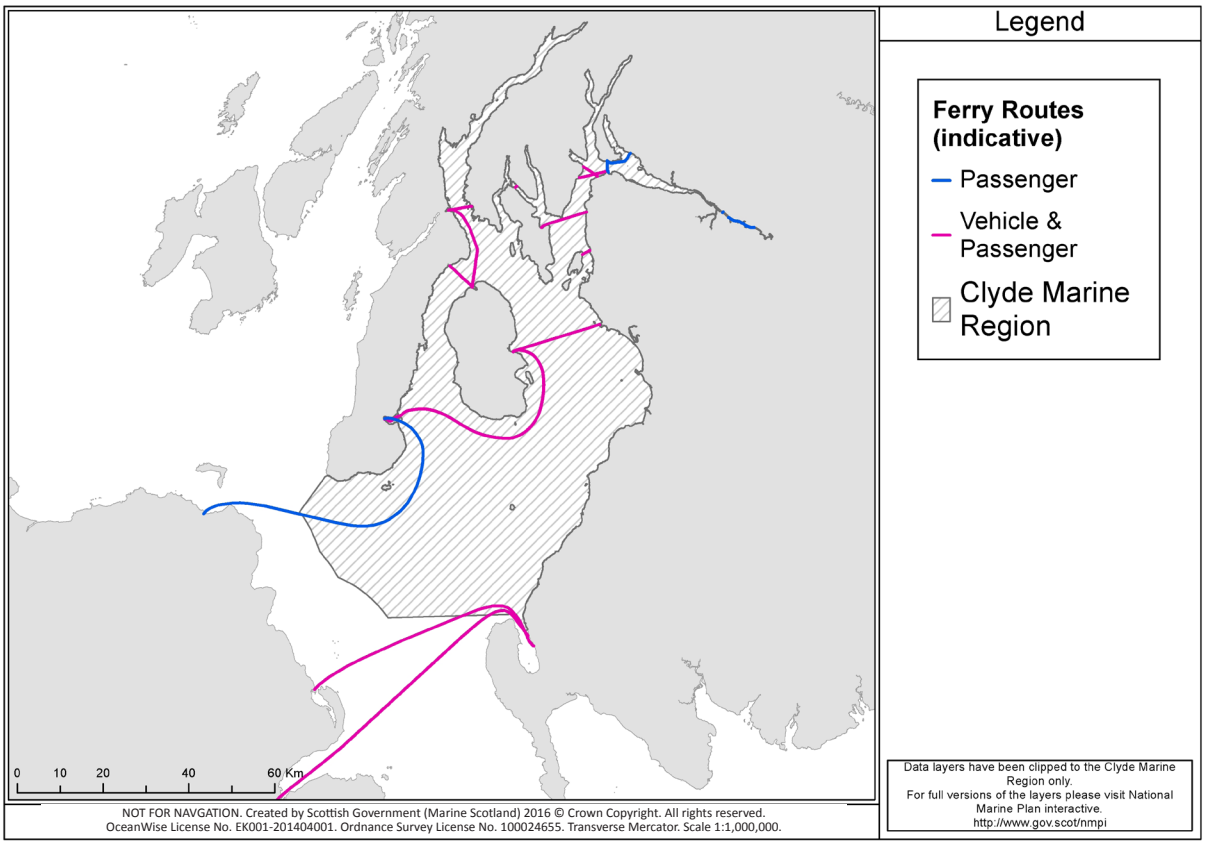
Data for 2004–2013 shows the change in ferry journeys, see figure 6.51:

- passenger journeys are down -11% (driven by a steep decline in use of the Gourock to Dunoon subsidised service; excluding this, journeys are down -2.8%);
- car journeys are down -7% (again, due to Gourock to Dunoon change to passenger-only service; excluding this, journeys are up +3.6%); and
- commercial vehicle journeys are up +36%.

As noted above, this decline largely stems from a steep reduction in users of the subsidised service which operates between Gourock and Dunoon town centres, which has been subject to a number of changes over the last decade. In 2011 the service changed from a passenger and vehicle service to a passenger only service (due to changes in legislation regarding the subsidising of vehicle carrying services) which appears to be the driver for the decline in passenger journeys.

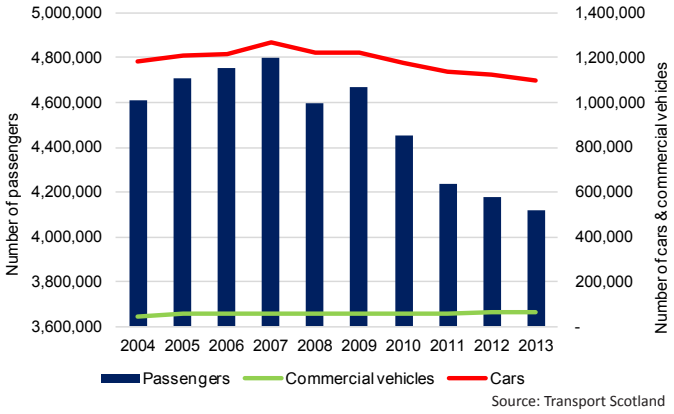
The Road Equivalent Tariff (RET) scheme is sponsored by the Scottish Government and provides subsidies to ferry passengers by setting fares on the basis of the cost of travelling an equivalent distance by road. The scheme was set up in 2008 to encourage economic growth and employment within fragile island communities. Within the CMR, a pilot was carried in October 2014 on the Ardrossan-Brodick and Kintyre-Lochranza routes.

Map 33. Passenger and Car Ferry Journeys, 2014



In October 2015, the RET was rolled out to the remaining Clyde ferry routes, including: Wemyss Bay to Rothesay; Colintraive to Rhubodach; Largs to Cumbrae; and Tarbert to Portavadie. This is expected to uplift the number of passenger journeys on these routes. Despite RET only being in place on Arran for two months of 2014, the Ardrossan to Brodick route saw a +1.3% increase in passengers over the course of the year, and a +7.1% increase in cars (in comparison to a +2.6% increase from 2012 to 2013). Commercial vehicles, which are not subsidised by RET, declined by -2.6%. Tables 6.17 to 6.20 provide a detailed breakdown of journeys by route.

Figure 6.51 Clyde Ferry service users, 2004–2013



Source: Transport Scotland

Table 6.17 Passenger journeys, 2004–2013 (000s)

ROUTE	OPERATOR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	% CHANGE
Ardrossan – Brodick	CalMac	716.6	742.6	735.9	749.0	707.4	715.7	731.1	692.4	688.7	706.1	-1%
Colintraiv – Rhubodach	CalMac	268.4	279.9	264.6	257.5	256.3	260.6	264.3	228.0	217.1	222.1	-17%
Gourock–Dunoon*	CalMac	619.8	624.7	615.2	607.2	550.8	533.5	499.2	409.2	341.3	299.2	-52%
Largs–Cumbrae	CalMac	682.9	698.6	722.6	750.4	710.8	720.4	727.3	697.7	695.4	708.9	+4%
Lochranza – Tarbert/Claonaig	CalMac	54.0	54.0	52.4	54.5	50.2	54.4	52.1	46.9	43.7	43.0	-20%
Tarbert – Portavadie	CalMac	52.9	57.9	67.6	60.4	59.5	69.7	68.1	61.7	60.9	61.7	+17%
Wemyss Bay – Rothesay	CalMac	764.2	750.1	759.7	770.3	741.0	755.9	735.3	711.5	690.1	676.9	-11%
Gourock – Dunoon	Western Ferries	1,254.7	1,280.3	1,306.9	1,329.4	1,308.5	1,336.2	1,313.8	1,332.7	1,389.3	1,342.7	+7%
Renfrew – Yoker	Clydelink	129.1	145.1	149.9	149.5	141.4	147.8	n/a	n/a	n/a	n/a	n/a
Gourock – Kilcreggan	SPT/ Clydelink	69.5	72.8	74.9	71.3	70.0	71.6	63.5	57.7	52.6	57.0	-18%
Total		**4,612.0**	**4,706.0**	**4,749.7**	**4,799.5**	**4,596.0**	**4,665.9**	**4,454.7**	**4,237.9**	**4,179.2**	**4,117.7**	**-9%**

Source: Transport Scotland
* Operator and type of service has changed over the period – passenger and vehicle service changed to a passenger service. Operators – CalMac, Cowal Ferries and Argyll Ferries.

Table 6.18 Car journeys, 2004–2013 (000s)

ROUTE	OPERATOR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	% CHANGE
Ardrossan – Brodick	CalMac	125.82	130.96	131.96	137.40	131.09	136.01	134.20	127.85	127.04	130.40	+4%
Colintraive –Rhubodach	CalMac	92.7	93.5	89.6	90.2	88.2	87.3	84.6	80.9	76.4	75.5	-19%
Gourock – Dunoon*	CalMac	90.2	84.9	77.8	80.1	71.8	70.7	61.4	25.8	n/a	n/a	n/a
Largs – Cumbrae	CalMac	132.4	135.9	139.4	151.3	143.1	139.8	138.7	136.0	134.1	134.9	+2%
Lochranza – Tarbert/Claonaig	CalMac	16.8	17.7	17.3	17.9	16.7	17.6	16.6	14.7	14.0	13.9	-17%
Tarbert – Portavadie	CalMac	18.6	18.8	19.1	20.9	21.0	21.6	21.2	19.7	19.0	18.5	-1%
Wemyss Bay – Rothesay	CalMac	152.1	152.5	158.2	164.2	159.9	162.7	155.7	152.9	150.1	144.8	-5%
Gourock – Dunoon	Western Ferries	553.4	571.5	577.8	602.0	588.0	584.0	564.2	577.9	605.5	578.5	+5%
Other	-	2.6	2.6	2.6	2.6	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total		**1,184.7**	**1,208.2**	**1,213.8**	**1,266.6**	**1,219.7**	**1,219.9**	**1,176.6**	**1,135.8**	**1,126.2**	**1,096.5**	**-5%**

Source: Transport Scotland
* Passenger only service, 2012 onwards

Table 6.19 Commercial vehicles, 2004–2013 (000s)

ROUTE	OPERATOR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	% CHANGE
Ardrossan – Brodick	CalMac	10.9	12.2	11.4	13.5	12.5	11.6	13.2	11.4	12.0	12.4	+14%
Colintraive – Rhubodach	CalMac	12.7	15.3	16.5	17.4	17.5	15.7	14.9	15.0	14.1	12.9	+1%
Gourock – Dunoon*	CalMac	6.1	6.0	6.0	5.3	3.9	3.8	3.5		..	..	n/a
Largs – Cumbrae	CalMac	5.2	5.3	6.5	7.4	6.6	5.3	5.0	5.4	5.6	6.8	+30%
Lochranza – Tarbert/Claonaig	CalMac	0.4	0.4	0.4	0.6	0.5	0.5	0.5	0.5	0.5	0.4	+21%
Tarbert – Portavadie	CalMac	0.3	0.6	0.9	0.6	0.5	0.7	0.5	0.6	0.6	0.5	+52%
Wemyss Bay – Rothesay	CalMac	13.2	11.0	14.2	13.6	14.1	12.1	12.6	14.1	14.2	13.2	0%
Gourock – Dunoon	Western Ferries	32.8	35.3	33.7	33.0	32.2	33.8	33.0	37.9	40.0	37.9	+16%
Other	-	0.3	0.3	0.4	0.4	..	..	..	..	..	..	n/a
Total		**81.9**	**86.5**	**89.9**	**91.8**	**87.8**	**83.5**	**83.3**	**86.4**	**87.1**	**84.1**	**+3%**

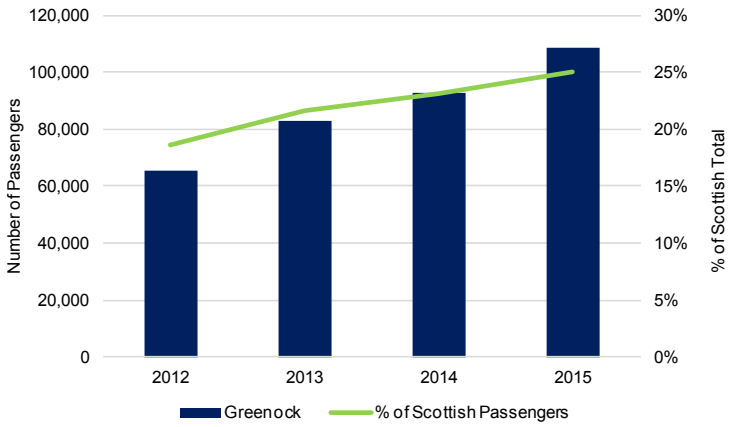
Source: Transport Scotland
* Passenger only service, 2012 onwards

Table 6.20 Troon to Larne (P&O), 2004–2013 (000s)*

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	% CHANGE
Passengers	120	214	208	231	206	213	225	208	169	180	+50%
Cars	27	56	56	66	59	62	62	60	47	50	+86%

Source: Transport Scotland
*In January 2016, P&O announced that this route will cease to operate with immediate effect

Figure 6.52 Cruise passengers, 2012–2015



Source: Cruise Scotland and http://marine.gov.scot/data/cruise-port-statistics-2010-2014

6.9.3 Cruise ships

There are two cruise ports in the CMR for which Cruise Scotland collect data – Holy Loch (minor port) and Greenock Ocean Terminal.

In October 2015, City Deal funding was secured for a £14.2m upgrade to port facilities at Greenock Ocean Terminal, to expand the quayside and construct a new passenger terminal. The current infrastructure is constraining growth in the cruise ship market and the City Deal project is estimated to support an increase in passenger numbers from 110,000 in 2015 up to 150,000 – 210,000 by 2025.

Other infrastructure developments which could boost the cruise ship market include the redevelopment of Brodick pier on the Isle of Arran (to include a double berth pier) which will allow the

island to tap into the growing cruise ship market, with a projection of 13,000 passengers per year.[552]

Data for cruise passengers for the period 2012–2015 is presented in figure 6.52.

The number of passengers has been increasing over the last few years, although without the corresponding rise in cruise ship numbers as there is a continuing trend towards larger vessels (800+ passengers).

The value of the cruise ship market to the Scottish economy is significant and estimated by Cruise Scotland at £50m per annum.[553] The wider CMR could benefit in the region of £10m per annum (based on one fifth of total passenger numbers and pro rata spend). Once disembarked at Greenock, Cruise Scotland identifies that key attractions for cruise visitors include Loch Lomond, Glasgow and Edinburgh, meaning that the economic impacts will be spread across central Scotland.

6.9.4 Freight traffic

The Clyde has one major Port Authority for commercial freight traffic – Clydeport – which includes Ardrossan, Glasgow (King George V Dock), Greenock Ocean Terminal, Inchgreen Dry Dock, Rothesay Dock and Hunterston. These facilities are operated by Peel Ports Clydeport. In addition, there are commercial freight operations at three minor ports; Ardrishaig, Ayr, and Troon, figure 6.53.

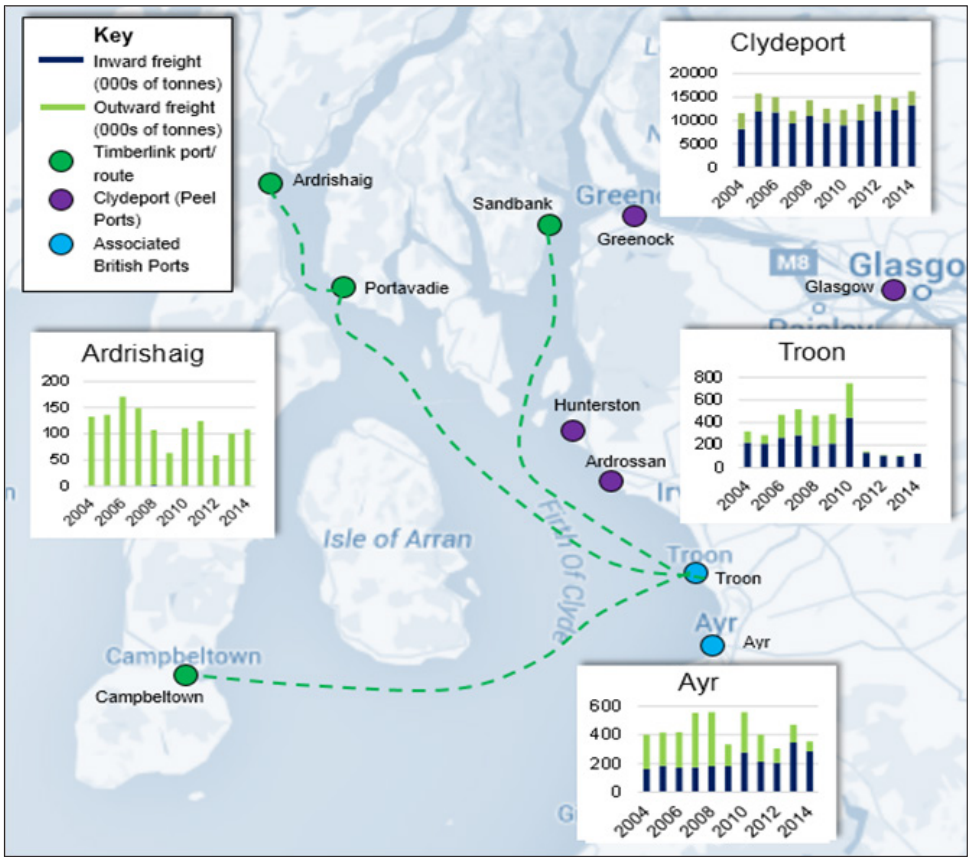
Freight traffic moving through Scottish ports is on a downward trend, having fallen from 109 million tonnes in 2005 to 71 million tonnes in 2014 (-35%). However, the Clyde has bucked this trend, see figure 6.54.

Figure 6.54 Freight traffic Clyde Marine Region as % of Scotland, 2005–2014



Source: Department for Transport (DFT) and http://marine.gov.scot/data/port-statistics-2005-2013
Includes: Ardrossan, Glasgow, Greenock, Hunterston, Ardrishaig, Ayr and Troon.

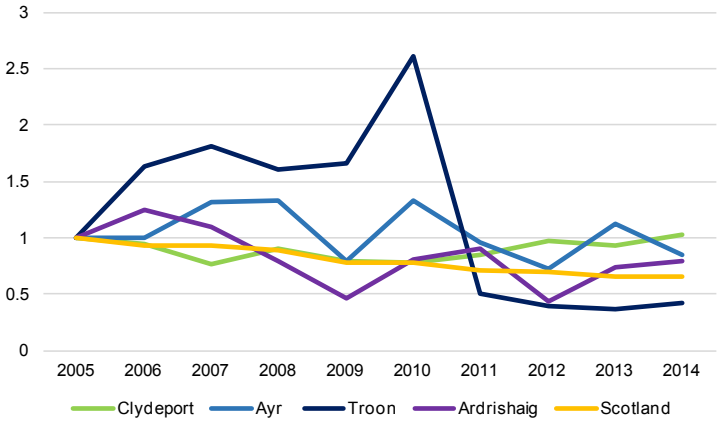
Figure 6.53 Commercial Ports in the Clyde Marine Region



Note: Freight tonnage data for Portavadie, Sandbank and Campbeltown is not available

552. EKOS, 2014
553. Cruise Scotland

Figure 6.55 Change in freight traffic in Clyde Marine Region (2005=1)



Source: DFT

Figure 6.55 and table 6.21 detail the change in freight traffic broken down by port and table 6.22 shows the change in vessels docking.

Figure 6.56 shows the importance of CMR port operations for supporting Scotland's import market with over 80% inward traffic, compared to 36% nationally.

Figure 6.57 and 6.58 look at Clydeport activities in more detail and identify that the majority of cargo is shipping from/to the EU or internationally.



Greenock tugs © PETER SANDGROUND

Table 6.21 All port freight traffic, 2005–2014 (000's tonnes

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	% CHANGE
Clydeport	15,737	14,981	12,063	14,338	12,552	12,283	13,431	15,421	14,783	16,201	+3%
Ayr	418	419	553	557	335	558	402	304	470	355	-15%
Troon	287	469	520	463	477	749	144	114	105	123	-57%
Ardrishaig	136	171	149	107	63	111	124	59	100	109	-20%
Clyde Marine Region Total	**16,579**	**16,040**	**13,285**	**15,465**	**13,427**	**13,701**	**14,101**	**15,898**	**15,458**	16,788	**+1%**
Scotland Total	**108,890**	**101,587**	**101,952**	**96,346**	**85,580**	**84,818**	**77,413**	**76,138**	**71,992**	71,381	**-34%**

Source: DFT
Note: Freight tonnage data for Portavadie, Sandbank and Campbeltown is not available

Table 6.22 Cargo vessels arriving in port, 2005–2014

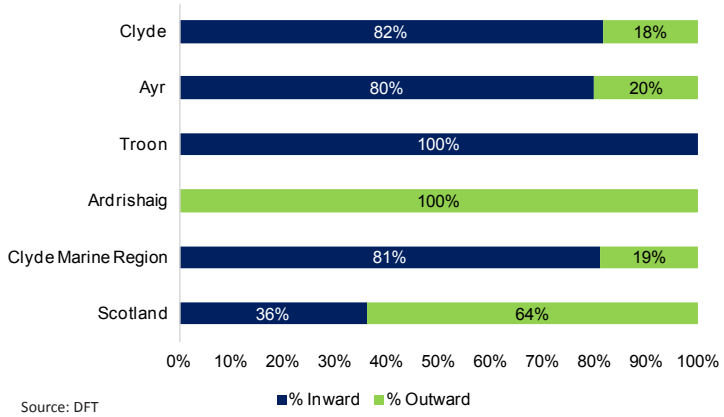
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	% CHANGE
Clydeport	1,111	1,099	1,147	1,134	1,160	1,383	1,698	1,971	1,960	2,776	+150%
Ayr	177	208	160	223	166	244	160	125	173	148	-16%
Troon	*	*	*	*	786	771	736	421	462	474	-40%
Ardrishaig	*	*	*	*	62	81	110	65	89	87	+40%
Clyde Marine Region Total	**1,288**	**1,307**	**1,307**	**1,357**	**2,174**	**2,479**	**2,704**	**2,582**	**2,684**	3,485	**+171%**
Scotland Total	**18,405**	**18,050**	**17,799**	**17,270**	**17,422**	**18,089**	**18,696**	**18,616**	**17,879**	19,630	**+7%**

Source: DFT
* No data available

6.9.5 Timberlink

Timberlink provides a freight link between four ports in Argyll and Bute (Ardrishaig, Campbeltown, Portavadie and Sandbank) and Troon, from where timber is transported for processing in Ayrshire. In June 2014 it was estimated that Timberlink has mitigated the impact of over 1.3 million tonnes of timber transport from the haulage roads between Argyll and Ayrshire since 2000.[554] This has environmental and carbon reduction benefits, reduces road congestion and provides a considerable saving on road maintenance.[555] There is soon to be a dedicated timber freight site at Ardcastle on Loch Fyne.

Figure 6.56 Inward and outward freight by port, 2014



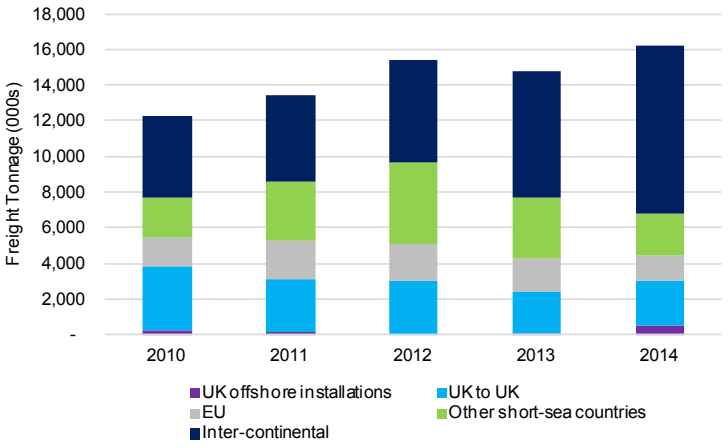
Source: DFT

6.9.6 Disposal of dredged materials

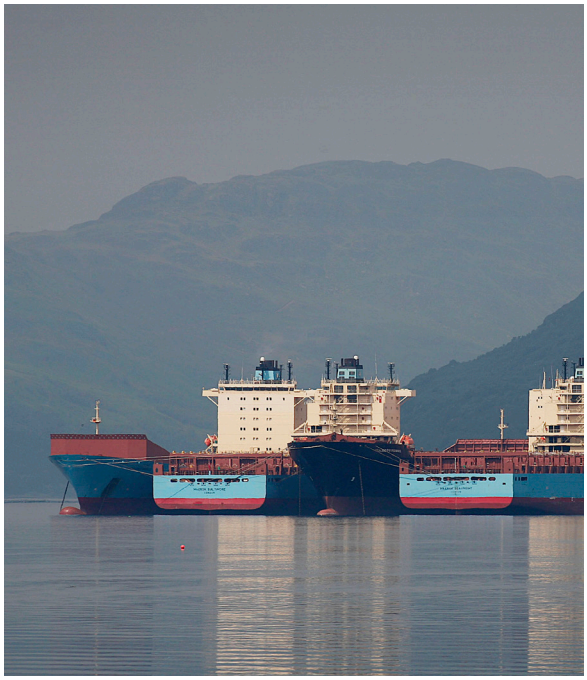
Dredging involves the removal of sediments and debris from the sea bed of harbours and ports to maintain or increase the depth of navigation channels and berthing areas to ensure the safe passage of vessels.

The disposal of dredged material is licensed and monitored by Marine Scotland. Previously there were five sites for disposal in the CMR (Campbeltown, Rothesay Bay, Girvan, Ayr Bay and Cloch Point near Dunoon), however, only Cloch Point is currently listed as an 'open site'. Combined revenue for disposal licenses in the years between 2007 and 2013 was £97,240, 20% of the Scottish total, figure 6.59.

Figure 6.57 Clydeport freight by destination/origin (000s tonnes)

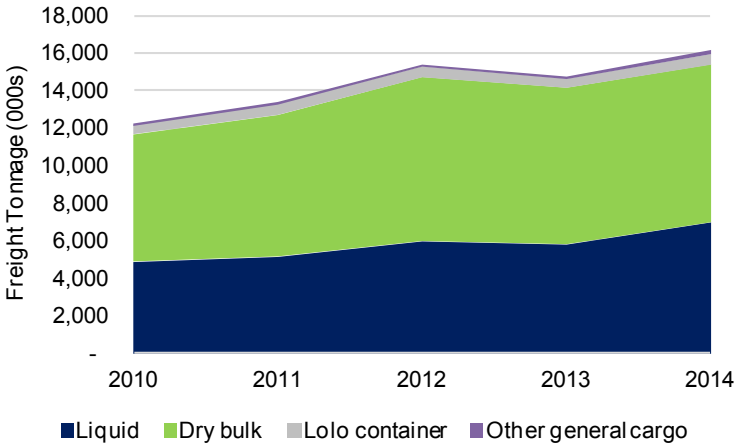


Source: DFT



Ships in Loch Striven © PETER SANDGROUND

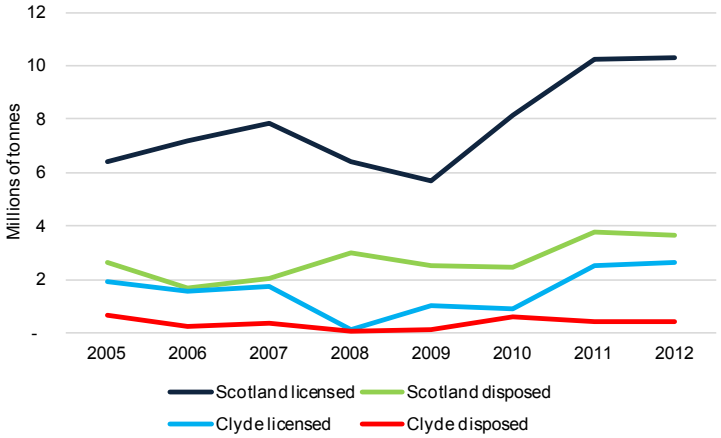
Figure 6.58 Clydeport freight by type (000s tonnes)



Source: DFT
Note: Lolo (Lift-on/lift-off) - cargo ships with onboard cranes
Dry bulk moving through Clydeport includes coal, biomass, aggregates and chemicals while the liquid bulk includes petrochemicals.

554. Forestry Commission Scotland, 2014
555. Forestry Commission Scotland, 2010

Figure 6.59 Disposal of waste (dredged) material, 2005–2012



Source: Marine Scotland, http://marine.gov.scot/data/waste-disposal-dredge-spoil-2005-2012

The difference between the volume of dredged material that is licenced and that which is disposed of is due to the Harbour Authority having to estimate the volume pre application; this will normally lead to an overestimation as there are financial and other penalties for breaching the condition of the licence i.e. disposing of a greater volume of materials than they are licensed for.

6.9.7 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of the shipping and transport sector is provided below.

Climate change mitigation

It should be noted that there are also wider environmental benefits that can be generated through the shipping and transport sector. For example, the use of ships to transport bulk cargo will significantly reduce the road journeys/miles with a knock on impact of potentially reducing CO_2 output and emissions from road transport. Recent activity to reduce the environmental impact of shipping and transport in the CMR includes CalMac's 'Project EcoShip' pilot, which involves the installation of an Advanced Fuel Management System within passenger ferries to reduce fuel and CO_2 emissions. One of the pilot projects includes the MV Caledonian Isles on the Ardrossan to Brodick route.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Provides employment opportunities for a skilled workforce - shipbuilding is a big employer despite recent challenges • Training and Modern Apprenticeship opportunities, in 2014 there were 124 MAs working in the Govan and Scotstoun shipyards • Cruise ships provide a boost to tourism numbers and spend across the region and Scotland • Commercial port operations are vital to sustain Scotland's import and export trade • Supports the sustainability of many coastal towns that rely on commercial freight and tourism – jobs in the local economy • Proposed infrastructure upgrades will create jobs in the construction sector • Strong supply chain linkages – ship/boat maintenance, logistics, and distribution • Ferry routes are lifeline support to island communities. • Transport by cargo ships can have a positive environmental impact through bulk cargo transport – reducing road journeys and CO_2 output – key priority for the Glasgow and Clyde Valley Strategic Development Plan[556]	• Competition for coastal locations and routes – although numerous bodies responsible for management and co-ordination of activities • Potential conflict with other sectors e.g. expanding port facilities could impact natural heritage conservation interests • Potential conflict between commercial and leisure activity – much of this is managed by Peel Ports Clydeport through measures such as the Clyde Moorings Committee and the publication of a Clyde Leisure Navigation map to support safety and minimise conflict[557] • An increase in the number of cars visiting islands in the Clyde can have knock-on impacts such as increased road congestion and shortage of accommodation.

556. Clydeplan, 2015
557. Peel Ports Clydeport, 2015

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Pollution	Introduction of hazardous substances	Terminals within Peel Ports Clydeport are used for importing coal, chemicals and crude oil, so there is potential for leaks and spillages. There are, however, cargo handling and safety procedures in place and an Emergency Procedure, Port Waste Management guidance document in the event of a chemical spillage.[558] Further, the Clyde Clean Oil Spill Response Plan has been updated in mid-2016. Within the Clyde there have been no significant leaks or spills requiring a response in recent history. Vessels that use the ports and harbours are likely to be treated with antifoulant to protect the bottom of the boat from fouling. The International Maritime Organization (IMO) provides regulatory guidance on the types of chemicals that can be used as part of these antifouling treatments.
	Release or reintroduction of hazardous substances	As is the case in many ports or harbours, there is a risk that dredged materials could contain 'legacy' contaminants (oil, heavy metals, pesticides, etc.). Dredging and disposal activities are licenced by both Marine Scotland[559, 560] and (within their area of jurisdiction) by Peel Ports Clydeport. Before any navigation-related dredging is allowed to take place on the Clyde, the chemical status of the sediments must be established through sampling and analysis, and disposal to sea will only be authorised if the sediment meets strict quality requirements. In exceptional cases where the dredging of contaminated sediment is necessary, the dredging process itself is controlled and the sediments must be disposed to a suitably licensed land-based facility
Hydrological	Water flow/ wave exposure change	The Clyde estuary has historically been narrowed by land reclamation and deepened to allow shipping access to ports. It is classified under the Water Framework Directive as a Heavily Modified Water Body and has Moderate Ecological Potential (see Chapter 4.1 – Water Framework Directive). The decreased water flow has led to layering of the water column and contributed to de-oxygenation of the Clyde estuary in the past. Since the 1970s, oxygen levels in the Clyde have been steadily improving to the point where levels in the inner Clyde are now able to support most ecosystem functions (see Chapter 4.7-Dissolved Oxygen).
Other physical	Underwater noise	Whereas no Clyde specific studies have been undertaken, there is emerging evidence nationally and internationally to indicate that certain species can be sensitive to high frequency impulsive sounds (e.g. sonar); to continuous low frequency (ambient) noise; and/or to high amplitude, low and mid-frequency impulsive sounds. Under the EU Marine Strategy Framework Directive Programme of Measures, Defra[561] is establishing a monitoring programme for continuous low frequency (ambient) sounds and a registry for impulsive sounds. These and other initiatives will contribute to policy development and help to determine whether any local level interventions are needed. See Chapter 4.9 Noise.
Biological	Introduction of INNS	Within the CMR there are 11 Non-Native Species (NNS) identified in the biosecurity plan that are of 'concern'. Organisms present in ballast water and living on ship hulls are just two of many 'pathways' by which NNS can be introduced. Whilst in practice the Clyde is an area where more ballast water is taken up than is discharged, port operators rely on vessels' compliance with international law as there are no are no specific requirements on ports under the International Convention on Ballast Water Management. In the meantime, guidance is in place to limit potential impacts, for example, vessels are not allowed to pump out non-sterilised water into ports. See Chapter 5.10 on Non-Native Species for more information on this.
	Physical effects of suspended sediment	Increased levels of suspended sediments can detrimentally affect filter feeders, and certain seabed habitats can be susceptible to smothering by the deposition of sediments (whether as a result of disposal of dredged material or the deposition of sediments that have been re-suspended in the water column as a result of the dredging process). In order to ensure that significant effects are avoided, potential impacts are considered as part of the licensing process for both dredging and disposal activities, and mitigation measures can be included as conditions on the licence where necessary. There are no Clyde specific data available regarding this potential impact.
Other physical	Litter	There are no Clyde specific data regarding the impact of litter deposited in the region from shipping and transport activities, however, marine litter is currently the focus of the EU Marine Strategy Framework Directive. In common with many EU Member States, the UK has only a limited understanding of current levels, properties and impacts of marine litter. The UK's Marine Strategy Framework Directive Programme[562] of Measures highlights the importance of effective implementation of various existing measures, and there is also a focus on data collection in order to better understand the problem and to inform future measures.

558. Peel Ports Group
559. The Scottish Government, 2016a
560. Marine Scotland, 2913
561. Department for Environment Food and Rural Affairs, 2015
562. European Commission, 2016a

6.9.8 Regional Look Forward

The commercial ports in the CMR are vital for sustaining and growing Scotland's export/import base, with exports increasing annually since the mid-2000s. The value of Scottish (foreign) exports was £27.9bn in 2013 and the Scottish Government has set ambitious targets of increasing the value of exports 50% by 2017.

Cost savings in the sector will partly be driven by new ship technologies and larger vessels; therefore the region needs the infrastructure, facilities and capacity to support this. Hunterston is identified as a key port in National Planning Framework 3 (NPF3) as it is a major deep water port and benefits from good transport connections and close proximity to the Glasgow metropolitan region. The future development of the port is likely to include the development of manufacturing and servicing support for offshore renewable energy development, which includes strategic grid connections through, for example, the Irish-Scottish Links on Energy Study (ISLES) project.

As part of the NPF3 consultation, North Ayrshire Council commissioned a study to support its proposals for Hunterston to gain 'national development status' - Hunterston Competitive Advantage Study. The study highlighted that Hunterston is well placed to potentially serve the oil platforms within the East Irish Sea, a number of which are expected to be commissioned over the period 2018–2025.[563] Clydeport freight is dominated by fuel imports – with coal (39%) and crude oil (29%) amounting to 68% of all inward and outward freight at the port in 2014. Coal is transported from Hunterston via rail to the Drax power station in Yorkshire and Longannet power station in Fife. However, with the UK set to phase out coal power entirely by 2025 and Longannet having closed in March 2016, coal imports have already fallen away sharply. Hunterston benefits from a number of advantages – natural deepwater, a significant land footprint, and good rail and utility connections. Peel Ports Clydeport is working, in partnership with Scottish Enterprise and North Ayrshire Council, on developing a suite of development options for the bulk terminal and the marine construction yard. There are also significant opportunities around the emerging Ayrshire Growth Deal which could see Hunterston providing a key role for inward investment and local job opportunities.

While there is no specific development information for the ABP operated ports of Troon and Ayr, Scottish Development International promote the Clyde as part of Scotland's Energy Ports provision.[564]

The Scottish Ferries Plan 2013–2022[565] provides strategic guidance for the provision of ferry services in Scotland and identifies investment priorities for the continued delivery of lifeline services between the islands and mainland Scotland.

The key recommendations and actions identified for ferry routes in the Clyde are presented below:

- **Ardrossan to Brodick** – increased summer sailings and funding approved for development of double berth pier, new terminal building and associated infrastructure works at Brodick. The recent CalMac passenger journey data show an increase in passenger journeys of +7.1% on the previous year since the introduction of RET. The Ardrossan Task Force has been formed and is chaired by Transport Scotland. This is currently evaluating the necessity for enhanced harbour infrastructure and the investment required to facilitate the new ferries which will be brought into service in 2018;
- **Claonaig to Lochranza** – route to be retained;
- **Tarbert to Portavadie** – route to be retained;
- **Ardrossan to Campbeltown** – summer only service, in December 2015 the three-year pilot was confirmed as a permanent seasonal service (transporting an average of over 10,000 passengers and 2,000 cars per annum);
- **Wemyss Bay to Rothesay** – current service adequate and any upgrade considered to be disproportionately expensive;
- **Colintraive to Rhubodach** – route to be retained with timetable adjustments – last sailing in the summer months now 9pm;
- **Gourock to Dunoon** – identified as important route and a number of improvements were identified:
  - the implementation of an Improvement Plan by Argyll Ferries
  - replacement vessel for the MV AliCat
  - a feasibility study of a future passenger and vehicle service on the town centre route
  - recommendation that a non-subsidised vehicle carrying ferry service could be incorporated in the route
- **Largs to Cumbrae** – route to be retained, timetable adjustments - last sailing in the summer months to be later.

The cruise ship market in the Clyde (and across Scotland more generally) is forecast to grow, with estimates from the expansion of Ocean Terminal at Greenock identifying scope for an increase of 50,000 to 110,000 additional passengers every year.

563. North Ayrshire Council
564. Scottish Development International (2015)
565. Transport Scotland, 2012

6.10 Waste water treatment and industrial outfalls

Summary

Waste water treatment (WWT) is the process by which waste water is treated to protect public health while taking into consideration, and lessening the impact of this output on the marine environment. Waste water from mains sewerage systems, combined overflows, industrial outflows and some private domestic sites is subject to one of four levels of treatment at waste water treatment plants before it is released into rivers or the sea. Waste water treatment works reduce contamination in the water to acceptable levels before it is released into the environment.

The type of treatment waste water undergoes depends on the size of the nearby population or the sensitivity of waters receiving the output.[566] Scottish Water provides and maintains sewerage infrastructure and services to households around Scotland and treats all waste water in compliance with SEPA regulations. Sewage system infrastructure improvements made by Scottish Water over the last five years (some are still ongoing) have reduced the impact of point source pollution on the marine and coastal environment, by reducing the input of nutrients which can lead to eutrophication.

The objective of the Urban Waste Water Treatment (UWWT) Directive (1991)[567] (transposed into Scottish law as the Urban Waste Water Treatment (Scotland) Regulations 1994, and amended in 2003[568]) is to protect the environment from the damaging effects of untreated urban waste water and discharges from certain industrial sectors.[569] It requires the collection and treatment of waste water according to the size of agglomerations and imposes other regulations such as pre-authorisation of discharge of waste water, monitoring and other controls.[570] Nitrate levels of waters are surveyed every four years to determine the impact of sewage discharges. If the discharges are found to be affecting waters they are designated as 'nutrient sensitive' and measures to reduce the amount of nutrients entering the water are put in place.[571]



The River Clyde and a view of Glasgow © P&A MACDONALD

566. Baxter *et al*., 2011
567. European Commission, 2016b
568. The Urban Waste Water Treatment (Scotland) Amendment Regulations 2003
569. This includes: Milk-processing, manufacture of fruit and vegetable products, manufacture and bottling of soft drinks, potato-processing, meat industry, breweries, production of alcohol and alcoholic beverages, manufacture of animal feed from plant products, manufacture of gelatine and of glue from hides, sk and bones, malt-houses and fish-processing industry
570. European Commission, 2016b
571. The Scottish Government, 2016c

Waste water treatment and industrial outfalls in the Clyde Marine Region

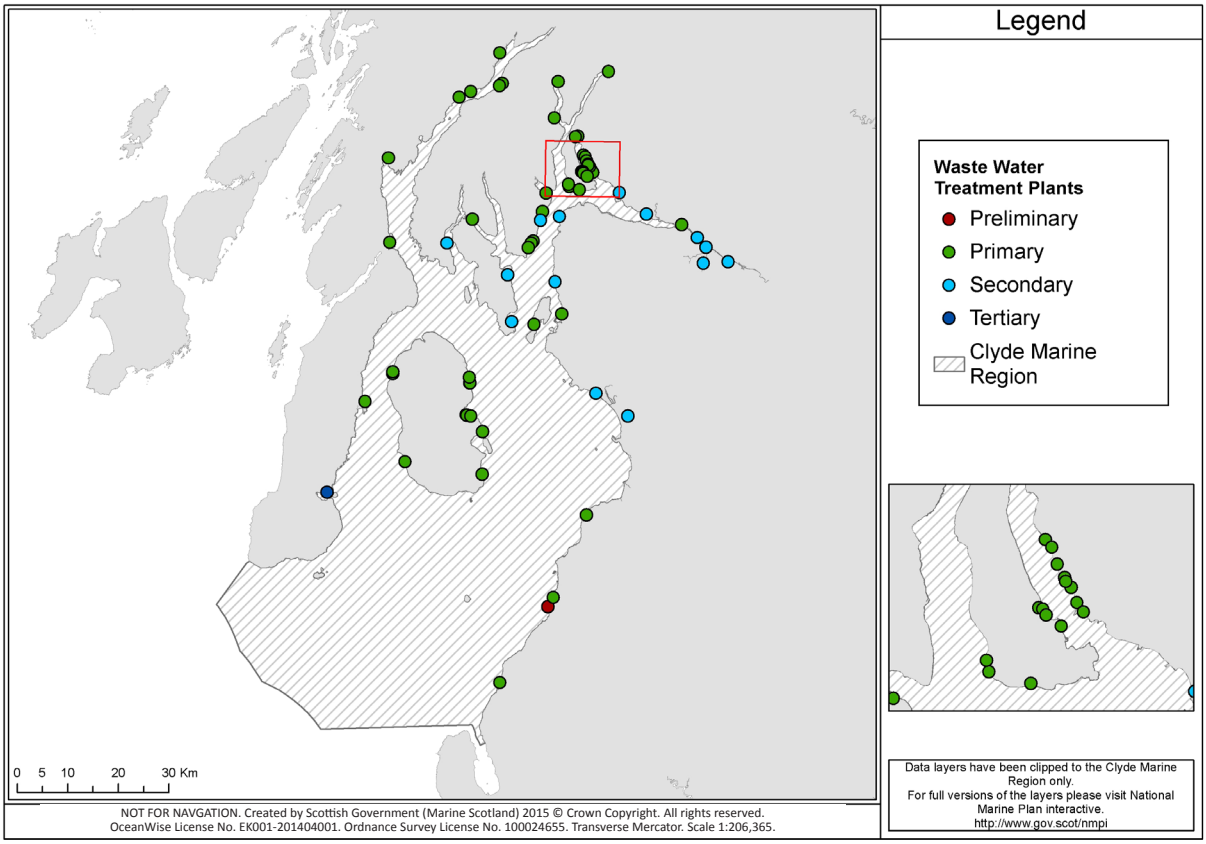
The Clyde Marine Region (CMR) is one of the most industrialised and urbanised areas in Scotland. Data from 2013 show there are 73 sewage outfalls in total (from sewage mains and industrial outfalls) along its coast. Maps 29 and 30 below show the locations and types of waste water outfalls and industrial marine discharges in the CMR.

- 7 are industrial outfalls and 66 are waste water treatment (WWT) plant outfalls
- One processes preliminary waste (removal of coarse solids and large materials), 50 carry out primary treatment which is a physical and/or chemical process involving settlement of suspended solids, 14 carry out secondary treatment involving biological treatment designed to reduce the oxygen demand and bacterial content of sewage and one carries out tertiary treatment. Tertiary treatment can include filtration, removal of nutrients such as phosphorous and disinfection.
- In 2011, 46 plants output between 0-1000m^3 of waste water into the sea per day, 11 plants output between 1,000-50,000m^3 and four plants output 50,000 to 150,000m^3 per day.[572]

Industrial discharges are licensed if the volume of effluent is >10 m^3/day and the population equivalent is >15. SEPA regulates such outfall discharges through the Controlled Activities Regulations (CAR). Within the CMR, types of industry discharging effluent into the marine environment include: the energy sector, food and beverage sector, chemical industry, intensive livestock production and paper and wood production and processing. Information on pollutants released through industrial activity are monitored and recorded through the Scottish Pollutant Release Inventory (SPRI). SEPA has created an application[573] where the data can be fully examined according to waste, pollutant, local authority, company details and a number of other conditions.

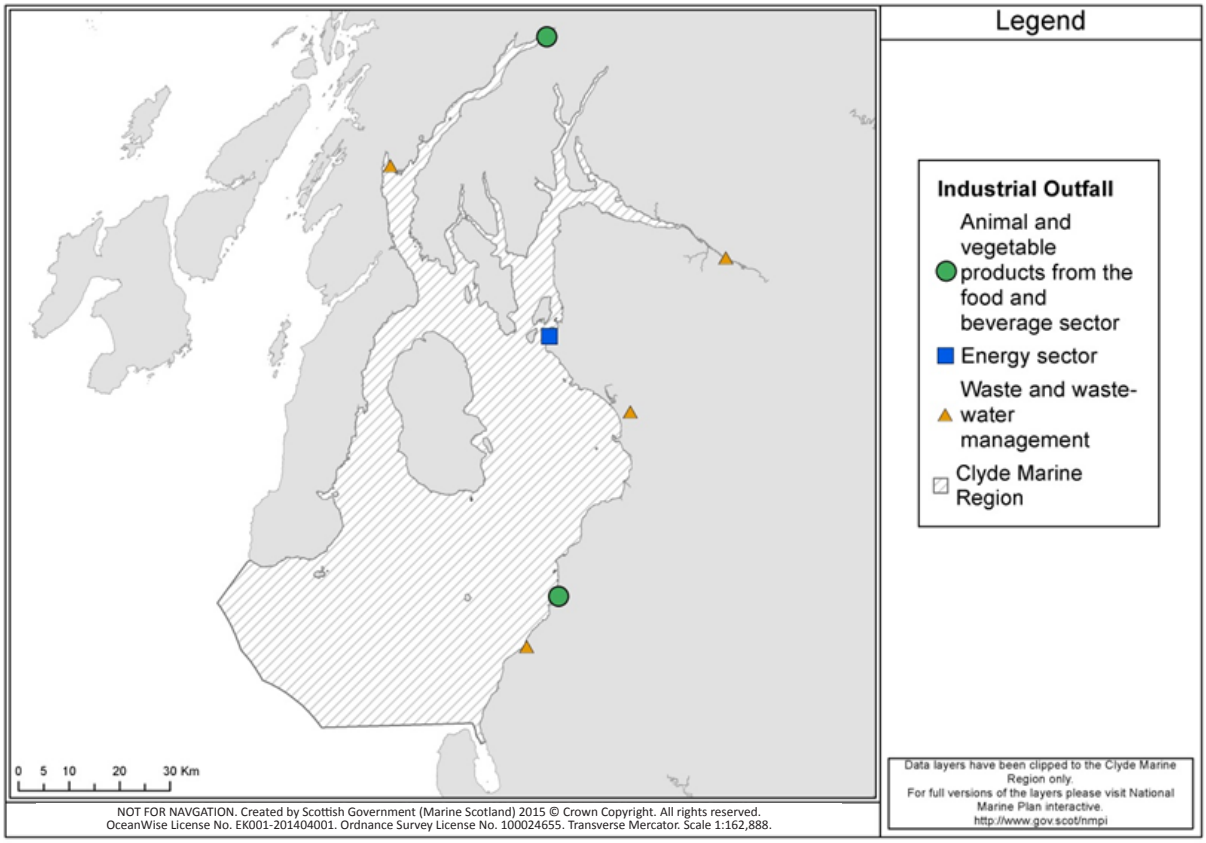
In addition to waste water treatment outfalls, there are also many private outfalls, some of which have septic tank, biodisc/filter secondary treatment or no treatment.

Map 34. Types and location of waste water treatment plants in the Clyde Marine Region, 2012



572. Baxter *et al.*, 2011
573. Scottish Environment Protection Agency, e

Map 35. Types and location of industrial marine discharges (from the Scottish Pollutant Release Inventory) in the Clyde Marine Region, 2013



6.10.1 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of marine waste water treatment and industrial outfalls is provided below.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Provides employment opportunities for a skilled workforce • Provides clean seas for other activities to take place, in particular recreation and aquaculture • Provides a service to society	• Pollution through system failure or overflows following heavy rain • Possible obstruction on seabed • Local nutrient enrichment which may affect other users of the marine environment • Private outfalls can be an issue for shellfish growers, particularly oyster farmers in terms of the risk of norovirus.

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Pollution	Hazardous substances	Any metal, radioactive or organic contaminants from industrial discharges may reduce water and sediment quality.
	Addition of nutrients and organic matter (including faecal material)	The addition of nitrogen and phosphorus can result in the hypernutrification of the environment, which can lead to excessive plant growth and plankton blooms. This can in turn cause oxygen depletion and along with the addition of organic matter (including pathogens present in faecal material) can have a damaging effect on marine organisms as well as making water unsafe for recreational or aquaculture purposes (see Chapters 4.3-4.5).
Other physical	Litter	If litter is present in waste water or due to overflow, there is a risk of entanglement or ingestion by wildlife.

6.10.2 Regional Look Forward

Scottish Water has a £3.5bn investment programme for 2015–21 and has developed a new delivery model which involves working in partnership to deliver both maintenance and improvements to existing assets. Scottish Water is also developing rural frameworks which will allow more efficient delivery of improvements through smaller contractors at a local level.

A £250m, five-year programme of work, from 2013 to 2018, is currently underway which will improve water quality and the natural environment of the Clyde estuary. It will also enable the Greater Glasgow area to continue to grow and develop, alleviate sewer flooding and deal with the effects of increased rainfall and climate change. The investment includes upgrades to around 200 Combined Sewer Overflows (CSOs), or outfall pipes - safety valves used to control waste water during heavy rainfall - on the River Clyde and tributaries such as the River Kelvin and White Cart Water. It also includes waste water improvements in the south west of Glasgow to remove excess surface water from areas with known 'pinchpoints', which cause restrictions in the system, and a number of key projects to tackle flooding in parts of the city.

6.11 Water abstraction

Summary

Water abstraction is the *'removal or diversion of water from the natural water environment, by a variety of means, including pumps, pipes, boreholes and wells'* (SEPA). Water abstraction in the Clyde Marine Region (CMR) is dominated by energy production. Hunterston B nuclear power station uses 97% of the 2,640,847m^3 of water licensed to be abstracted from and returned to the Clyde each year for industrial cooling. One other power station is licensed to abstract water, the Claddoch hydro power station on the Isle of Arran, for 25,920m^3 per day. The remainder of abstraction licenses are used for fish processing or other industrial processes, for example chemical treatment and agriculture.

Defining the sector

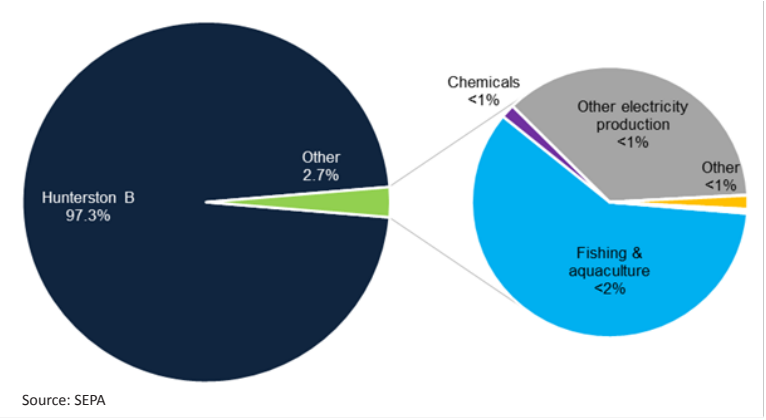
While water abstraction can improve the efficiency of some sectors (through cost savings), it is challenging to define and identify the economic value of the sector. This section only considers the activities related to water abstraction and does not quantify the economic contribution of the sector.

The breakdown of water abstraction activities is considered below in figures 6.60 and table 6.23, and shows that the main water abstraction activity supports the Hunterston B Power Station. The power station is owned and operated by EDF Energy and employs some 770 people. The station was originally scheduled to stop generating power in 2011. However, due to a £20m investment in the facility it will now remain operational until 2023. The financial benefits to the local economy have been estimated at £40m per year.[574]

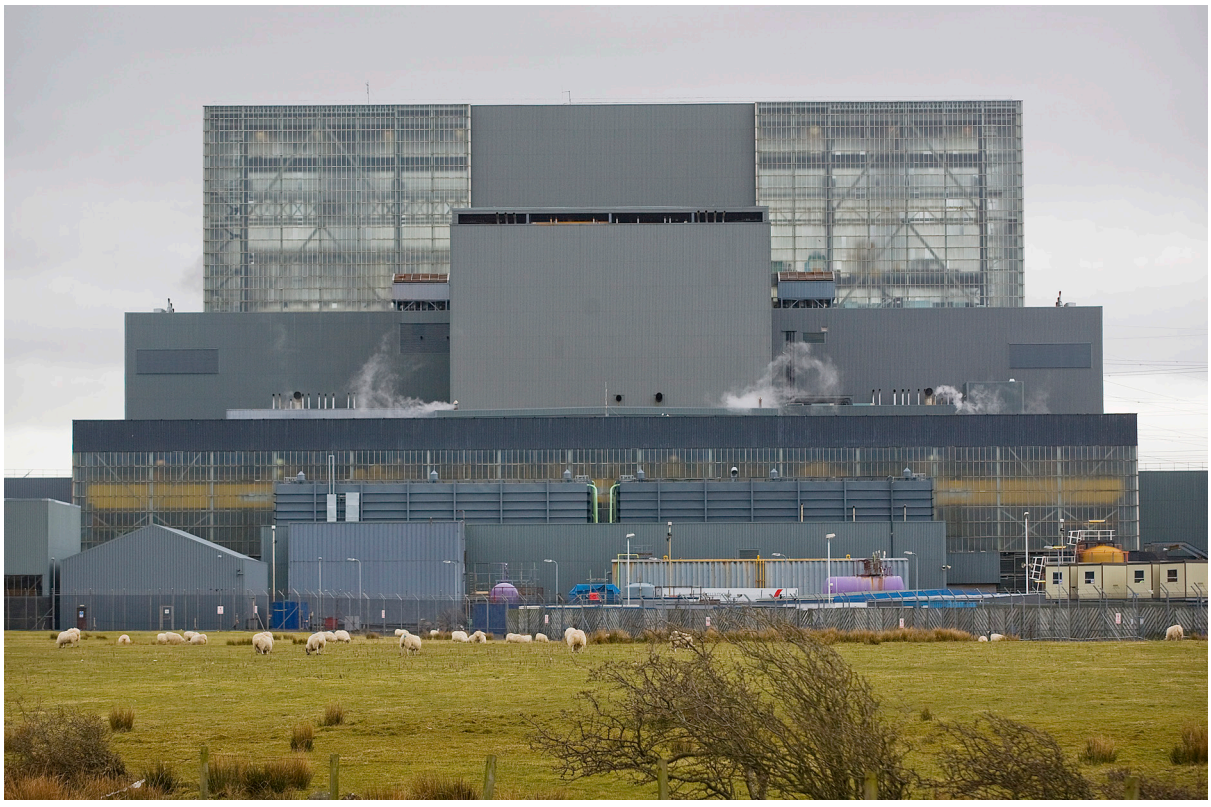
Water abstraction activities

Figure 6.60 breaks down the water abstraction activities in the CMR.

Figure 6.60 Coastal water abstraction in the Clyde Marine Region, 2014



Source: SEPA



Hunterston B © PETER SANDGROUND

574. BBC News, 2012a

Table 6.23 Number of licenses and amount of water abstracted according to industry in the Clyde Marine Region, 2014

SECTOR	ABSTRACTION TOTAL (m^3/DAY)	Number of licenses
Electricity, gas, steam and hot water supply	2,595,920	2
Fishing and aquaculture	42,200	3
Manufacture of chemicals and chemical products	1,175	1
Other business activities	1,150	3
Public administration and defence	182	2
Other service activities	100	1
Sewage and refuse disposal and sanitation	80	2
Construction	40	1
Manufacturing of food and beverages	0	1
Total	**2,640,847**	**16**

Source: SEPA

6.11.1 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of human activity in the water abstraction sector is provided below.

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	**NEGATIVE**
• Vital for the operation of Hunterston B power station which is a big local employer and supplies electricity to 1.7 million homes • Supports other marine sectors including fishing and aquaculture	• Potential conflict with other sectors by limiting nearby activity e.g. aquaculture

ENVIRONMENTAL PRESSURES AND IMPACTS		
PRESSURE THEME	**PRESSURE**	**IMPACT**
Hydrological	Temperature change	After water has been abstracted and used, the water is returned to the Clyde at a higher temperature and treated with chemicals (no conclusive studies have been undertaken on the potential effects of chemical treatment). This could potentially create a suitable habitat for invasive species to colonise. A change in average temperature of the habitat may also impact negatively on native species.
Biological	Removal of species	There is no specific information available at the Clyde level, however, given the significant abstraction operations at Hunterston there will likely be some negative effect caused by species being removed through water extraction pipes. Evidence suggests that the removal of fish via the abstraction intake process is less of an issue at coastal locations due to the larger body of water.[575]

6.11.2 Regional Look Forward

As highlighted above, water abstraction is important for the cooling towers at the power station. However, Hunterston B is scheduled to cease operations and start decommissioning in 2023, therefore significantly reducing the demand for water abstraction in the CMR.

575. Baxter *et al.*, 2011

6.12 Marine management, education, research and development

Summary

Maritime management includes the statutory bodies that have responsibility for the management, operation, and conservation of Scotland's seas, coastlines and inland waterways for leisure, commercial and other uses. Marine Scotland is the over-arching body with responsibility for managing Scotland's seas for prosperity and environmental sustainability and work closely with key partners including Scottish Natural Heritage (SNH) and the Scottish Environment Protection Agency (SEPA).

At the national level, there are numerous bodies, agencies and groups that have a remit, or interest in the marine environment and key to co-ordinating activity is the Marine Strategy Forum, established in 2009, to allow strategic cross-sector collaboration across numerous organisations.[576]

At the regional level, marine planning is being developed by the Clyde Marine Planning Partnership (CMPP) which works to further the integrated and sustainable management of the Clyde's environmental, economic and community resources.

The Clyde 2020 project was launched by the Cabinet Secretary in 2014 and will inform the regional marine plan for the Clyde. The Clyde 2020 vision is: '*The Firth of Clyde is a healthy and thriving marine ecosystem that is capable of adapting and mitigating for the challenges of climate change and supports sustainable fishing, tourism, leisure and other sustainable developments while offering protection to the most fragile species and habitats. This will enhance the quality of life for local communities and contribute to a diverse and sustainable economy for the West of Scotland.*'

In terms of the research and education activities in the Clyde Marine Region (CMR), there are a number of institutions and organisations that provide dedicated research resources and facilities to study the marine environment, such as the Field Studies Council, Millport (formerly University Marine Biological Station). There are not-for-profit organisations such as Community of Arran Seabed Trust (COAST) and the Clyde Marine Mammal Project (CMMP) that focuses on community facilitated research.

In addition, there are Higher and Further Education (HE/FE) institutions that provide a range of courses and qualifications that have a focus on the marine environment.



Research sampling of the intertidal zone © CMPP

576. The Scottish Government, 2015

Defining the Sector

The marine management, education, research and development sector is vital for the management of seas, waterways, and coastline, however, given the diverse nature of the sector it is challenging to define and identify the economic value of the sector. Therefore, this section only considers the activities and does not quantify in detail the economic contribution of the sector.

6.12.1 Contribution to the Economy

The impact of marine management, education, research and development organisations is challenging to quantify from official data sources due to the nature of the work of many of the organisations.

As the over-arching body responsible for management of the marine environment, Marine Scotland has a staff of around 700, primarily based in Edinburgh. The 2015/16 core budget for Marine Scotland was around £55m[577] (representing a decline of -2.5% in real terms on the 2014/15 budget).

The Marine Alliance for Science and Technology for Scotland (MASTS) is a research collaboration project that brings together the marine research activity of research institutes, universities, government and non-departmental public bodies from across Scotland with a combined research expenditure of over £66m annually.

Although located in Oban (just outwith the direct CMR), the Scottish Association for Marine Science (SAMS) is an independent research organisation specialising in marine science – with research strengths in marine renewables, aquaculture, marine biotechnology, marine policy, deep-sea systems, climate change and polar science. SAMS provides undergraduate and post graduate education (as well as vocational and non-vocational learning) and consultancy services. SAMS employs around 165 regular staff and a number of seasonal staff on a project by project basis.

6.12.2 Marine Management and Activities

Marine Scotland was established in 2009 to oversee the management of Scotland's seas, including marine planning, licensing, enforcement, policy development, and scientific research and monitoring. It is a directorate of the Scottish Government, with its remit within the Exclusive Economic Zone (EEZ), which typically encompasses 200 nautical miles of sea from the coast.
It operates a number of fisheries protection vessels and aircraft, including the MPV Minna based in Greenock. Marine Scotland operate two fishery offices in the CMR:

- Ayr: with responsibility for the Ayrshire coast, the Cumbraes and Inverclyde; and
- Campbeltown: with responsibility for Kintyre, Arran, Bute and Loch Fyne.

The Scottish Environment Protection Agency (SEPA) is a non-departmental public body, established in 1996 as Scotland's environmental regulator. Its powers extend three nautical miles from the coast (under WFD 12 nautical miles for chemical contaminants). SEPA's responsibilities include River Basin Management Planning, reporting on bathing water quality, regulating water abstraction, monitoring pollution, Flood Risk Management including running a flood warning service. In the CMR, SEPA have offices in Ayr, Glasgow, Lochgilphead and Balloch.

Scottish Natural Heritage (SNH) is a public body which is responsible for Scotland's natural heritage. SNH advises the government on all aspects of nature, wildlife management and landscape across Scotland. Its marine remit extends from the coast to the limits of territorial waters. SNH operate offices in Lochgilphead, Dunoon, Clydebank and Ayr.

The Joint Nature Conservation Committee is a UK-wide body which advises on delivering national and international nature and conservation responsibilities, working closely with SNH.

Historic Environment Scotland was established in 2015 through the merging of Historic Scotland and the Royal Commission on the Ancient and Historic Monuments of Scotland. An executive agency of the Scottish Government, it has responsibility for designating, recording and conserving Scotland's built heritage. The organisation collects, records and interprets information on Scotland's maritime and coastal heritage. Historic sites managed by the organisation are detailed in the Historic Environment and Cultural Heritage section.

Crown Estate Scotland (Interim Management) is a public body which manages more than half of the country's foreshore, and virtually Scotland's entire seabed to the 12 nautical mile limit. However, much of the foreshore in the CMR is not managed by the Crown Estate Scotland (Interim Management); for instance, the entire coastlines of Arran and Bute, much of the Ayrshire coast and upper Loch Fyne are owned privately or by other bodies.

The Northern Lighthouse Board is a non-departmental public body which oversees lighthouses and navigational lights in Scotland and the Isle of Man. The Board are responsible for eight lighthouses in the CMR, located in: Sanda, Davaar, Pladda, Holy Isle (2), Lady Isle, Turnberry and Ailsa Craig.

The Clyde Marine Planning Partnership (formerly the Firth of Clyde Forum) was constituted in February 2016 and is an unincorporated association which works to further the integrated and sustainable

577. The Scottish Government,2014c

management of the Clyde's environmental, economic and community resources. Its members and supporters include authorities with Clyde coastline, private sector operators, government agencies, and community groups. The Forum has been involved in implementing marine planning initiatives, including the voluntary Firth of Clyde Marine Spatial Plan (2010). The Partnership has been given delegated authority by Scottish Ministers to develop the first statutory Clyde Regional Marine Plan.

The Local Authorities and Loch Lomond and The Trossachs National Park have planning responsibility down to the Mean Low Water Spring mark. They also have planning responsibility for the aquaculture sector.

The West Coast Regional Inshore Fisheries Group (WCRIFG) covers the coastline from the national border in the Solway Firth to Cape Wrath in the North West and thus includes the Clyde. WCRIFG is a non-statutory body which works with fishermen and public agencies to improve the management of Scotland's inshore fisheries (i.e. within six nautical miles), and to advocate on behalf of inshore commercial fishermen. WCRIFG was established with an aim of being the main route for engagement between commercial fishermen and marine planning partnerships.

A number of other public bodies have marine management roles in Scottish waters, including the CMR. Oil and gas extraction is reserved to the Department for Energy and Climate Change, the Department for Transport have responsibility for shipping and the Ministry of Defence for military activity. Peel Ports Clydeport is the Harbour Authority responsible for much of the CMR from Glasgow, in the sealochs (except Gareloch and Loch Long) and out to Arran. The Queen's Harbour Master has jurisdiction in Gareloch , Loch Long and Loch Goil (Ministry of Defence facilities). ABP Ports are responsible for Troon and Ayr harbours. Caledonian Maritime Assets Ltd own harbours/slipways at Brodick, Lochranza, Rhubodach, Cumbrae, Largs, Wemyss Bay, and Gourock. Argyll & Bute Council own Campbeltown Harbour, Carradale Harbour, Dunoon Pier and Rothesay Harbour within the CMR. There are also Tarbert Harbour Authority and Holy Loch Port.

6.12.3 Research and Education

The Marine Alliance for Science and Technology for Scotland (MASTS) is a network of 700 researchers in marine science from across Scotland – including most of the marine research in Scottish universities. It was launched in 2009 with seven years of funding from the Scottish Funding Council (SFC), and has ambitions to become self-supporting beyond the SFC funding period. Consortium and Associate members in the Clyde include the University of Glasgow, the University of Strathclyde and the University of the West of Scotland.

Marine Scotland Science has its principal marine laboratory in Aberdeen, although with a national remit. The unit carries out research and monitoring of Scotland's aquatic environment and its flora and fauna.

A variety of marine related courses are available to study at educational institutions in the CMR. Only courses that are explicitly marine-focused are detailed below, however, many other courses will include a marine element, including science, geography and tourism/hospitality courses. COAST on the Isle of Arran hosts 2 to 3 MSc students and 1 PhD student on average per year.

6.12.4 Pressures and Impacts

An assessment of the socio-economic and environmental pressures and impacts of the marine management, education, research and development sector is provided below. There are no environmental pressures to consider as part of the sector review.

6.12.5 Regional Look Forward

The continuation of collaborative engagement and working between the various bodies and organisations with a remit or interest in the marine environment will be essential for the successful management of marine resources and integration of the various sector activities. An improving state of the marine environment in the CMR will provide opportunity for this sector in the future. National policy and emerging regulatory issues will play a significant role in the future of the CMR, although the establishment of a regional planning body – the newly constituted CMPP – will ensure there is a degree of regional influence. A new Marine Discovery Centre is proposed for the Isle of Arran which will include research facilities and education on marine issues facing the CMR.

The CMPP is directed by Scottish Ministers to develop a Regional Marine Plan for the CMR. This involves producing an Assessment (this document) to consider the condition of the region, including the impact of human activity on the region. The Partnership will then begin development of the Regional Marine Plan following the Ecosystem Approach with input from many local stakeholders and the general public.

Looking at the education sector, there is a greater focus on school level engagement, for example the Keep Scotland Beautiful Eco schools and the RSPB schools programme. In part this is driven by the Scottish Government's Curriculum for Excellence through Outdoor Learning[578] and initiatives to promote sustainability and access to outdoor learning – One Planet Schools.[579]

578. Learning and teaching Scotland, 2010
579. The Scottish Government, 2012c

Table 6.23 Marine Education

HE/FE INSTITUTION	COURSES/EXPERTISE	STUDENTS AND STAFF
City of Glasgow College: Faculty of Nautical Studies	Marine Engineering, Nautical Science, Shipping and Maritime Operations, Officer training, RYA courses	3,800 students (13% of total college roll in 2012/13)
University of Glasgow	Marine Ecology, Seabird Ecology, Coastal System Management, Marine System Science. The University also has a field station on Loch Lomond – the Scottish Centre for Ecology and the Natural Environment (SCENE).	Student numbers: • Biology total: 3,095 • Earth, Marine & Environmental Science: 105 • Bioscience: 337
University of Strathclyde	Marine Engineering, Naval Architecture, Ship & Offshore Structures, Offshore Renewable Energy, Subsea & Pipeline Engineering,	550 students and 55 teaching staff.
Field Studies Council, Millport (formerly the University Marine Biological Station)	Courses to suit all levels (primary school to university). Marine biology, Microbiology lab, aquarium, research vessel. Ownership transferred to the FSC and a multimillion pound refurbishment of the site has been completed.	18 teaching/research staff and 5,000 visiting students per annum. Provide subsidies for teacher training and children from disadvantaged backgrounds – promoting inclusivity.
University of the West of Scotland (UWS)	Institute of Engineering and Energy Technologies, which brings together expertise from different disciplines. Includes focus on renewable energy. Applied Bioscience & Zoology (includes marine ecology and toxicology).	6 teaching and research staff. 10 PhD students and 30-40 undergraduate students' per year.
West College Scotland	HNC/NC Engineering with Renewable Energy Systems.	No data on students or staff available.
Glasgow Maritime Academy	Independent academy offering a range of marine qualifications and accreditations.	No data on students or staff available.

Source: Higher Education Statistics Agency 2013/14, Online search & contact with institutions

SOCIO-ECONOMIC PRESSURES AND IMPACTS	
POSITIVE	NEGATIVE
• Opportunities to access training and accredited academic courses – subsidies available • Marine research activity and attracting investment to CMR and Scotland • Provide employment opportunities • Co-ordinated activity of numerous management, operational and research organisations and bodies • promoting the Clyde and related marine research through international conferences and events	• Competing uses with other sectors for coastal access • Research sector may compete with industry for project funding

7. Research and knowledge gaps

Listed here are the significant gaps identified during the drafting of this Assessment. Many of these gaps, whilst important for the Clyde Marine Region (CMR), may well link into projects and research from other regions or at a national level. It is not intended to discount the importance of any other projects and research which may be ongoing or undertaken in the future to improve our understanding of human activities and impacts in the CMR.

Ecosystem Services

- Mapping and valuation of Ecosystem Services provided by the CMR.
- Cumulative impacts on ecosystem functioning.

Future changes due to climate change

- Impact on marine ecosystems particularly changes in acidity and on ecosystem services provision for fishing, aquaculture, recreation and tourism (including risk assessment).
- Roll-out of Sea-Level Rise project to the whole of the CMR. A better understanding of wave overtopping, increased fluvial input and the funnelling effect linked to the depth and shape of the seabed in the sea lochs and estuary.
- Increased storm water run-off and the impact this will have on the release of untreated waste water from sewage treatment plants.

Noise

- No published data available about levels of noise, changes in levels of noise over time or impacts on marine species. The Marine Noise Registry (MNR) records human activities in UK seas that produce loud, low to medium frequency (10Hz – 10kHz) impulsive noise.
- Impact on fish and invertebrates from the particle motion component of underwater noise production.

Marine Litter

- Seabed and water column analysis. Analysis of Clyde area ongoing by MSS. Surface litter is trawled by manta ray tow for MSS input to MSFD.
- A better understanding of the significance of concentrations of microplastics. Work is ongoing at the University of the West of Scotland into mussels, sediment and fish.

Mobile species

- Populations and distribution of sharks, skates and rays, cetaceans, in particular Harbour porpoise use of the Inner Firth area as highlighted by the Clyde Marine Mammal Project.

Fish and shellfish

- Stock assessments for pelagic and demersal fish and scallops.
- A better understanding of the impact of the Hematodinium parasite on Nephrops stocks.

Seabirds and waterbirds

- Understanding the reasons for the decline in some seabird and waterbird species.

Priority Marine Features

- The location of these features outside the MPA search areas where more detailed surveys have already been undertaken.

Marine Protected Areas

- The effects of nature conservation MPAs on species diversity, reproduction and survival.
- Examine the ecological connectivity of features within and between sites and between sites and the wider marine environment. This may provide opportunities to enhance of better protect connectivity and therefore, ecosystem services, resilience and services.

Shipping and transport

- The potential impacts of increased marine traffic. A recent report issued by CalMac has highlighted a potential increase in marine traffic due to the likely development of commercial deep water berths for both industrial and tourist (cruise ship) use.

Sport, Recreation and Tourism

- A more accurate analysis of the true economic contribution of marine sport, recreation and tourism is required for the CMR.
- Study needed of the current capacity of marinas in the CMR and likely future levels of demand for sail and power boating.

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9. Appendices

Appendix I
Coastal and marine ecosystem services

What are ecosystem services?

An ecosystem is a biological community of interacting living organisms and their physical environment. These are linked through nutrient cycling and energy flows such as food webs. Ecosystem services fit into the broader concept of the Ecosystem Based Approach (EBA) to environmental management. The EBA is about integrating conservation of natural resources with social and economic needs and objectives of society in a way that sustains the health of an ecosystem/s on which we depend. It is often described as a holistic approach which considers the needs of all users and attempts to balance these with sustainable development and exploitation of the ecosystem, including its goods and services.

Ecosystem services provide benefits to people from the ecological functions of healthy ecosystems. The UK NEA assessment defines them as *'the benefits provided by ecosystems that contribute to making human life both possible and worth living.'* The concept of Ecosystem Services is a way to discuss the dependence of humans on nature and what that means to us socially and economically.

These benefits can be categorised as tangible or intangible, and are further defined into the following descriptors: Provisioning services (raw materials- sometimes known as ecosystem goods), Regulating services, Cultural services and Supporting services.

Ecosystems do not necessarily provide all of these services at the same time. This publication from Natural England looks in detail at the ecosystem services provided by each kind of marine or coastal habitat: publications.naturalengland.org.uk/publication/301112.

The Marine Strategy Framework Directive requires member states to apply an ecosystem based approach to marine management in working towards attaining Good Environmental Status. The Marine Scotland Act and National Marine Plan are also aligned with the ecosystem approach, ensuring that the health of the marine environment in a central consideration in marine planning.

Why are ecosystem services important to Marine Planning?

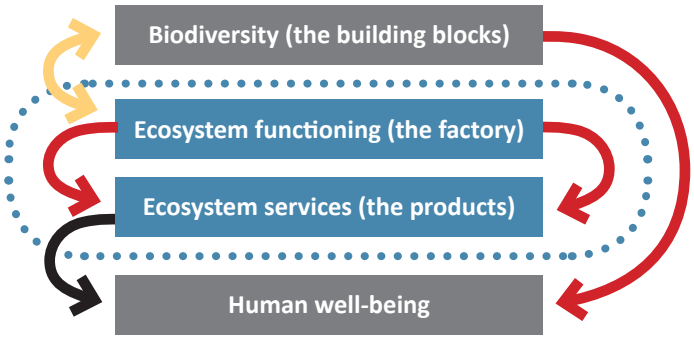
- **Indicator of ecosystem health** – Effective marine planning consists of monitoring pressures on the marine and coastal environment and regulating the human activities causing these pressures. There is a clear link between how well an ecosystem functions (or the health of the ecosystem) and the level of biodiversity associated with it. Degradation of systems undermines ecosystem resilience, which in turn reduces the ability of the ecosystem to provide ecosystem services, which ultimately affects human wellbeing.

This chart shows the goods and benefits that humans derive from coastal and marine natural processes

GOODS/BENEFITS DERIVED FROM COASTAL/MARINE NATURAL PROCESSES				
MARINE ECOSYSTEMS	**INTERMEDIATE SERVICES**	**FINAL ECOSYSTEM SERVICES**		**GOODS/BENEFITS**
Components e.g. • Habitats and species • Sea space • Sea water • Substratum Processes e.g. • Production • Decomposition • Food web dynamics • Ecological interactions • (inter- and intra-specific) • Hydrological processes • Geological processes • Evolutionary processes	• Primary production • Larval and gamete supply • Nutrient cycling • Water cycling • Formation of – species habitat – physical barriers – seascape • Biological control • Natural hazard regulation • Waste breakdown and detoxification • Carbon sequestration	• Fish and shellfish • Algae and seaweed • Ornamental materials • Genetic resources • Water supply • Climate regulation • Natural hazard protection • Clean water and sediments • Places and seascapes	Built human and social capital	• Food (wild, farmed) • Fresh feed (wild, farmed, bait) • Fertiliser and biofuels • Ornaments and aquaria • Medicines and blue biotechnology • Healthy climate • Prevention of coastal erosion • Sea defence • Waste burial/removal/ neutralisation • Tourism and nature watching • Spiritual and cultural well-being • Aesthetic benefits • Education, research • Health benefits

Source: UK National Ecosystem Assessment website http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx, accessed May 2015.

KEY: Supporting Regulating Provisioning Cultural



- **Managing change to a system** – Understanding ecosystem services can help us to understand or predict the implications of changes in ecosystems, and allow us to consider this in terms of their impact on humans. Ecosystem services therefore provide a method to monitor the impacts of ecosystem change and can also be used to identify triggers for intervention in management.
- **Considering the value of ecosystem services (natural capital)** – Degradation of an ecosystem service represents a loss of natural capital. Availability of natural capital is crucial to the functioning of an economy. In the past degradation of natural capital i.e. logging a forest, fisheries, extracting oil, has only been reflected in growth of national GDP. Economics is now starting to give a value to ecosystems goods and services. These values come from their role in supporting our lives, their cheapness, and our limited ability to replace them with human-engineered alternatives. Ecosystem services 'valuation' (in economic terms) allows there to be a reflection in markets of the benefits nature provides for people. However it should also be remembered that there are other ways of valuing ecosystem services.
- **Supports an Ecosystem Based Approach to management** – The ecosystem approach is a central principal of marine planning, and integrates the management of human activities with knowledge of ecosystem dynamics to achieve sustainable use of ecosystem good and services, while maintaining the health and resilience of an ecosystem.
- **Supports better management and planning choices** – Considering the value of ecosystem services is relevant to governance and planning purposes, as it allows more informed management choices, and allows for the influence of human behaviour. It also assists in setting planning priorities. It can be utilised in policy, project and programme appraisal and can help determine liability and compensation in environmental litigation. For example, the associated ecosystem services provided by Marine Protected areas and Priority Marine Features (such as improved system quality and local-scale provisioning) played an important role in guiding their implementation.

MARINE ECOSYSTEM SERVICES ACCORDING TO THE MILLENIUM ASSESSMENT CATEGORIES		
PROVISIONING SERVICES **Products obtained from ecosystems**	**REGULATING SERVICES** **Benefits obtained from the regulation of ecosystem processes**	**CULTURAL SERVICES** **Non-material benefits obtained from ecosystems**
• Food provision (fisheries and aquaculture) • Water storage and provision • Biotic materials • Fiber, timbres, and fuel	• Water purification • Air quality regulation • Flood/storm protection • Erosion control • Climate regulation • Weather regulation • Ocean nourishment • Life cycle maintenance • Biological regulation • Human disease control	• Spiritual and religious • Recreation and ecotourism • Aesthetic • Inspirational • Educational • Sense of place • Cultural heritage
SUPPORTING SERVICES		
• Photosynthesis • Primary production • Nutrient cycling • Resilience and resistance • Biologically mediated habitat		

Useful links

1. *The State of Europe's Seas* report covers an assessment of our seas at an EU wide scale, discusses the use of ecosystem based management, whether we are meeting the targets set under the MSFD and our use of the seas natural capital www.eea.europa.eu/publications/state-of-europes-seas
2. This Natural England report looks in detail at the ecosystem services provided by each kind of marine and coastal habitat, e.g. intertidal zones, maerl beds, salt marshes and estuarine habitats http://publications.naturalengland.org.uk/publication/301112
3. The UK National Ecosystem Assessment is the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity http://uknea.unep-wcmc.org/
4. These two short videos provide further explanations of ecosystem services www.youtube.com/watch?v=wMIUglBligI and www.youtube.com/watch?v=oU9G2E_RYJo

Appendix II Nature conservation designations and Site Condition around the Clyde Marine Region

Marine and coastal species and habitats

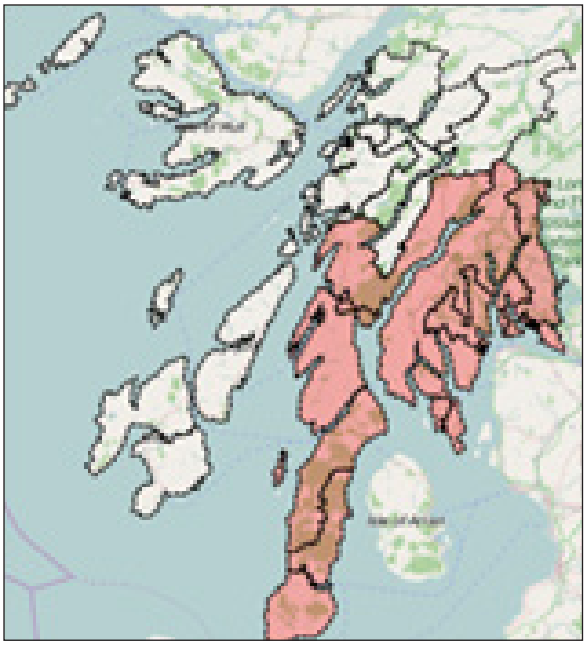
(includes any species directly reliant on a marine or coastal habitat)

NAME	DESIGNATION	MARINE/COASTAL FEATURE/S	SITE CONDITION	COMMENT
Clyde Sea Sill	Nature Conservation mpa	Marine Geomorphology – sand ribbon fields, sand banks and sand wave fields Fronts Black Guillemot Circalittoral and offshore sand and coarse sediment communities	N/A	Conservation Objective 'Conserve' for all features.
Ballantrae Shingle Beach	SSSI	Shingle	Unfavourable Declining	Unfavourable condition linked to nutrient enrichment through stock feeding, and both natural and anthropogenic influences affecting shingle dynamics. Management review in progress. Stock feeding has ceased.
Girvan to Ballantrae Coast Section	SSSI	Llondovery (stratigraphy)	Favourable Maintained	Ordovician Igneous feature previously considered in unfavourable condition due to illegal tipping and coastal defence works, however these have more recently been judged not to be affecting important exposures sufficiently to affect feature condition.
		Arenig-Llanvirn (stratigraphy)	Favourable Maintained	
		Ordovician Igneous (petrology)	Unfavourable No change	
		Caradoc – Ashgill (stratigraphy)	Favourable Maintained	
Sgavoch	SSSI	Ordovician Igneous (petrology)	Favourable Maintained	
Ailsa Craig	SPA	Seabird assemblage, breeding	Favourable Maintained	Declines in the three gull species at least partly reflect national declines and may result in part from reductions in food availability.
		Guillemot, breeding	Favourable Maintained	
		Kittiwake, breeding	Unfavourable Declining	
		Gannet, breeding	Favourable Maintained	
		Lesser black-backed gull, breeding	Unfavourable Declining	
		Herring gull, breeding	Unfavourable Declining	
	SSSI	Tertiary Igneous (petrology)	Favourable Maintained	
		Gannet, breeding	Favourable Maintained	
		Seabird colony, breeding	Favourable Maintained	
		Beetles	Favourable Maintained	
		Flies	Favourable Maintained	
Turnberry Lighthouse to Port Murray	SSSI	Old Red Sandstone Igneous (petrology	Favourable Maintained	
Turnberry Dunes	SSSI	Beetle assemblage	Favourable Maintained	
Maidens to Doonfoot		Carboniferous – Permian Igneous (petrology)	Favourable Maintained	
		Old Red Sandstone Igneous (petrology)	Favourable Maintained	
		Lower Carboniferous (stratigraphy)	Favourable Maintained	
		Maritime cliff	Favourable Maintained	
		Shingle	Favourable Maintained	
		Invertebrate assemblage	Favourable Maintained	

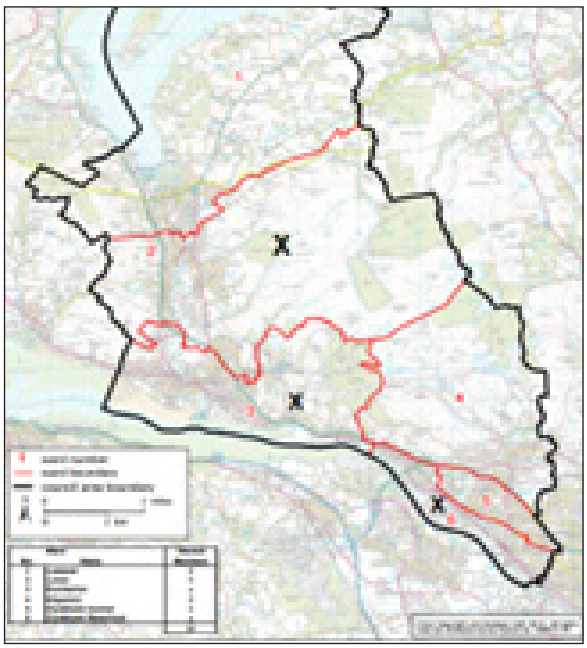
NAME	DESIGNATION	MARINE/COASTAL FEATURE/S	SITE CONDITION	COMMENT
Troon Golf Links and Foreshore	SSSI	Sand dunes	Unfavourable No change	Long-term lack of grazing has resulted in some loss of habitat diversity and encroachment by native and non-native scrub. Scrub management by the golf course has restored some dune grassland and further measures are under discussion.
Ballantrae Shingle Beach	SSSI	Shingle	Unfavourable Declining	Unfavourable condition linked to nutrient enrichment through stock feeding, and both natural and anthropogenic influences affecting shingle dynamics. Management review in progress. Stock feeding has ceased.
Western Gailes	SSSI	Invertebrate assemblage	Unfavourable No change	Long-term lack of grazing has resulted in some loss of habitat diversity in the sand dune habitats, and encroachment by non-native scrub. This has reduced the availability of habitat for sand dune insects. Strandline vegetation and insects that live on strandline vegetation and detritus have suffered losses due to unauthorised mechanical beach cleaning. Mechanical beach cleaning has now ceased.
		Sand dunes	Unfavourable No change	
Bogside Flats	SSSI	Saltmarsh	Favourable Maintained	Mudflat feature under review.
		Mudflats	Not yet monitored	
Ardrossan to Saltcoats Coast	SSSI	Carboniferous – Permian Igneous (petrology)	Favourable Maintained	
South Arran	Nature Conservation MPA	Burrowed mud	N/A	Conservation Objective 'Conserve' for all features except maerl beds which have the conservation objective 'enhance'.
		Maerl beds		
		Kelp and seaweed communities on sublittoral sediment		
		Ocean quahog aggregations		
		Seagrass beds		
		Maerl or coarse shell gravel with burrowing sea cucumbers		
		Shallow tide-swept coarse sands with burrowing bivalves		
South Coast of Arran	SSSI	Maritime cliff	Favourable Declining	Some decline in habitat condition has been attributed to localised under grazing and bracken encroachment. Management measures have recently been agreed in some areas to control bracken and promote grazing. The shingle vegetation has suffered minor damage from small-scale shingle extraction and vehicle use.
		Shingle	Unfavourable No change	
		Tertiary Igneous (petrology)	Favourable Maintained	
Dippin Head, Arran	SSSI	Tertiary Igneous (petrology)	Favourable Maintained	
Clauchlands Point – Corrygills, Arran	SSSI	Tertiary Igneous (petrology)	Favourable Declining	
		Saltmarsh	Favourable Maintained	
		Maritime cliff	Favourable Maintained	
Corrie Foreshore and Limestone Mines, Arran	SSSI	Upper Carboniferous (stratigraphy)	Favourable Maintained	
		Lower Carboniferous (stratigraphy)	Favourable Maintained	
		Permian – Triassic (stratigraphy	Favourable Maintained	
Laggan, Arran	SSSI	Palaeozoic Palaeobotany	Favourable Maintained	
North Newton Shore, Arran	SSSI	Non-marine Devonian (stratigraphy)	Favourable Maintained	
Drumadoon to Tormore, Arran	SSSI	Permian – Triassic (stratigraphy)	Favourable Maintained	
		Tertiary Igneous (petrology)	Favourable Maintained	
Southannan Sands	SSSI	Sandflats	No site condition New site (previously part of Portencross Coast SSSI)	Within area zoned for industrial development around Hunterston.
Kames Bay, Cumbrae	SSSI	Sandflats	No site condition	Feature status under review
Ballochmartin Bay, Cumbrae	SSSI	Sandflats	No site condition	Feature status under review

NAME	DESIGNATION	MARINE/COASTAL FEATURE/S	SITE CONDITION	COMMENT
Largs Coast Section	SSSI	Non-marine Devonian (stratigraphy)	Favourable Maintained	
Inner Clyde	SPA	Redshank, non-breeding	Favourable Maintained	
	SSSI	Saltmarsh	Favourable Maintained	
		Cormorant, non-breeding	Unfavourable Declining	
		Oystercatcher, non-breeding	Favourable Recovered	
		Red-breasted merganser, non-breeding	Favourable Maintained	
		Redshank, non-breeding	Favourable Maintained	
		Goldeneye, non-breeding	Favourable Maintained	
		Eider, non-breeding	Favourable Maintained	
		Red-throated diver, non-breeding	Favourable Maintained	
	Ramsar	Redshank, non-breeding	Favourable Maintained	
Rhu Point	SSSI	Quaternary of Scotland	Favourable Maintained	
Ruel Estuary	SSSI	Saltmarsh (and other non-marine)	Favourable Maintained	
North End of Bute	SSSI	Breeding bird assemblage including red-throated diver	Favourable Maintained	
Upper Loch Fyne & Loch Goil	Nature Conservation MPA	Ocean quahog aggregations	N/A	Conservation Objective 'Conserve' for all features except flame shell beds where the conservation objective is 'enhance'.
		Burrowed mud		
		Flame shell beds		
		Horse mussel beds		
		Sublittoral mud and specific mixed sediment communities		
Strone Point, North Loch Fyne	SSSI	Dalradian, structural and metamorphic geology	Favourable Declining	
Sanda Islands	SSSI	Maritime cliff	Favourable Declining	For birds - 25% or more population decline not due to local issues but part of UK issue.
		Black guillemot, breeding	Favourable Maintained	
		Puffin, breeding	Unfavourable Declining	
		Shag, breeding	Unfavourable Declining	
		Great black-backed gull, breeding	Favourable Recovered	
		Fulmar, breeding	Favourable Maintained	
		Storm petrel, breeding	Favourable Maintained	
		Cormorant, breeding	Favourable Maintained	
		Kittiwake, breeding	Favourable Maintained	
		Guillemot, breeding	Favourable Maintained	
		Razorbill, breeding	Favourable Maintained	
		Manx shearwater, breeding	Favourable Maintained	

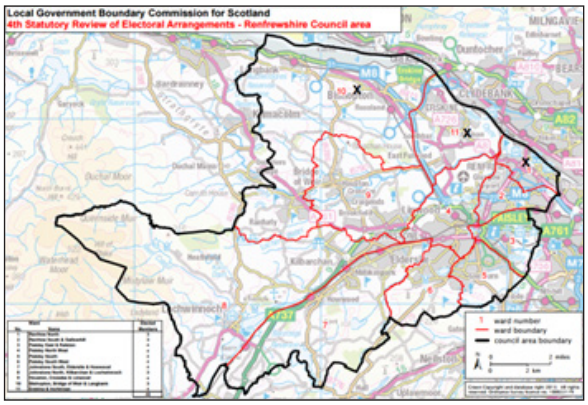
Appendix III
Coastal Wards used for Productive Section – Clyde Marine Region



Argyll and Bute includes CAS wards: 04C23 Ardenslate; 04C34 Arrochar, Luss, Arden and Ardenconnel; 04C25 Auchamore and Innellan; 04C19 Bute Central; 04C18 Bute North; 04C20 Bute South; 04C02 Campbeltown Central; 04C36 Cardross; 04C07 Craignish – Glenaray; 04C28 East Central Helensburgh; 04C03 East Central Kintyre; 04C21 East Lochfyne; 04C33 Garelochhead and Cove; 04C29 Helensburgh Central; 04C27 Helensburgh East; 04C30 Helensburgh North; 04C31 Helensburgh West; 04C26 Holy Loch; 04C22 Kirn and Hunter's Quay; 04C05 Knapdale; 04C06 Lochgilphead; 04C24 Milton; 04C04 North and West Kintyre; 04C35 Roseneath, Clynder and Kilcreggan; 04C01 South Kintyre; 04C32 West Helensburgh and Rhu.



West Dunbartonshire includes the Multimember wards of 2 Leven; 3 Dumbarton; 6 Clyde Waterfront.



Glasgow includes the Multimember wards 13 Garscadden/Scotstounhill; 12 Partick West; 10 Anderston/City; 9 Calton; 8 Southside Central; 5 Govan.

South Lanarkshire includes the Multimember Ward 12 Rutherglen Central and North.



Renfrewshire includes the Multimember Wards of 1 Renfrew north; 10 Bishopton, Bridge of Weir and Langbank; 11 Erskine and Inchinnan.

All wards from Inverclyde, North Ayrshire and South Ayrshire were included.



Common seals in the Clyde © SARAH BROWN

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