Plankton

Scottish Government
Riaghaltas na h-Alba
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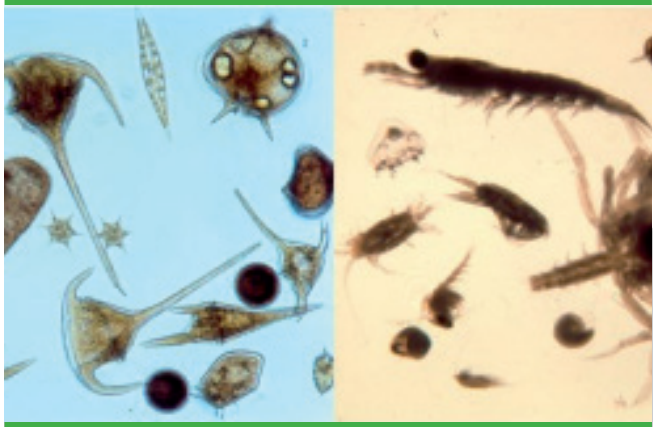
Key message

Significant changes in the plankton community have occurred in some marine regions over the last three decades. The effects of these changes are not known but this observed ecological reorganisation could have an impact on the entire marine food web.



Background

The pelagic habitat is the term used to describe the water column from the sea bed to the surface. The plankton community (phytoplankton and zooplankton) is the component that is used in this assessment. Phytoplankton are single celled microscopic organisms that harness light energy from the sun via photosynthesis. This energy is transferred, via grazing by small animals called zooplankton, to higher levels in the marine foodweb such as shellfish, fish and mammals.

Currently there is no defined threshold to assess if plankton communities are in a 'good' or 'bad' state. In Scottish waters the diversity of the plankton community can vary with region. Assessing the status of the plankton community over multiple regions thus presents a challenge as they are influenced by multiple pressures including climate change and eutrophication. Long term, high frequency time series e.g. thirty years of data are needed to robustly assess change in the plankton community (Edwards *et al.*, 2010).

This assessment uses plankton data from Scottish waters (Figure 1) generated by government laboratories (Marine Scotland Science), agencies (Scottish Environment Protection Agency – SEPA) and institutes (Continuous Plankton Recorder (CPR) Survey at Marine Biological Association, Scottish Association for Marine Science - SAMS). Plankton taxa were grouped into different ecological life forms. The presence of increasing/decreasing trends in life form abundances and the relationship with sea surface temperature (SST), a proxy for climate change, were investigated. Due to the nature of the statistical methods employed, the full time duration of each data set was used (Bedford *et al.*, 2020).

For further information on this topic go to: https://marine.gov.scot/sma/assessment/plankton

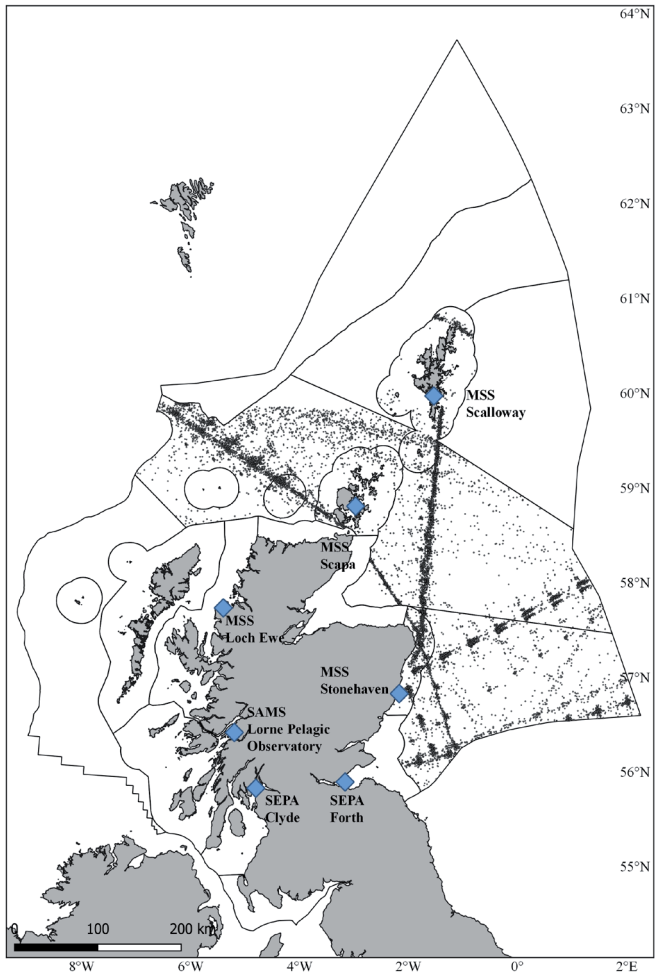


Figure 1:
Map showing plankton sampling locations providing data used in the assessment and Scottish Marine Regions (SMRs) and Offshore Marine Regions (OMRs). Blue diamonds = fixed point sampling sites. Grey dots = CPR sampling tracks.

Results

Analysis of the full time series of data reveals significant trends in the abundance of selected plankton life forms in SMRs and OMRs. A summary of trends is given in Tables 1 and 2.

Diatoms show a significant increasing trend since the 1980s in SMRs in the north and east of Scotland i.e. North East (CPR), Orkney (SCObs, CPR), Shetland (CPR), Fladen and Moray (CPR) and North Scotland Shelf (CPR). This is coincident with an increase in phytoplankton biomass as determined by the Plankton Colour Index (PCI), determined by the CPR. This increase in diatoms also led in some instances to increases in associated life forms such as pelagic diatoms and large phytoplankton. There is only one time series (CPR: Long Forties) where the dataset extends back to the 1960s. This time series shows a declining trend in diatoms from 1960s – 1980s, followed by a subsequent increase. The Lorn Pelagic Observatory showed a decrease in abundance but there is a gap of 17 years in the time series of data. No trend was observed in sites in the Forth and Clyde but this could be an artefact of the short duration of the time series.

Dinoflagellates in Long Forties (CPR) and North Scotland Shelf (CPR) show a significant decreasing trend, while the SCObs monitoring site at Loch Ewe (West Highlands) showed an increasing trend. Data from other SMRs did not show any significant trends.

Large copepods show significant declining trend in Long Forties (CPR), Fladen and Moray Firth (CPR) and Shetland (CPR) whereas at North East (CPR) the trend was positive. Small copepods, more abundant than large copepods, show significant decreasing trend only at Long Forties (CPR). Meroplankton show significant increase in Long Forties (CPR), Fladen and Moray Firth (CPR), Shetland (CPR) and North Scotland Shelf (CPR).

The short duration of fixed point monitoring sites meant that trends identified were in the main not significant. This could be due to the short number of years compared with CPR data and assessing trends using these fixed point datasets will improve in the future as the duration of these time series increases. Some sites, however, show changes in many life forms e.g. zooplankton in Loch Ewe with negative trends for all life forms. The paucity of data from the west and northern areas mean that the plankton community in these regions have not been assessed.

Examples of trend plots for the different life forms are presented in Figure 2a, 2b, 2c, 2d and 2e.

Table 1: Summary trends in plankton life form abundance (SMRs). nd = no data, ↔ no trend, ↗ significant positive trend, ↘ significant negative trend. Where life form abundances are significantly correlated with SST, the box has been highlighted in purple.

Lifeform	Forth	North East		Orkney Islands		Shetland Islands		West Highlands	Argyll	Clyde
	SEPA (2010-2017*)	SCObs Stonehaven (1999-2017)	CPR (1980-2017)	SCObs Scapa (2001-2017*)	CPR (2001-2017*)	SCObs Scalloway (2008-2017)	CPR (1980-2017)	SCObs Loch Ewe (2003-2017)	SAMS Loch Creran (1970- 2015*)	SEPA (2010-2017)*
Diatoms	↔	↔	↗	↗	↗	↔	↘	↔	↘	↔
Dinoflagellates	↔	↔	↔	↔	↔	↔	↔	↗	↔	↔
Large phytoplankton	nd	↔	nd	↗	nd	↔	nd	↔	nd	nd
Small phytoplankton	nd	↔	nd	↔	nd	↔	nd	↔	nd	nd
Pelagic diatoms	↔	↔	↗	↗	↔	↔	↗	↔	nd	↔
Tychopelagic diatoms	↔	↔	↔	↗	↔	↔	↔	↔	nd	↔
Small copepods	nd	↔	↔	nd	↔	nd	↔	↘	nd	nd
Large copepods	nd	↔	↗	nd	↔	nd	↘	↘	nd	nd
Holoplankton	nd	↔	↔	nd	↘	nd	↔	↘	nd	nd
Meroplankton	nd	↔	↔	nd	↔	nd	↗	↘	nd	nd
Fish larvae	nd	↔	↔	nd	↔	nd	↔	↘	nd	nd
Crustaceans	nd	↔	↔	nd	↘	nd	↔	↘	nd	nd
Gelatinous	nd	↔	nd	nd	nd	nd	nd	↘	nd	nd
	* a number of missing data points				*excluding 2003, 2010				*excluding 1982 - 1999	* a number of missing data points

Table 2: Summary trends in plankton life form abundance (OMRs). nd = no data, ↔ no trend, ↗ significant positive trend, ↘ significant negative trend. Where life form abundances are significantly correlated with SST, the box has been highlighted in purple.

Lifeform	Long Forties	Fladen & Moray Firth	North Scotland Shelf
	CPR (1958-2017)	CPR (1980-2017)	CPR (1990-2017*)
Diatoms	↔	↗	↗
Dinoflagellates	↘	↔	↘
Large phytoplankton	nd	nd	nd
Small phytoplankton	nd	nd	nd
Pelagic diatoms	↔	↗	↗
Tychopelagic diatoms	↔	↔	↔
Small copepods	↘	↔	↔
Large copepods	↘	↘	↔
Holoplankton	↘	↔	↔
Meroplankton	↗	↗	↗
Fish larvae	↗	↔	↔
Crustaceans	↘	↔	↔
Gelatinous	nd	nd	nd
			* excluding 1991, 1996, 1999

The current assessment of temperature in Scottish waters shows that SST is increasing in all Scottish marine and offshore marine regions with the exception of the Hatton OMR. Some plankton life forms in this assessment show a significant correlation with SST (e.g. meroplankton, diatoms in some OMRs, see Tables 1 and 2 highlighted in purple) while no correlation was observed between other lifeforms and temperature in all the regions assessed. This suggests that influences other than temperature are also driving observed changes.

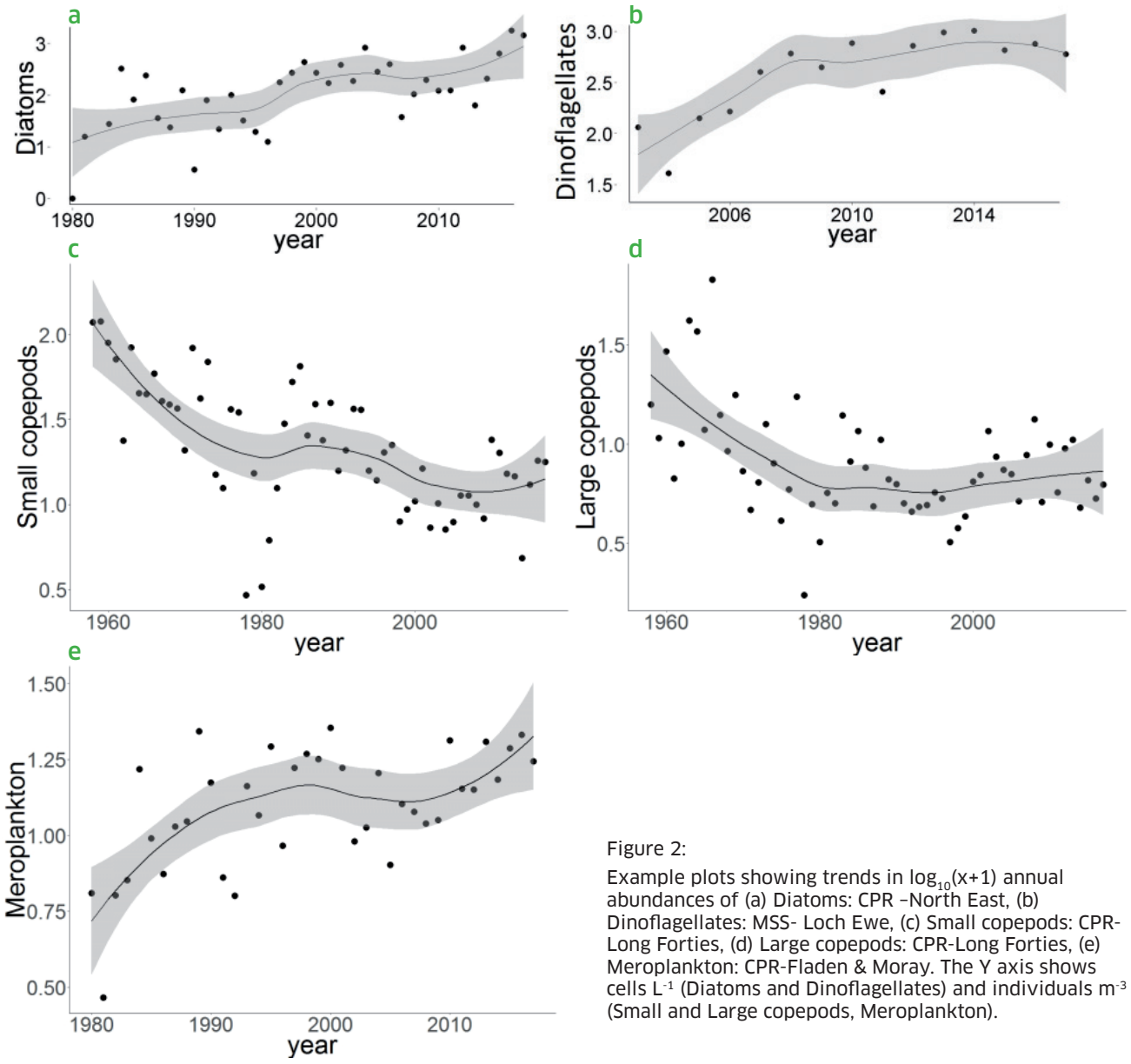


Figure 2:

Example plots showing trends in $\log_{10}(x+1)$ annual abundances of (a) Diatoms: CPR –North East, (b) Dinoflagellates: MSS- Loch Ewe, (c) Small copepods: CPR-Long Forties, (d) Large copepods: CPR-Long Forties, (e) Meroplankton: CPR-Fladen & Moray. The Y axis shows cells L^{-1} (Diatoms and Dinoflagellates) and individuals m^{-3} (Small and Large copepods, Meroplankton).

Conclusion

This assessment reveals that the plankton community in Scottish waters is changing. Results reveal significant changes in the abundance of a number of plankton life forms over the last three decades. Some of the changes observed include increasing trends in diatoms and meroplankton and declining trends in large and small copepods, crustacean and holoplankton lifeforms. These are consistent with trends reported in the greater North Sea and North Atlantic (Bedford *et al.*, 2020).

The effects of these changes are not known but this observed reorganisation of the plankton community could impact the marine food web as food supply to higher levels of the food web is reduced. For example the decline of small copepods in the OMR Long Forties may result in a lack of food for fish.

There has been significant increase in SST in the SMRs and OMRs in which the pelagic habitat was assessed. A correlation was observed between SST and the abundance of some, but not all, life forms in some regions which suggests that SST is not the only driver influencing change in the plankton community in Scottish waters.

This assessment is in agreement with the UK wide assessment detailed in Bedford *et al.* (2020).

Knowledge gaps

The impacts of these observed changes in the plankton community on higher trophic levels of the food web is not known.

Lack of monitoring of micro zooplankton, nano/picoplankton, marine bacteria, viruses and fungi means that these components of the plankton community cannot be assessed. Coastal zooplankton data are sparse and there is a lack of plankton data from the west coast, far west and northern regions.

Cessation of monitoring will increase the number of regions where there is a lack of plankton community data.

Pressure datasets from other variables e.g. carbonate chemistry, nutrient loading, fishing, seabed disturbance are required.

Status and trend assessment

Region assessed	Status with confidence	Trend with confidence
All Scotland		
SMRs		
Argyll		
Clyde		
Forth and Tay		
North East		
Orkney Islands		
Shetland Isles		
West Highlands		
Western Islands		

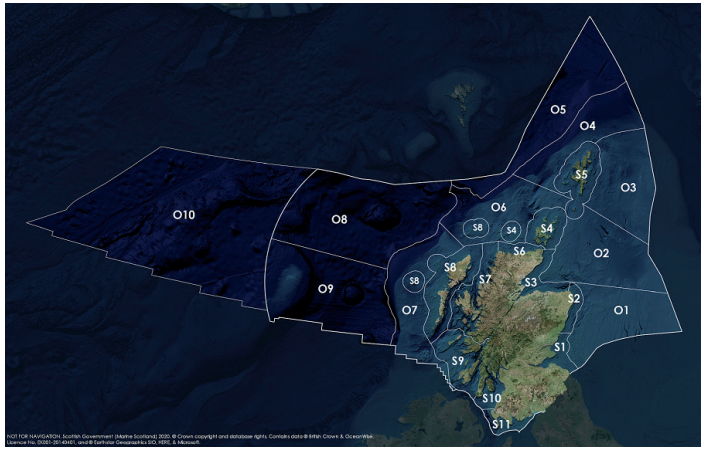
Region assessed	Status with confidence	Trend with confidence
OMRs		
Fladen and Moray		
Long Forties		
North Scotland Shelf		

Status and trend assessment legend

Status assessment **(for Clean and safe, Healthy and biologically diverse assessments)**		**Trend assessment** **(for Clean and safe, Healthy and biologically diverse and Productive assessments)**	
	Many concerns		No / little change
	Some concerns		Increasing
	Few or no concerns		Decreasing
	Few or no concerns, but some local concerns		No trend discernible
	Few or no concerns, but many local concerns		All trends
	Some concerns, but many local concerns	**Confidence assessment**	
	Lack of evidence / robust assessment criteria	**Symbol**	**Confidence rating**
	Lack of regional evidence / robust assessment criteria, but no or few concerns for some local areas		Low
	Lack of regional evidence / robust assessment criteria, but some concerns for some local areas		Medium
	Lack of regional evidence / robust assessment criteria, but many concerns for some local areas		High

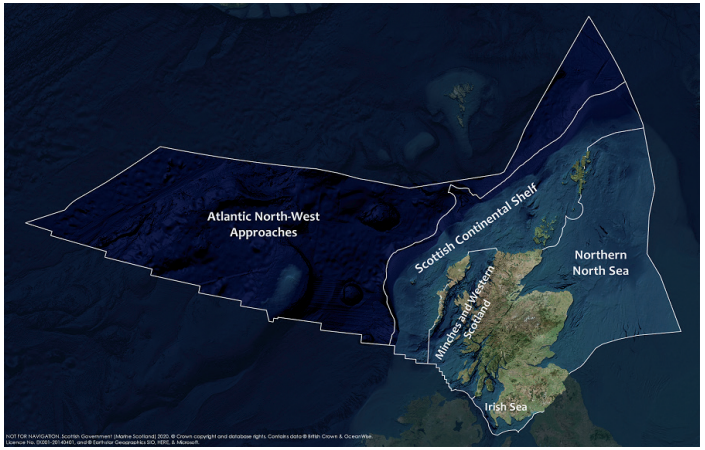
Overal confidence

Assessment regions

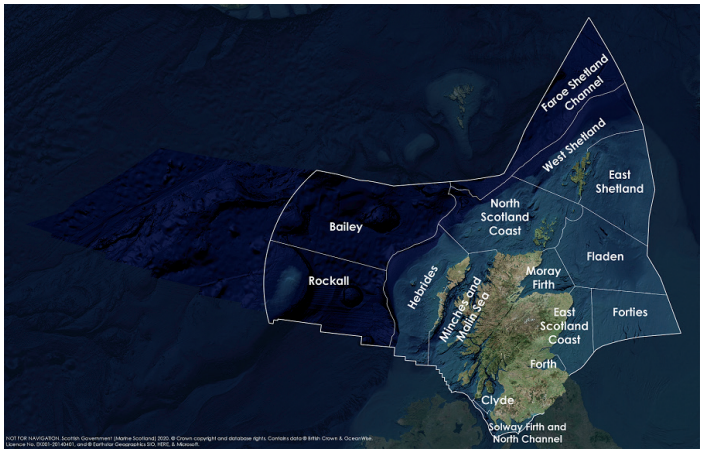


The Scottish Marine Regions (SMRs; S1 – S11) and the Scottish Offshore Marine Regions (OMRs, O1 – O10)

Key: S1, Forth and Tay; S2, North East; S3, Moray Firth; S4 Orkney Islands, S5, Shetland Isles; S6, North Coast; S7, West Highlands; S8, Outer Hebrides; S9, Argyll; S10, Clyde; S11, Solway; O1, Long Forties, O2, Fladen and Moray Firth Offshore; O3, East Shetland Shelf; O4, North and West Shetland Shelf; O5, Faroe-Shetland Channel; O6, North Scotland Shelf; O7, Hebrides Shelf; O8, Bailey; O9, Rockall; O10, Hatton.



Biogeographic, Charting Progress 2 (CP2) Regions. These have been used as the assessment areas for hazardous substances.



Scottish Sea Areas as used in Scotland's Marine Atlas 2011. These are sub divisions of the biogeographic, or Charting Progress 2 (CP2), Regions.

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NatureScot
Scotland's Nature Agency
Buidheann Nàdair na h-Alba

JNCC
Joint Nature Conservation Committee

SEPA
Scottish Environment Protection Agency

This material was published on the Scottish Marine Assessment 2020 portal, December 2020