Stock Annex: Sandeel (*Ammodytes marinus*) in the North Sea area 7 (SA7)

Stock-specific documentation of standard assessment procedures used by ICES.

Stock: Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 7r (northern North Sea, Shetland)

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A. General

A.1. Stock definition

Stock identity

Most area boundaries developed for WKSAN 2010 were based on the Christensen *et al.* (2008) bio-physical model of larval transport (HBM-ERGOM) but this did not include the area north of 59 °N. An earlier biophysical model (Proctor *et al*. 1998) and recent evidence from otolith microchemistry (Gibb *et al.,* 2017) indicate that sandeel aggregations around Orkney and Shetland, as well as grounds further west, belong to a single population. The boundaries agreed during WKSand 2016 mostly reflect the North Sea extent of these grounds. However, only inshore grounds around Shetland have been fished for any period of time.

A.2 Fishery

Around Shetland, sandeels were fished commercially on a number of small inshore grounds within 10 km of the coast. The fishery at Shetland started in the early 1970s and peaked in 1982 when 52,000t were landed. However, the fishery was closed from 1 July 1989 until 1995 following poor recruitment and the fishery ended in 2006 following a series of poor year-classes. Most of the sandeel catch consists of the lesser sandeel *Ammodytes marinus*, although unknown quantities of other *Ammodytidae* spp. were caught as well.

A.3 Ecosystem aspects

Sandeel are small, short-lived, lipid-rich, shoaling fish. Commercial catches showed a steep decrease in catches between August and April indicating that the overwintering period for adult sandeel on average lasts for 8 months (Reeves, 1994) interrupted only by spawning in December/January (Gauld and Hutcheon, 1990). During the period when sandeel are buried in the sandeel, they are inaccessible to many predators such as surface-feeding seabirds, though they continue to be eaten by some predatory fish,

seals, and diving seabirds which apparently can dig them out of the sand. Shetland is home to some internationally and nationally important concentrations of breeding seabirds. During the 1980s there was a substantial reduction in the breeding success of a number of seabird species beginning with Arctic Tern (*Sterna paradisea*), from around 1984. It was clear that the poor breeding success of these terns was largely due to the low availability of sandeels, particularly 0-group sandeels (Monaghan *et al*., 1989).

Bottom–up effects on sandeel

There is strong evidence that sandeel stocks are affected by bottom-up processes involving climate and plankton stocks. This species hatches in winter around the onset of the spring bloom and the match between hatching and zoolankton production appears important to early survivorship (Wright and Bailey, 1996). Evidence from observations on 0-group distributions and plankton (Wright, 1996) together with model simulations of larval transport (Proctor *et al.,* 1998) also indicated that low recruitment coincided with years when sea circulation was unfavourable to the transport of young sandeels into Shetland waters from Orkney.

Top–down effects on sandeel

Sandeel are important prey to a long list of predators. The sensitivity of the best known species is listed in Table A.3.1.

Table A.3.1. Documented evidence on dependencies of North Sea top predators on sandeel. Table shows, for each predator species, the levels of mobility; proportion of diet made up by sandeel; and documented cases of effects of low sandeel abundance on top predators. Mobility describes the potential of the predator to relocate to different feeding areas in response to localised prey shortages: I, immobile year-round; IB, immobile during the breeding season only; M, mobile year-round. Diet proportions refer to the percentage composition by mass of a particular prey type, averaged over one year and over North Sea: note that local and seasonal percentages can be substantially higher or lower. Shading of species cells indicates high likelihood of effects of low forage fish availability, resulting from both a low potential to relocate and a high (>20%) proportion of forage fish in the diet. Shading of diet indicates >20% (light grey) or >50% (dark grey), and shading of reported effects indicates those on condition or growth (light grey) and on reproductive success (dark grey). From Engelhard *et al.* (2014); Literature sources: [1] Windsland *et al.* (2007); [2] Sharples *et al.* (2009); [3] Cunning-ham *et al.* (2004); [4] Reijnders *et al.* (2010); [5] ICES (2011); [6] Engelhard *et al.* (2014); [7] Santos *et al.* (2008); [8] MacLeod *et al.* (2007); [9] BWPi (2004); [10] Mendel *et al.* (2008); [11] Harris and Wanless (1991); [12] Stienen (2006); [13] Rindorf *et al.* (2000); [14] Furness (2007); [15] Wanless *et al.* (2005); [16] Mitchell *et al.* (2004); [17] Frederiksen *et al.* (2004); [18] Engelhard *et al.* (2013); [19] Rindorf *et al.* (2008); [20] Pomeroy *et al.* (1999); [21] Reilly *et al.* (2014).

Predator	Mobility	% Sandeel in diet	Reported effects of low forage fish abundance
Marine mammals			
Minke whale *Baleonoptera acutorostrata*	M	56%	No evidence reported for the North Sea
Grey seal *Halichoerus grypus*	IB	41%	No evidence reported, in peer reviewed literature though there is a reference in Engelhard *et al.* 2014 to an unpublished study.
Harbour seal *Phoca vitulina*	IB	37%	Later pupping dates [4], which in turn are associated with higher likelihood of breeding failure and lower pup weights [20]
Striped dolphin *Stenella coeruleoalba*	M	3%	No evidence reported
Harbour porpoise *Phocoena phocoena*	M	2%	Poor nutritional status of stranded animals reported to concur with low sandeel intake in 2002 and 2003 [8], but this does not appear to be linked to low recruitment of sandeel in the dredge survey in Firth of Forth [HAWG 2016].
Seabirds			
Sandwich tern *Sterna sandvicensis*	I	high	Highly vulnerable to changes in local food supply (especially clupeids): reproductive performance, breeding numbers and breeding distribution [12]
Arctic tern			Cury et al 2011, also papers by Monaghan's group; massive decline in breeding numbers in Shetland following collapse of sandeel stock in area 7
Shag *Phalacrocorax aristotelis*	I	high	Reproductive output probably limited by local sandeel availability at Isle of May [13] see also Cury et al 2011; massive decline in breeding numbers in Shetland following collapse of sandeel stock in area 7
Great skua *Catharacta skua*	IB	10-95%	Reproductive success influenced by local sandeel availability [14] also several papers by Votier et al, Cury et al 2011, Meek et al 2011
Arctic skua			Cury et al 2011, Phillips & Furness, Meek et al 2011; massive decline in breeding numbers in Shetland following collapse of sandeel stock in area 7
Puffin *Fratercula arctica*	IB	55%	No evidence reported for the North Sea; massive decline in breeding numbers in Shetland following collapse of sandeel stock in area 7
Guillemot *Uria aalge*	IB	42%	Provisioning of chicks influenced by local abundance and quality of sandeel and sprat [15] see also Cury et al 2011
Razorbill *Alca torda*	IB	37%	Reproductive output probably limited by local sandeel availability at Isle of May [16]
Kittiwake *Rissa tridactyla*	IB	28%	Reproductive performance strongly dependent on local sandeel availability [17] see also Cury et al 2011, Cook et al 2014; massive decline in breeding numbers in Shetland following collapse of sandeel stock in area 7
Gannet *Morus bassanus*	IB	18%	No evidence reported
Lesser black-backed gull *Larus fuscus*	M	low	No evidence reported

Northern fulmar *Fulmarus glacialis*	M	11%	Decline in breeding success with reduction in sandeel in fulmar diet, particulary around Shetland (Cury et al 2011)
Fish			
Saithe *Pollachius virens*	M	5%	No evidence reported
Horse-mackerel *Trachurus trachurus*	M	17%	No evidence reported
Whiting *Merlangius merlangus*	M	7% 85% on sandbanks [21]	Positive correlations between local sandeel abundance and condition [18]. However, [21] finds that whiting are not prey-limited in the Firth of Forth even in years of low sandeel abundance.
Starry ray *Amblyraja radiata*	M	18%	No evidence reported
Grey gurnard *Eutrigla gurnardus*	M	12%	Positive correlations between local sandeel abundance and condition [18]
Cod *Gadus morhua*	M	4%	Positive correlation between overlap with sandeel and growth in the North Sea [19]
Haddock *Melanogrammus aeglefinus*	M	15% 45% on sandbanks [21]	Haddock were not found to be prey limited during years of low sandeel abundance in the Firth of Forth [21]
Mackerel *Scomber scombrus*	M	10%	No evidence reported

Furness and Tasker (2000) reviewed the ecological characteristics of seabirds in the North Sea and ranked species from highly sensitive (e.g. terns, kittiwake, Arctic skua) to insensitive (e.g. northern gannet) to reductions in sandeel abundance. They argued that the most sensitive seabirds would be those with high foraging costs, little ability to dive below the sea surface, little 'spare' time in their daily activity budget, short foraging range from the breeding site, and little ability to switch diet. From their analyses, they produced a map of seabird sensitivity in the North Sea (Figure A.3.2).

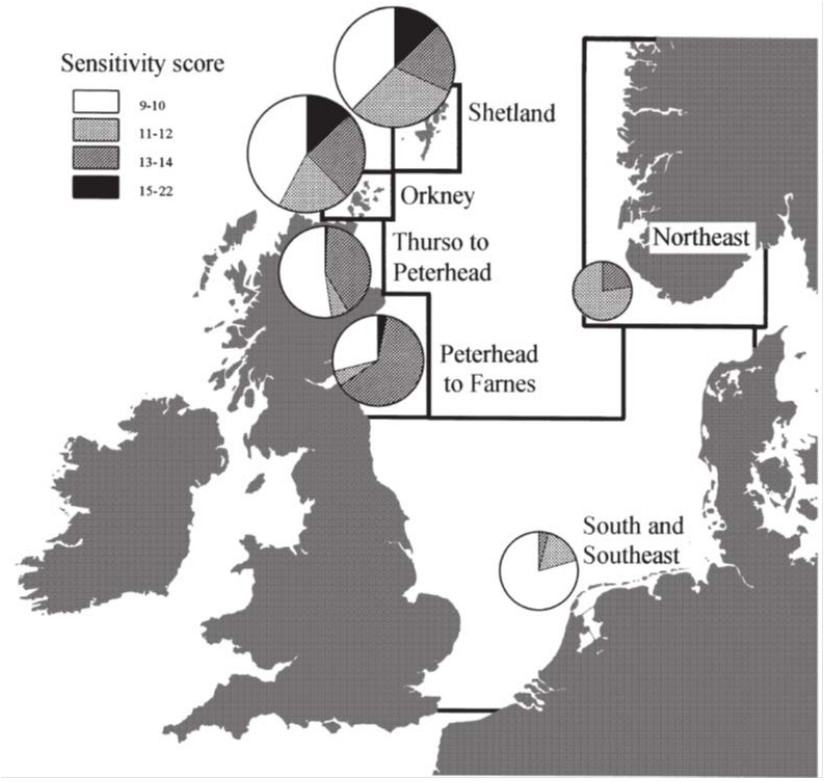
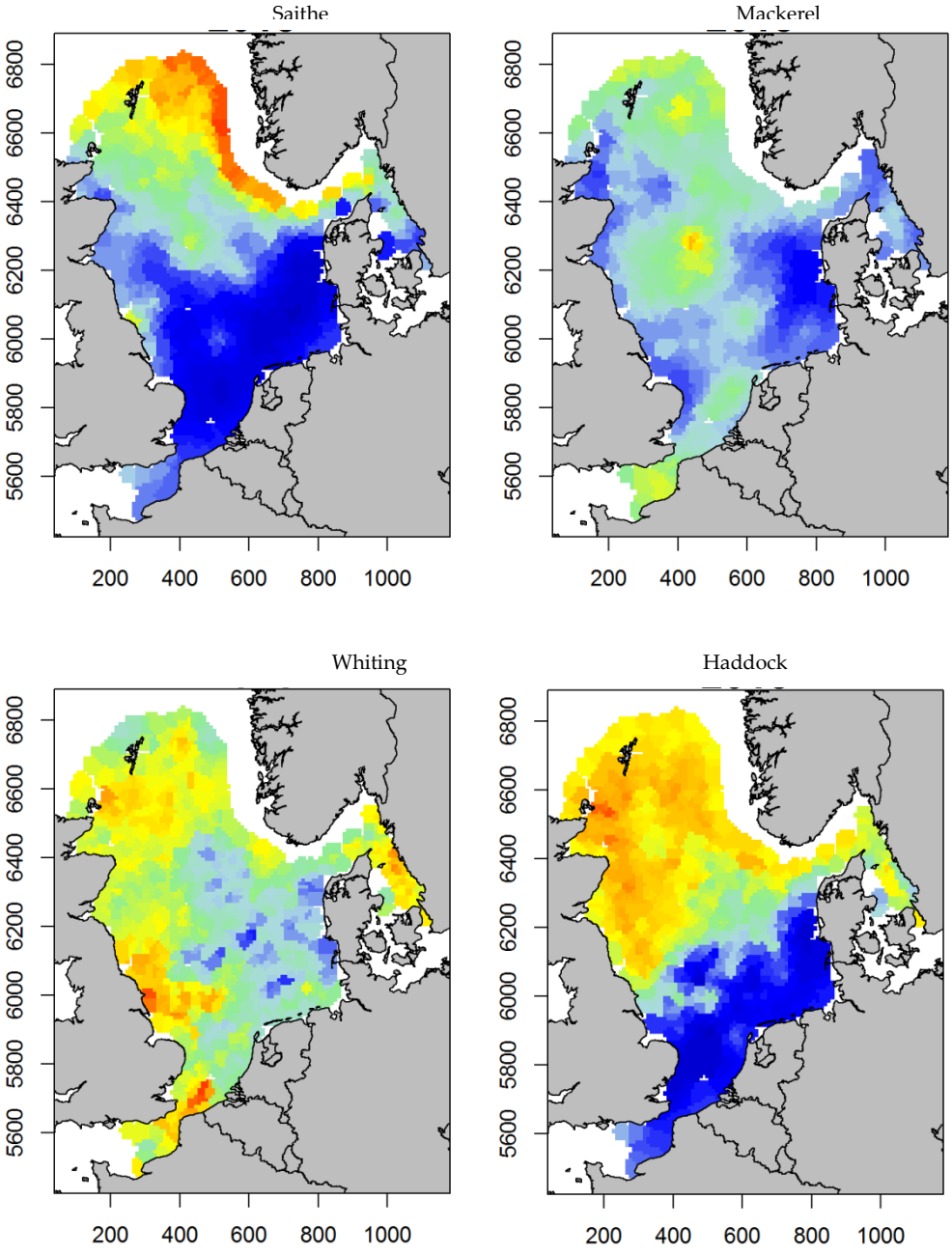


Figure A.3.2. Numbers of pairs of seabirds of high sensitivity to sandeel abundance, breeding in different parts of North Sea. Areas are defined as Shetland, Orkney, Thurso to Peterhead, Peterhead to Farnes (inclusive), southern and southeastern North Sea, and north-eastern North Sea. Size of each circle indicates size of local breeding population of seabirds of high sensitivity score. From Furness and Tasker (2000). Note that this map is now rather out of date, as many seabird populations in the northern North Sea have declined dramatically in numbers whereas populations in the south have remained more robust. The relative importance of southern areas has therefore increased since this map was produced.

Distribution of sandeel predators

Saithe and haddock tend to have a northerly distribution, whereas Gurnards, whiting and mackerel tend to be more widespread (Figure A.3.3). The abundance of fish predators is generally lower in the German bight area. Within the northern area, saithe is more abundant in the eastern areas. Seabirds and grey seals tend to be distributed close to the coast of northern Britain, with the exception of sandwich tern, which is concentrated close to the coast in the German bight (ICES 2016 WKSand report). The distribution of cetaceans seems highly variable between years (ICES 2016 WKSand report).


Saithe
Mackerel
Whiting
Haddock
5600
5800
6000
6200
6400
6600
6800
200
400
600
800
1000

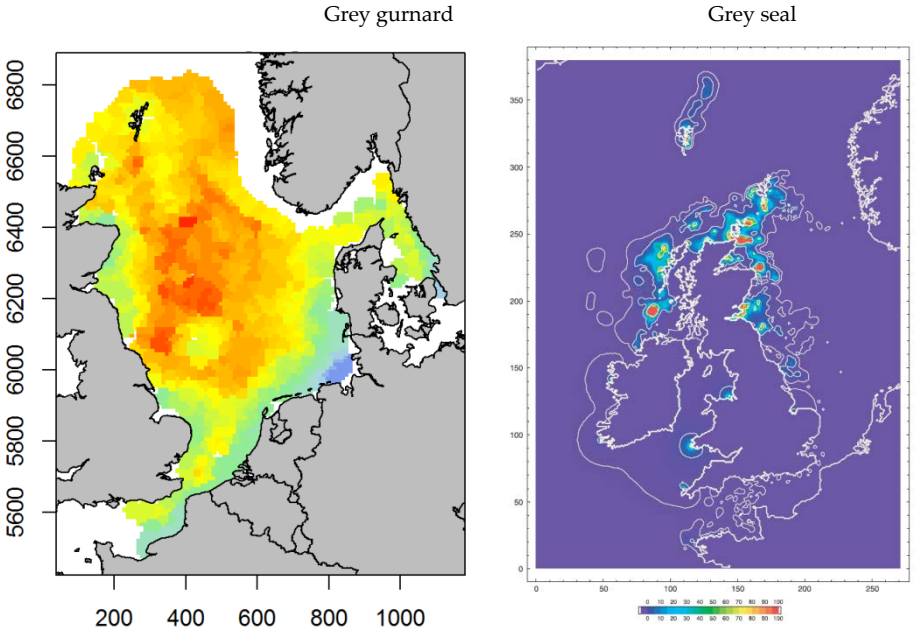


Figure A.3.3. Distribution of saithe, mackerel, whiting, haddock, grey gurnards and grey seals. Fish distributions are 2015 distributions derived from www.FishViz.org. Grey seal distribution is derived from Matthiopoulos *et al.* (2004).

Spatial patterns in sandeel size and condition

Sandeel length and weight at age varies substantially across the North Sea with sandeel around Shetland growing relatively slowly but at a similar rate to SA4 (Wright, 1996).

Implications for ecosystem–based management

Since 1991 management measures for Shetland have taken account of the importance of the region for breeding seabirds. Poloczanska *et al.* (2004) used stochastic population models to evaluate the likely effect of varying fishing mortality on kittiwake breeding success in Shetland. The models indicated that even with low exploitation rates, poor years for seabird breeding were inevitable. This may explain why, after a few years of good recruitment, there was a protracted period of low recruitment leading to a second collapse in the 2000s.

B.1 Commercial catch

This is a category 5 stock with no or incidental landings in recent years. As such, there is no stock assessment of Sandeel in this area.

Marine Scotland Science conducted a trawl survey at coastal grounds between 1985 and 2007, which provided indices of recruitment but this was ended following the cessation of the fishery.

C.1 References

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