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New fish records and records of rare southern species in Icelandic waters in the warm period 1996-2005

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During past 10 years 22 southern fish species not previously recorded within the Icelandic 200 mile EEZ have been recorded in the area. Some of these species have been found on common fishing grounds and close to land and are therefore considered to reflect actual changes that are taking place in the fish fauna around Iceland. Nine of the first time records (flounder (*Platichthys flesus*), blue shark (*Prionace glauca*), violet cuskeel (*Brotulotaenia crassa*), blackdevil anglerfish (*Melanocetus johnsonii*), pink sabertooth (*Evermannella balbo*), palebelly searsid (*Barbantus curvifrons*), *Lycodes terraenovae*, *Poromitra megalops*, and *Chaunax suttkusi*) are from more than one location or from different years. Several rare species that used to be recorded only occasionally (or that had not been recorded for a long time) have in recent years been recorded almost annually (twaite shad (*Alosa fallax*), mackerel (*Scomber scombrus*), sea lamprey (*Petromyzon marinus*) and garpike (*Belone belone*)). Also several rare southern species have during recent years clearly been extending their distribution to more northern locations (snake pipe fish (*Entelurus aequoreus)*, greater fork-beard (*Phycis blennoides*), blue antimora (*Antimora rostarata*)). The observed variations in new and rare fish species in Icelandic waters are discussed in the context of a positive hydrographic anomaly (temperature and salinity) both the Atlantic water to the south and in the Sub-Arctic waters to the north of Iceland since the middle of the 1990s.

Keywords: Icelandic waters, new fish records, rare fish records, climate warming.

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1. Introduction

The water around Iceland is a transition area between relatively warm and saline Atlantic water to the south of the country and Arctic and even Polar water masses to the north (e.g. Malmberg and Valdimarsson, 2003; Jonsson and Valdimarsson, 2005). This transition in the hydrography is reflected in the faunal composition (e.g. Astthorsson et al., 2007; Ingolfsson, 1996) around Iceland. Long term monitoring of hydrographic conditions in Icelandic waters has demonstrated an almost continuous positive temperature and salinity anomaly since 1996 (Anon, 2006). This increased temperature and salinity appear to be a part of a larger scale change observed in the North Atlantic Ocean in recent years (Anon, 2004).

During recent warming in Icelandic waters marked changes have been observed in the distribution and abundance of many commercially exploited fish stocks (e.g. haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*), whiting (*Merlangius merlangus*), monkfish (*Lophius piscatorius*), herring (*Clupea harengus*), capelin (*Mallotus villosus*), blue whiting (*Micromesistius poutassou*) (see Astthorsson et al., 2007 for overview)).

In recent years many new species of fish have also been reported from Icelandic waters (e.g. Jonsson, 1994a, 1994b, 1995; Jonsson et al., 1993, 1995, 1996,

1997, 1998, 1999a, 1999b; Jonsson and Palsson, 2000, 2001, 2002, 2003, 2004, 2005)), while some rare southern species have been seen more frequently and or found to show a more northward distribution (e.g. Jonsson and Palsson, 2004; 2005). Hitherto these findings have mainly been reported on annual basis and no attempt been made to look at these changes in a longer time perspective.

In this paper we summarize the findings for the past 10 years of new fish species in Icelandic waters, discuss some species that in recent years have been observed more frequently and give examples of rare species that have demonstrated an increased northward distribution. The findings are discussed in relation to the warming that has been observed in Icelandic waters since 1996.

2. Material

The Marine Research Institute has for many years systematically collected information on first records and records of rare fish species in Icelandic waters. This undertaking has mainly been conducted through fruitful cooperation with fishermen and the general public and has proved to be very positive for all partners. Through it the scientists get valuable information on the fish fauna in Icelandic waters and the fishermen and public get a satisfying response to their interest and/or curiosity. The present paper is mainly based on material which has been brought to the institute by interested fishermen and other laymen during past 10 years but also supplemented by material collected by the institutes own research vessels.

The sampling gears cover pelagic and demersal trawls, nets and long lines. The areas of sampling are the main fishing grounds within the Icelandic 200 mile EEZ. Inherent in such a sampling is a very heterogeneous coverage with some areas being heavily fished while other are not being covered at all. Nevertheless the new and rare fish records provide a valuable information on the distribution of fish in Icelandic waters.

The hydrographic data presented were collected in May-June at 100m depth at station 5 (63º00´, 21º28´) in the Atlantic water on Selvogsbanki transect to the southwest of Iceland.

3. Results and Discussion

3.1 Oceanographic features

Iceland is surrounded by two primary water masses (Fig. 1). The warm and saline Atlantic water is brought towards the southern shores of the island as a branch of the North Atlantic Drift. This then flows westward as the Irminger Current and north along the west coast. Most of this water turns west towards Greenland while a smaller branch continues northwards onto the north Icelandic shelf (Valdimarsson and Malmberg, 1999). South of Iceland the temperature of the Atlantic water ranges from 6-11ºC but the salinity is typically from 35.0-35.2.

The other primary water mass is Polar water. It is fresh ($S < 34.5$) and cold ($T < 0$ ºC), and flows as the East Greenland Current through Fram Strait and south along the shelf and continental slope off East Greenland and mainly exits the Nordic Seas through the Denmark Strait. Mixing and cooling of Atlantic and Polar waters form almost all the other water masses in the area except for the low salinity coastal water mass caused by freshwater run-off that flows clockwise around Iceland. The cold and low salinity East Icelandic Current, which flows southeastwards along the northeast Icelandic continental slope, carries with it Arctic water that is derived from the inflow of Atlantic water to the Iceland Sea, Polar water from the East Greenland Current and

Atlantic water from the North Icelandic Irminger Current (Stefansson, 1962; S. Jonsson, 1992).

For over 30 years a hydrographic section across Selvogsbanki on the shelf southwest of Iceland (Fig. 2) has been used to monitor the marine climate of the warm Atlantic water to the south of Iceland (Malmberg and Kristmannsson, 1992; Malmberg and Valdimarsson, 2003. The temperature and salinity is considered fairly stable but the long term observations have demonstrated some clear interannual variations. Thus salinity was particularly low during the periods 1974-78, 1985-88, and again 1992-95 (Fig. 2). These periods have been related to "Great Salinity Anomalies" in the northern North Atlantic (Dickson et al., 1988; Belkin et al., 1998). Since 1996 there has been a gradual increase in salinity and temperature (Anon, 2006; Malmberg and Valdimarsson, 2003).

Long term monitoring of hydrographic changes from the waters to the north of Iceland similarly demonstrate an almost continuous warm period since 1996 (Anon, 2006). The increase in temperature and salinity in Icelandic waters in recent years coincides with a larger scale change observed in the North Atlantic Ocean (Anon, 2004).

3.2 Records of new species

Table 1 lists the 22 fish species which have been recorded for the first within the Icelandic 200 mile EEZ between 1996-2005. The cumulative number of immigrant species is further shown in Figure 3. The data show that during the past 10 years the there has been an almost steady record of new species while for the most recent years there are some signs of the rate of increase decreasing. No new species were recorded in 2003 and 2005.

Here below the new species are dealt with in some detail on a year to year basis while at the end of the section we attempt to give a more holistic view of these species by grouping them on the basis of some common ecological and/or distributional features.

1996

Pseudoscopelus altipinnis. One 26 cm specimen was caught in November 1996 either on the Reykjanes ridge or on the Greenland halibut grounds to the west of Iceland (Jonsson et al., 1997). (Table 1, Fig. 6). In the North Atlantic Ocean *P. altipinnis* has previously been caught on the northern part of the Mid Atlantic Ridge, off the coast of Portugal and off west Africa (Jonsson and Palsson, 2006)

Blue shark (*Prionace glauca*). Several specimens were during the summer of 1996 caught on a line by Japanese tuna boats conducting experimental tuna fishery within the Icelandic EEZ far south of Iceland (Jonsson et al., 1997) (Table 1). Since 1996 many specimens have been caught almost every summer on tuna lines in the waters to the south of Iceland, the closest records being about 50 miles from the southern coast (Jonsson and Palsson, 2006) (Fig. 8).

Black devil anglerfish (*Melanocetus johnsonii*). One 17 cm specimen was caught in a pelagic trawl in the Irminger Sea near to the 200 mile limit south west of Iceland in May 1996 (Jonsson et al., 1997) (Table 1, Fig. 6). A second specimen (13 cm) was caugth in March 1999 in Vikurall to the west of Iceland (Jonsson and Palsson, 2000) and the third one (13 cm) in nearby waters in 2004 (Jonsson and Palsson, 2005).

Black devil anglerfish is know from all of the world oceans. The nearest previous records are from Dohrn Bank off East Greenland (Jonsson and Palsson, 2006).

1997

Chaunax suttkusi. Two specimens, 9.5 and 15.0 cm were caught in November and December 1997 (Table 1, Fig. 7). One was caught to the south of Westmanna islands to the south of Iceland and the other one over the Reykjanes Ridge (Jonsson et al., 1998). The third (16 cm) (Jonsson et al., 1999a) and the fourth fish (9.4 cm) (Jonsson and Palsson, 2002) were caught south of Surtsey island to the south of Iceland and deep to the west of Iceland in 1998 and 2001, respectively. In 2002 two more specimens (13 and 20 cm) were then caught in Grindavikurdjup off the south west coast (Jonsson and Palsson, 2003) (Fig. 7). In the Northeast Atlantic Ocean *C. suttkusi* has been recorded form the west of Ireland, in the Bay of Biscay and the Azores and along the coast of west Africa. In the western North Atlantic it has been caught from off the coast of South Carolina south to equator (Jonsson and Palsson, 2006).

Macroparalepis affinis. Single 23 cm specimen was caught at the offshore shrimp grounds to the north-west of Iceland in August 1997 (Jonsson et al., 1998) (Table 1, Fig. 6). This appears to be by far the northernmost record of this species in North Atlantic Ocean. The main distribution area of *M. affinis* is across the North Atlantic between ca. 20-40º N (Jonsson and Palsson, 2006).

1998

Legless searsid (*Platytroctes apus*). In April 1998 one specimen (18.5 cm) was caught in a pelagic trawl at ca. 750 m depth west of the Reykjanes ridge (Table 1, Fig. 6). In May another specimen (18.5 cm) was caught far south west of Iceland (south west of Ondverdarnes) in a pelagic trawl at ca. 590 m depth (Jonsson et al., 1999a). Legless searsid has been previously recorded from the Denmark Strait, off west Greenland, in the Bay of Biscay, off Portugal and west of Morocco (Jonsson and Palsson, 2006).

Atlantic bonito (*Sarda sarda*). One 59 cm specimen was caught for the first time in 1998 in a trout gill-net in Arnarfjord on the west coast (Jonsson et al., 1999a) (Table 1, Fig 4). This is a coastal species known from both sides of the North Atlantic Ocean. On the east side it has been recorded from the British Isles and southwards into the Mediterranean Sea and further to the coasts of South Africa. In the western Atlantic *S. sarda* is known from Nova Scotia and southwards to Mexico Bay and off South America (Jonsson et al., 1999a; Jonsson and Palsson, 2006). The present record appears to be by far the northern most in the North Atlantic Ocean.

Violet cuskeel (*Brotulotaenia crassa*). One 71 cm specimen was caught in 1998 to the west of Reykjanes ridge (Jonsson et al., 1999a) (Table 1, Fig. 7). A second (64 cm) specimen was caught in December 1999 in the outer reaches of Faxafloi on the south west coast (Jonsson and Palsson, 2001). A third specimen (70 cm) was caught deep south west of Reykjanes in May 2001. In the North Atlantic Ocean there are sporadic records of violet cuskeels from the waters south west of the British Isles, off southwestern Spain, Azores, Cape Werde islands and off western Africa (Jonsson and Palsson, 2006).

Neonesthes capensis. One 14 cm specimen was caught south of Westman islands in 1998 (Jonsson et al., 1999b) (Table 1, Fig. 6). *N. capensis* has previously been

recorded in the Bay of Biscay and in the North Atlantic between ca. 20-40º N (Jonsson and Palsson, 2006).

Headlight fish (*Diaphus effulgens*). One 11 cm specimen was caught southwest of Reykjanes in 1998 (Jonsson et al., 1999b) (Table 1, Fig. 6). Headlight fish is has been found in all of the world oceans. In the North Atlantic Ocean the main distribution is between ca. 15-45º N, but it has also been found near Madeira and the records nearest to Iceland seem to be deep west of Ireland (Jonsson and Palsson, 2006).

Brownsnout spookfish (*Dolichopteryx longipes*). One 9.5 cm specimen was caught in May 1998 deep southwest of Reykjanes (Jonsson and Palsson, 2002) (Table 1, Fig. 6). Brownsnout spookfish is an offshore and mesopelagic species known from all of the world oceans. In the northern North Atlantic Ocean it has been caught in the vicinity of the Azores, Madeira and Cape Werde islands (Jonsson and Palsson, 2006).

1999

Flounder (*Platichthys flesus*). This species was first caught with certainty near the mouth of the river Olfusa on the south west coast of Iceland in September 1999 (Jonsson and Palsson, 2001) (Table 1, Fig. 4). Previously, during the same year a suspicious “plaice/dab” had been caught by farmers in the vicinity but these were not brought to the Marine Research Institute for inspection (Jonsson et al., 2001). Since then the flounder has been recorded almost annually and from many different locations all around the country except for the north and northeast coasts (Fig. 5) (Jonsson et al., 2001). It seems evident that the flounder has distributed widely and rapidly in Icelandic coastal waters during the period since it was first recorded. This finding is of particular interest as the flounder is mainly confined to shallow water and estuaries and as the records at Iceland are the westernmost for the species in the North Atlantic Ocean. The nearest previous records are from Faroe Islands (Joensen and Tåning, 1970). The flounder is widely distributed along the coast of mainland Europe, from the White Sea in the north and southward to the coasts of Morocco (Nielsen, 1986) and it is also found in the North Sea and the Baltic (Jonsson and Palsson, 2006).

Pink sabertooth (*Evermannella balbo*). Two specimen (12.5, and 13.5 cm) were caught in a pelagic trawl, respectively at ca. 650 and ca. 680 m depth, just inside the 200 mile limit south west of Iceland in June-July 1999 (Jonsson and Palsson, 2001) (Table 1, Fig. 6). The third specimens (12 cm) was caught in 2001 at a ca. 775 m depth (Jonsson and Palsson, 2002) and the forth one (11cm) in 2003 at 725 m depth from almost the same area (Jonsson and Palsson, 2004). Pink sabertooth is widely distributed in the North Atlantic Ocean (from the Irminger Sea and south to the Equator), it is also present in the Mediterranean Ocean and has been recorded from the Indian Ocean (Jonsson and Palsson, 2006).

2000

Lamprogrammus shcherbachevi. One 183 cm specimen (the Icelandic specimen is amongst the largest specimens caught but was partly damaged at the tail fin) of this rare fish was caught at 55-73 m depth at Bodagrunn to the south west of Reykjanes (63º25´N, 23º50´W) in December 2000 (Table 1, Fig. 7) (Jonsson and Palsson, 2001) . *L. shcherbachevi* has only been recorded three times previously from the northern North Atlantic Ocean (west of Scotland (1995), off Faroe Bank (1997)) but it has

been caught off the coast of Angola in the sourthern Atlantic and southern Pacific Ocean, Indian Ocean and off west Australia (Jonsson and Palsson, 2006)

Lycodes terraenovae. Two specimens of this species were caught for the first time in Icelandic waters in 2000 (Table 1). One (30 cm) was caught at ca. 1060 m depth to the west of Iceland in the southern part of the Denmark Strait while the second one (50 cm) occurred at a ca. 1180 m depth to the south east of Iceland (Jonsson and Palsson, 2001). More specimens of *L. terraenovae* were caught to the southwest of Iceland in 2001 and deep south of Iceland in 2002 and 2003 (Jonsson and Palsson, 2002, 2003, 2004) (Fig. 8). The nearest previous records of *L. terraenovae* are from the south west of the Faroe Islands and west of Ireland. *L. terranovae* has also been caught on the continental slope off Florida, Newfoundland and in the Davis Strait to the west of Greenland. It has also been recorded off West Africa and west of South-Africa (Jonsson and Palsson, 2006).

Deepscale dory (*Grammicolepis brachiusculus*). One specimen was caught in the year 2000 off the south west coast of Iceland (Jonsson and Palsson, 2002) (Table 1, Fig. 4). This appears to be the northernmost record of deepscale dory hitherto. In the eastern North Atlantic Ocean deepscale dory has e.g. been recorded from the Bay of Biscay and off western Africa. In the western North Atlantic Ocean it is known from Georges Bank, Bay of Mexico and off northern South America (Jonsson and Palsson, 2006). Deepscale dory has also been recorded from the Pacific Ocean.

2001

Palebelly searsid (*Barbantus curvifrons*). In June/July one (13 cm) specimen was caught at in the Irminger Sea deep southwest of Iceland and in October another one deep west of Iceland (Jonsson and Palsson, 2002). The third specimen (10 cm) was caught in October 2004 deep west of Iceland (Table 1, Fig. 6). Palebelly searsid is a midwater species which in the North Atlantic has e.g. been observed along the northern part of the Mid Atlantic Ridge and from off the coasts of Spain southwards to Angola (Jonsson and Palsson, 2006)

Haplophryne mollis. One (8 cm) specimen was in June/July 2001 caught in the Irminger Sea southwest of Iceland (Jonsson and Palsson, 2002) (Table 1, Fig. 6). Several specimen of this species have also in recent years been caught in the Irminger Sea outside the 200 mile EEZ and earlier records nearest to Iceland are from the Dohrn Bank area off east Greenland (Jonsson and Palsson, 2006). In the North Atlantic *H. mollis* has also been recoreded form around Madeira and it is also known form the other world oceans (Jonsson and Palsson, 2006).

Poromitra megalops. In June/July 2000 10 specimens (8-13 cm) were caught at two stations in the Irminger Sea southwest of Iceland (Jonsson and Palsson, 2002) (Table 1, Fig. 6). *P. megalops* widely distributed in the northeastern North Atlantic Ocean to the south of Iceland (Jonsson and Palsson, 2006).

2002

Carapine grenadier (*Coryphaenoides carapinus*). One 18 cm specimen was in August/September 2001 caught in a Agassiz trawl off the south east coast of Iceland (Jonsson and Palsson, 2003) (Table 1, Fig. 8). Carapine grenadier has previously been caught in the oceanic waters to the south of Iceland, south of ca. 60° N and west of

Ireland and south towards the Equator. In the Northwest Atlantic Ocean it has been found over the continental slopes between Nova Scotia and Cape Hatteras and also it has been caught over the Mid-Atlantic Ridge (Jonsson and Palsson, 2006).

Sailfin dory (*Zenopsis conchifera*). One 24.5 cm specimen was caught in April 2001 in shallow water north of Reykjanes (Jonsson and Palsson, 2003) (Table 1, Fig. 4). The previous record nearest to Iceland is from the northwest of Ireland. From there this species is distributed south to the Bay of Biscay and southwards to the coasts of South Africa. Sailfin dory also inhabits the waters off the United States in the northwestern Atlantic Ocean and off Argentine and Uruguay in the southwestern Atlantic. Also it has been recorded form the Indian Ocean (Jonsson and Palsson, 2006).

2004

John dory (*Zeus faber*). One (35 cm) specimen was caught in shallow water off Sandgerdi of the south west coast in September 2004 (Jonsson and Palsson, 2005) (Table 1, Fig. 4). John dory has been recorded from the waters south west of the Faroe Isles, around the coast of the British Isles and in the North Sea and southwards along the coast of Europe, into the Mediterranean, and south to the southern tip of Africa (Jonsson and Palsson, 2006). This species is also known from the Indian Ocean, around Japan and off Australia.

1996-2005

The 22 species recorded for the first time during 1996-2005 may be grouped into four categories based on previously known general distribution and ecology and/or changes in type of fishing effort around Iceland (Table 2):

A. Continental Shelf species, with distribution in the North East Atlantic north to the British Isles and southern part of Norway. The species in this group are *S. sarda, Z. faber, Z. conchifera* and *P. flesus* (Fig. 4). Except for *P. flesus*, only a single specimen has been caught in Icelandic waters of each of the species in this group. As pointed out above *P. flesus* was first found in 1999 at the south coast, but has since extended its distribution north along the west coast seems to have established a spawning population in Icelandic waters (Fig. 5). During the last three decades of last century, *Z. conchifera* has expanded its range from southern Portugal to the Bay of Biscay and north to Ireland and British waters (Quero et al., 1998; Swaby and Potts, 1999). The single record of *Z. conchifera* from Icelandic waters indicates a continuing northward movement of this species. Similarly, *Z. faber* has been expanding its range being recorded in the Faroe Islands for the first time in 2001 and again in 2006 (Rógvi Mouritsen, pers. comm.).

B. Oceanic species previously known from more southerly distribution in the North Atlantic. This group consists of *P. altipinnis, M. affinis, N. capensis, D. effulgens, D. longipes, H. mollis, P. megalops , P. apus, M. johnsoni, B. curvifrons, E. balbo* (Fig. 6). All the species in this group are relatively small sized and thus only accidentally are kept within a catch in a commercial fishing gear with mesh size of 135 mm and they have always been recorded as single specimen. Seven of the first mentioned species have only been found at one location while *P. apus* has been recorded at two, *M. johnsonii* and *B curvifrons* at three and *E. balbo* at four.

Seven of the species in this group (*P. altipinnis, D. longipes, H. mollis, P. apus, M. johnsoni, B. curvifrons, E. balbo*) have only been recorded within an area deep to the southwest and west of Iceland at the outer reaches of the EEZ between ca.

61º30´-66º00´ N and ca 27º-30Vº (Fig. 6). The southern part of this area is the main area of fishery for pelagic redfish within the Icelandic EEZ while the northern part is an important ground for a fishery on Greenland halibut. The locations of these fisheries at the very southwestern border of the EEZ, where variations in the flow of Atlantic water are likely to be first reflected through changes in the marine fauna and also their special features as regards fishing gear and depth of operation, are probably the main reasons why so many new species have been found there. Similar fishing operations or sampling farther to the east of this area would probably demonstrate a much wider distribution of many of these species.

C. Rare species of sporadic occurrence inhabiting the continental slopes, some known to have a wide but irregular distribution. The species in this group are *L. shcherbachevi, G. brachiusculus, B. crassa,* and *C. suttkusi* (Fig. 7). All of these species have been recorded as single specimen. *L. shcherbachevi* and *G. brachiusculus* have only been recorded once, *B. crassa* three times and *C. suttkusi* six times.

The two ophidiid species, *B. crassa,* and *L. shcherbachevi,* have been recorded from the waters of the Faroe Islands (www.frs.fo; Nielsen and Schwarzhans, 2000). It has been suggested that *G. brachiusculus.* might have a continuous distribution from the Canary Islands to the Bay of Biscay, but records are few (Vasconcelos et al. 2003). Fish of the genus *Chaunax* has been expanding its distribution to the north, after the revision of the genus (Caruso, 1989) the species involved has been found to be *C. suttkusi* (Quigley et al., 1996; Quero et al., 1998). This species has also recently been recorded from the Mediterranean Sea (Ragonese et al., 2001).

D. Species recently found within the Icelandic EEZ probably due to new type of fishing or research cruises. In this group we have put *C. carapinus L. terraenovae, P. glauca* (Fig. 8). Only one specimen of *C. carapinus* has been caught hiterto, nine of *L. terraenovae* at nine stations, while *P glauca* has been caugth in considerable numbers at many stations and over a wide area.

C. carapinus was caught in deep waters by Agazziz trawl during benthic sampling outside all fishing grounds and six of the *L. terraenovae* specimens as well (ca. 1300-2300 m depth) (until recently no sampling with this kind of gear has been conducted in deep water outside traditional fishing grounds). However, *L. terraenovae* has also been caught by a bottom trawl at the deepest stations during trawl surveys on known fishing grounds (ca. 1000-1200 m depth). When Japanese long-liners began experimental fishing for tuna within the southern part of Icelandic EEZ *P. glauca* was found to be a frequent by-catch and during the period 1996-2005 the number caught per season has ranged form 30-846 specimen. The greatest abundance occurred between 60-62ºN and 16-24º W. However, possibly this may reflect more the distribution of the effort in the tuna fishery than the actual distribution of *P. glauca*. Any how this seems to indicate that *P. glauca* fairly common in the oceanic waters to the south of Iceland.

3.3 Previously recorded but seen more frequently in recent years

Mackerel (*Scomber scombrus*), twaite shad (*Alosa fallax*), sea lamprey (*Petromyson marinus)* and garpike (*Belone belone*) are examples of southern vagrant species in Icelandic waters that have been seen more frequently in recent years. Figure 9 shows the occurrence of these species in the period 1993 -2004. None of these species was recorded in Icleandic waters during the first three years considered. At the onset of the warming in 1996 mackerel was observed for the first time in a while and then the other species as the warming period prolonged (sea lamprey in 1998, garpike in 2001,

and twaite shad in 2001) The sea lamprey and twaite shad and have been observed annually since they were recorded in the recent warm period (Fig. 9).

The longer term records of mackerel in Icelandic waters are show in Figure 10. It was first recorded form southwest coast of Iceland in 1895 (Saemundsson, 1926) and since then it has been caught every now and again all around the country and even some times in small schools. Records of mackerel in Icelandic waters during the past ca. 100 years are confined to three main periods, namely at the turn of the 20th. century, the years between 1930-1940 and at the turn of the 21st. century. The latter two periods conform to the warming that took place in the North Atlantic during the early part of the 20 th. century and in again in recent years (Anon., 2004).

The mackerel is widely distributed on both sides of the North Atlantic Ocean. In the eastern Atlantic it is distributed from the Azores and Cape Verde Islands, in the Mediterranean and Black Seas and northwards to northern Norway and even the White Sea (Jonsson, 1992). In the western Atlantic it is distributed from of North Carolina and northwards to Labrador (Jonsson, 1992).

Similar to the mackerel, the long term records of twaite shad in Icelandic waters conform to some extent to long term changes in the marine climate. Twaite shad was first recorded in Icelandic waters 1829 (Fig. 11). The second and third records were documented some one hundred years later or in 1933 and 1939 (Fridriksson, 1948). Again a long time passed before twaite shad was again observed in Icelandic waters but that was in 1977 when a one specimen was caught in Eyjafjord on the north coast (Jonsson, 1992). In 1994 one specimen was caught in Faxafloi on the west coast (Jonsson et al. 1995). Since 2001 1-3 specimens of twaite shad have been caught annually in Icelandic waters (Jonsson and Palsson, 2002, 2003, 2004, 2005) (Fig. 9).

Twaite shad is a coastal species distributed from the coasts of the Black Sea and the Mediterranean and northwards along the coasts of Europe to the middle of the west coast of Norway (Jonsson and Palsson, 2006)

Jonsson (1992) considered the sea lamprey probably to be most common off the east coast Iceland. Only four of the 20 specimens shown in Figure 9. were, however, caught off the east coast and thus these more recent records do not support that suggestion.

The sea lamprey occurs at both sides of the North Atlantic Ocean. In the North East Atlantic it occurs from the Barents Sea and northern Norway southwards to Portugal and into the western Mediterranean of western Africa. In the North West Atlantic it occurs of south Greenland and then in the Bay of St. Lawrence and southwards to Florida (Jonsson, 1992).

Garpike was reported from Icelandic waters in 1701, another specimen was found in Iceland in 1764 and two in 1821 Jonsson (1992). All of these records are from the south coast. In the year 2000 one was found in the stomach of a cod caught off the southwest coast. In 2004 further 3 were recorded from off the southeast and east coasts. The one from off the east coast occurred in the stomach of a cod and that is the most northern record of this species in Icelandic waters.

The distribution area of garpike extends from the Mediterranean Sea northwards to northern Norway in the in the northeast Atlantic (Jonsson and Palsson, 2006). In Icelandic waters all of the records have until recently been from off the south coast.

3.4 Species extending their distribution to northern waters

Three rare fish species (snake pipe fish (*Entelurus aequoreus*), greater fork-beard (*Phycis blennoides*) and blue antimora (*Antimora rostrata)*) have in Icelandic waters in recent years been found to show a gradual northward distribution.

Snake pipe fish has until recently been considered to be confined to the southwest coast of Iceland. In 2001 snake pipe fish was recorded for the first time in a long while in Icelandic waters when one specimen was found of the west coast (Fig. 12) (Jonsson and Palsson, 2002, 2006). Further records off the south and west coast were registered in 2002, 2003 and 2004 (Jonsson and Palsson, 2003, 2004, 2005). In the autumn of 2004 snake pipe fish was also recorded form Eyjafjord and Oxarfjord off the north coast (Jonsson and Palsson, 2005). These last records demonstrate that snake pipe fish can now be considered to be distributed all around Iceland.

According Jonsson (1992) snake pipe fish is distributed in the northeast Atlantic Ocean from the coasts of the Azores and Portugal and northwards to the middle of the west coast of Norway and to the coasts of Iceland.

Greater fork beard was first recorded off the south coast of Iceland in 1903 (Saemundsson, 1926). Since then it has often been observed and probably it is fairly common in deep water off the southeast, south and the southwest coasts. In 2004 greater fork beard was for the first time caught off the north coast of Iceland to the north east of Grimsey Island (66º 39´ N, 17º 54´ W) (Jonsson and Palsson, 2004).

Greater fork-beard is distributed in the Mediterranean and the northeast Atlantic Ocean form northwest Africa and along the coasts of Portugal, Spain, the western British Isles, into the northern North Sea and along the coast of Norway (Jonsson and Palsson, 2006).

In Icelandic waters the main distribution area of blue antimora has been form Vikurall in the northwest (ca. 66º N) and south off the west coast, off the south coast and to the southeast (ca. 64º N) i.e. in the deep warm water to the south of the Greenland-Iceland-Scotland ridge (Jonsson, 1992). Every now and again vagrants have also been recorded off the east cost (Jonsson and Palsson, 2006). In October 2000 one specimen was caught at ca. 180 m of the middle of the east coast (65º48´ N, 11º56´ W, Jonsson and Palsson, 2006) and in 2003 one was caught northeast of the island Grimsey, off the north coast (66º39´ N, 17º55´ W, Jonsson and Palsson, 2004). The latter record is the first one off the north coast of Iceland (Fig. 13).

Blue antimora is widely distributed in all world oceans (Jonsson, 1992). In the northern North Atlantic Ocean it has been found off the continental shelf on both sides of the ocean, from off Florida in the southwest, northwards towards Labrador and south off Greenland and Iceland and then west of Ireland and southwards to Spain and Portugal.

3.6. Conclusions

We have here reported on 22 new species that have been found within the Icelandic EEZ since the onset in 1996 of a nearly a continued warm period around Iceland and in the North Atlantic Ocean. Of the 22 species we believe that three have most likely been caught because of fisheries with new gear and/or on new fishing grounds while 19 have not been caught until now inside the EEZ despite of continuous and heavy fishing. Some of these 19 species may possibly be old inhabitants of Icelandic waters

for a long time without being caught until now. However, the fact that many commercial species in Icelandic waters of southern origin have in recent years been showing marked changes in distribution and abundance and many of the rare species are also showing similar northward distributional changes we are of the opinion that most of the new records are probably reflecting actual changes that are taking place in the fish fauna due to the recent warming.

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Table 1. Fish species recorded for the first time and locations within the Icelandic EEZ in 1996-2004. The following abreviations are used for fishing gears: P, pelagic trawl; L, long line; B, bottom trawl; G, gill net; A, Aggazis trawl, D, Danish seine; For further information on single records see Jonsson and Palsson, 2006.

Year	English name	Latin name	Lat	Lon	Gear	Notes and additional records
1996		Pseudoscopelus altipinnis			P	Deep SW of Iceland
1996	Blue shark	Prionace glauca	6028	1620	L	Northernmost location in 1996 is shown. 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004
1996	Black devil angler fish	Melanocetus johnsoni	6250	3035	P	1999, 2004
1997		Macroparalepis affinis	6625	2721	B	Deep water shrimp grounds NW of Iceland
1997		Chaunax suttkusi	6252	2020	B	1998, 2001, 2002
1998	Legless searsid	Platytroctes apus	6200	2835	P	
1998	Atlantic bonito	Sarda sarda	6440	2330	G	
1998	Violet cuskeel	Brotulotaenia crassa	6140	2806	P	1999, 2001
1998		Neonesthes capensis	6312	1952	B	
1998	Headlight fish	Diaphus effulgens	6307	2341	B	
1998	Brownsnout spookfish	Dolichopteryx longipes	6149	2913	P	
1999	Flounder	Platichthys flesus			G	2000, 2001, 2002, 2003, 2004,
1999	Pink sabertooth	Evermannella balbo	6148	2750	P	1999, 2001, 2003
2000		Lamprogrammus shcherbachevi	6325	2350	B	
2000		Lycodes terraenovae	6523	2824	B	2001, 2002, 2003
2000	Deepscale dory	Grammicolepis brachiusculus	6307	2240	B	
2001	Palebelly searsid	Barbantus curvifrons	6314	2753	P	2001, 2004
2001		Haplophryne mollis	6130	2836	P	
2001		Poromitra megalops	6218	2013	P	
2002	Carapine grenadier	Coryphaenoides carapinus	6243	1432	A	
2002	Sailfin dory	Zenopsis conchifera	6315	2245	D	
2004	John dory	Zeus faber	6402	2300	B	

Table 2. Fish species recorded for the first time grouped on the basis of habitat/ecology and present knowledge.

English name	**Latin name**	**No. stations**	**No. specimen**
Shelf species			
Atlantic bonito	Sarda sarda	1	1
Sailfin dory	Zenopsis conchifera	1	1
John dory	Zeus faber	1	1
Flounder	Platichthys flesus	>15	>50
Oceanic species			
	Pseudoscopelus altipinnis	1	1
	Macroparalepis affinis	1	1
	Neonesthes capensis	1	1
Headlight fish	Diaphus effulgens	1	1
Brownsnout spookfish	Dolichopteryx longipes	1	1
	Haplophryne mollis	1	1
	Poromitra megalops	2	10
Legless searsid	Platytroctes apus	2	2
Black devil angler fish	Melanocetus johnsoni	3	3
Palebelly searsid	Barbantus curvifrons	3	3
Pink sabertooth	Evermannella balbo	4	4
Sporadic slope species of wide distribution			
	Lamprogrammus shcherbachevi	1	1
Deepscale dory	Grammicolepis branchiusculus	1	1
Violet cuskeel	Brotulotaenia crassa	3	3
	Chaunax suttkusi	6	6
Species found because of new fishing gear and exploration of new areas			
Carapine grenadier	Coryphaenoides carapinus	1	1
	Lycodes terraenovae	9	9
Blue shark	Prionace glauca	>100	>100

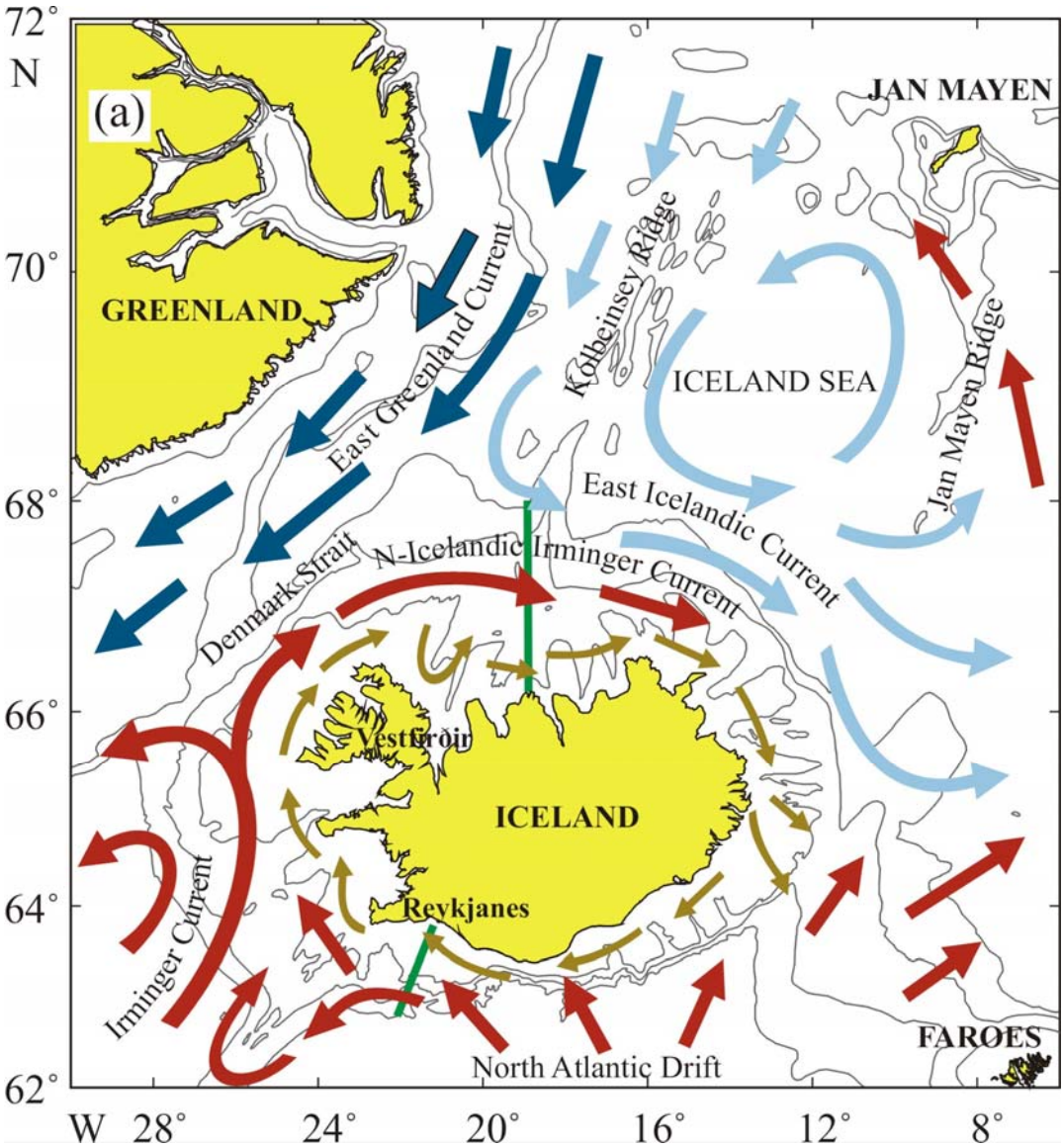

Figure 1. Ocean current around Iceland. The green lines show hydrographic monitoring transects (Selvogsbanki, south of Iceland; Siglunes, north of Iceland). From Vilhjalmsson, 2002

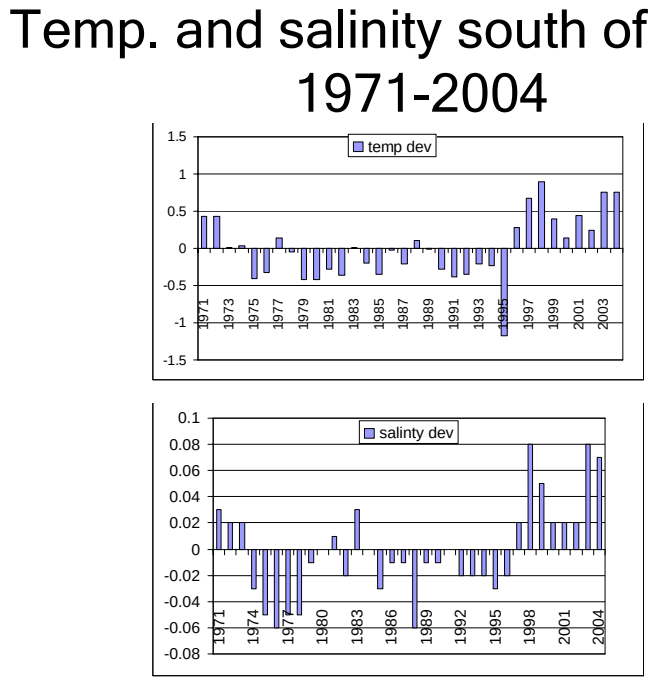

Figure 2. Temperature and salinity deviations in spring 1971-2004 at 100m depth on station 5 63º 00´ N, 21º 25´ W on Selvogsbanki transect to south of Iceland.

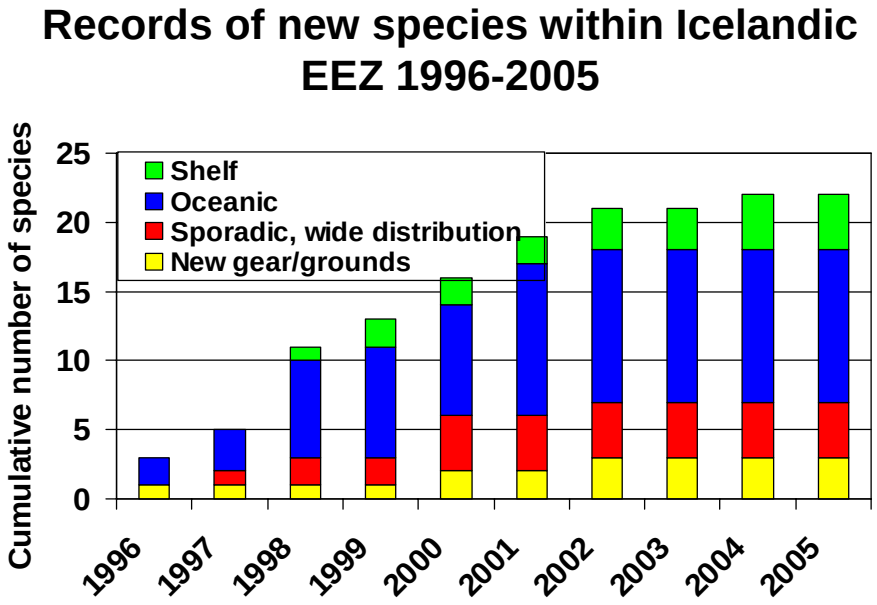

Figure 3. Cumulative record of new species within the Icelandic EEZ during 1996-2005. The species area grouped on the basis of general distribution and ecology and if record could possibly be related to new fishing methods

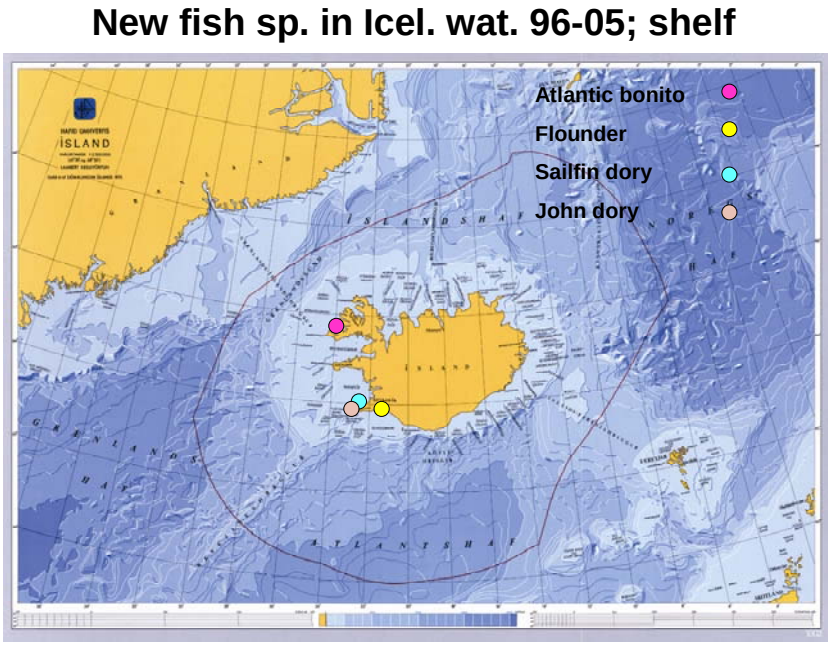

Figure 4. Records of new "coastal" species (see text for details) in Icelandic waters during 1996-2005. For flounder only first record in 1999 is shown, for more details see Fig. 5).

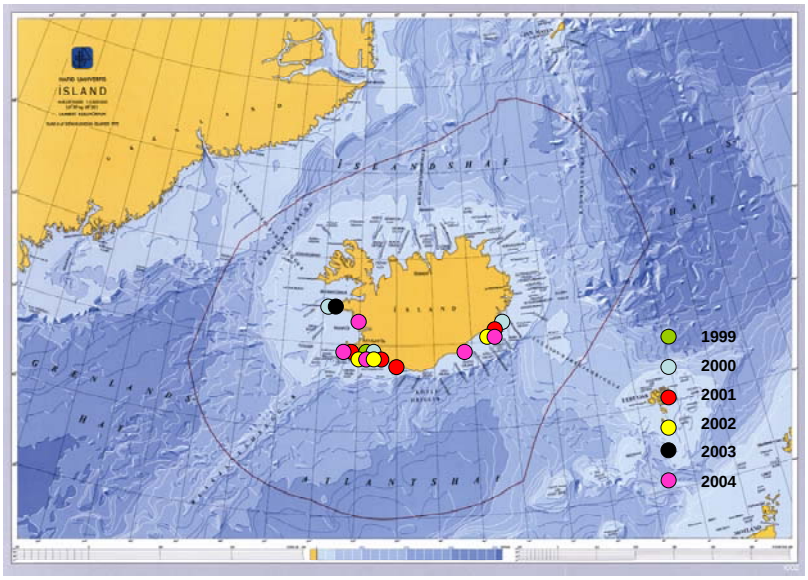

Figure 5. Records of flounder in Icelandic waters during 1999-2004.

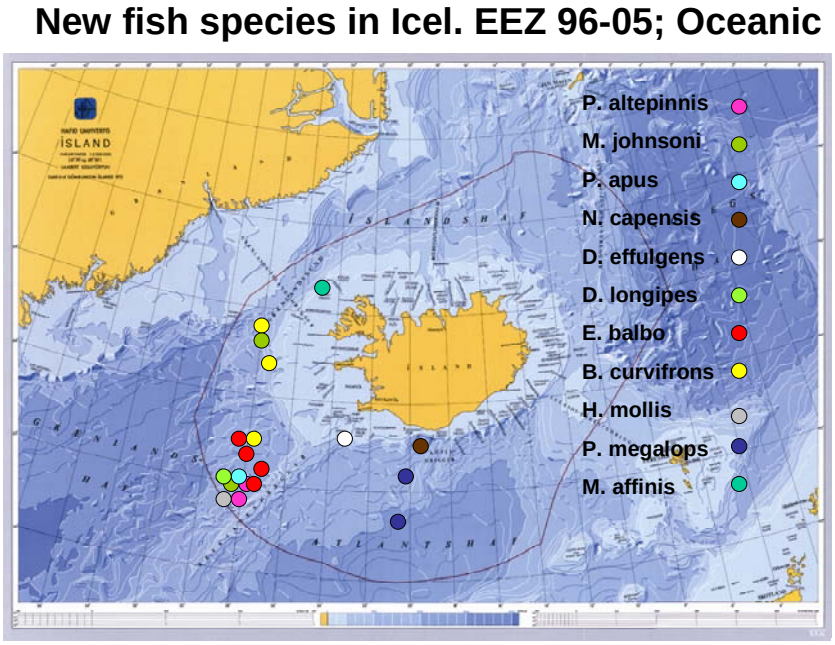

Figure 6. Records of new "oceanic" species (see text for details) in Icelandic waters during 1996-2005.

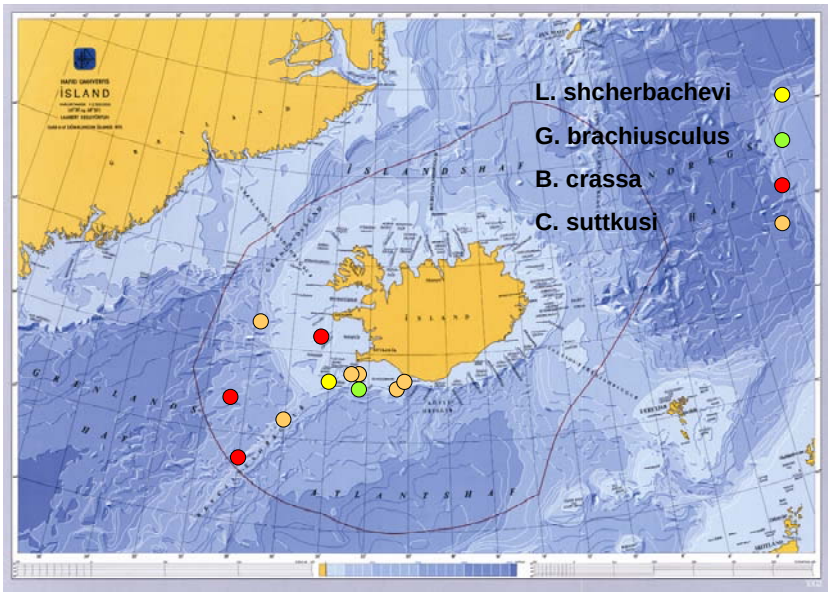

Figure 7. Records of new "sporadic, wide distribution" species (see text for details) in Icelandic waters during 1996-2005.

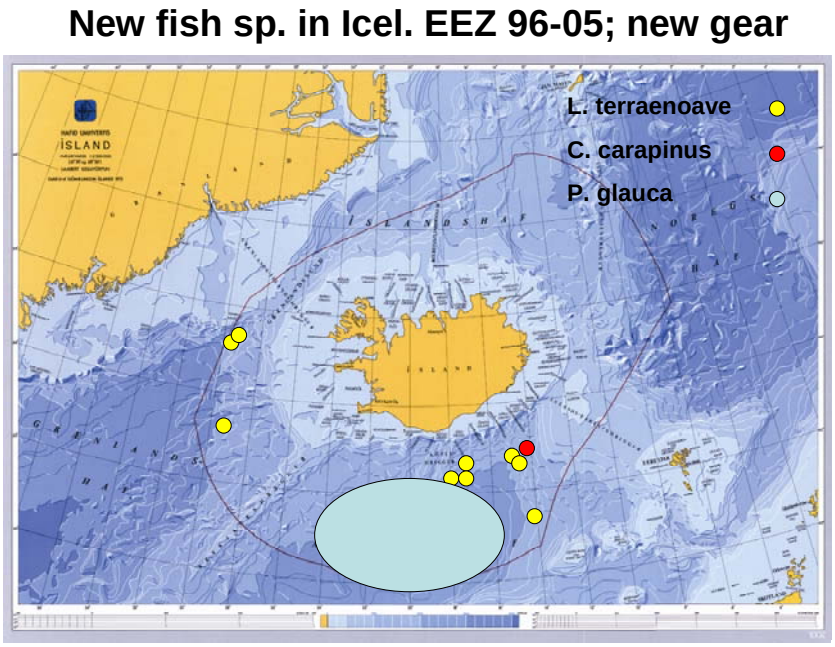

Figure 8. Records of new species that are most likely caugth because of "new gear or new grounds being explored" (see text for details) in Icelandic waters during 1996-2005.

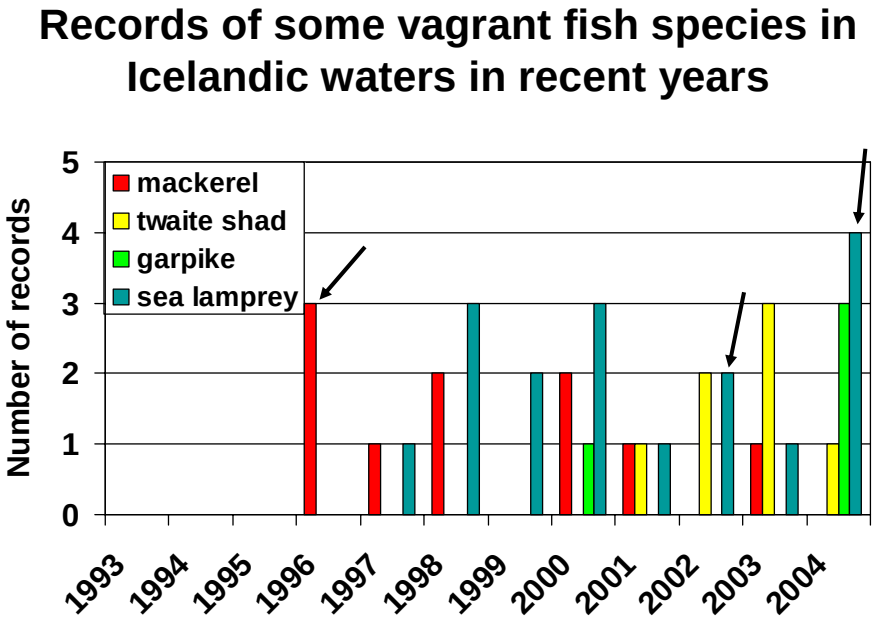

Figure 9. Records of vagrant fish specis in Icelandic waters during 1993-2004. The arrows indicate records where more than one specimen was caught.

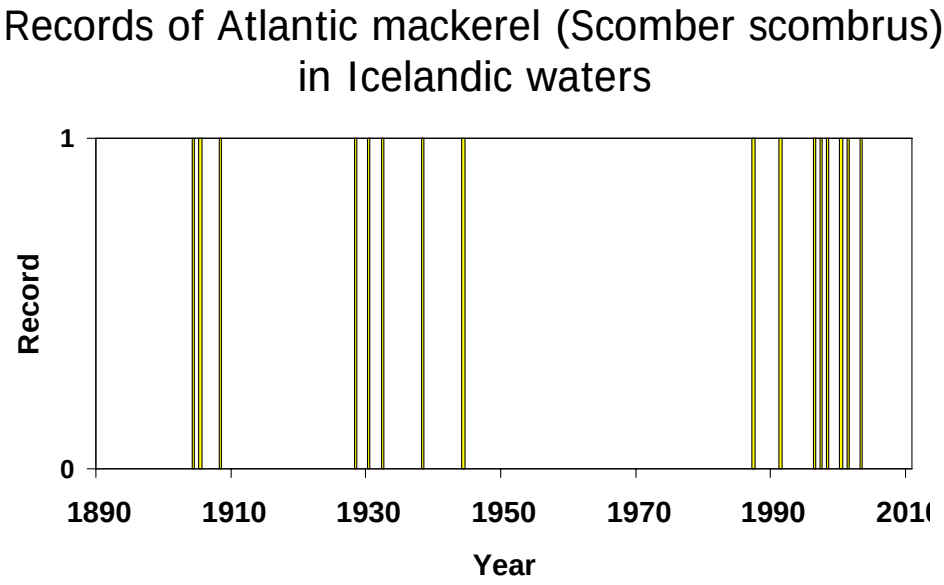

Figure 10. Years of reported records on Atlantic mackerel in Icelandic waters.

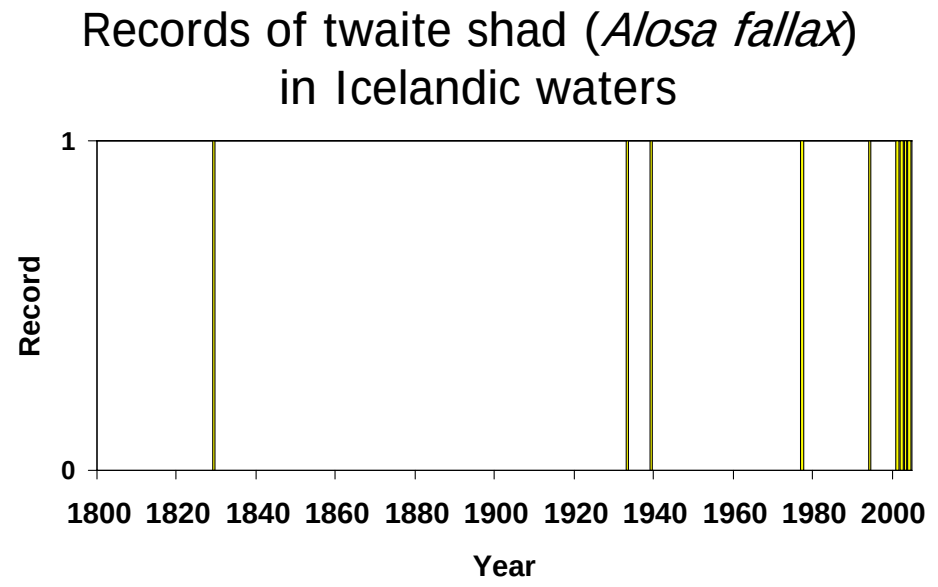

Figure 11. Years of reported records on twaite shad in Icelandic waters.

Recent records of snake pipefish (*Entelurus aequoreus*)

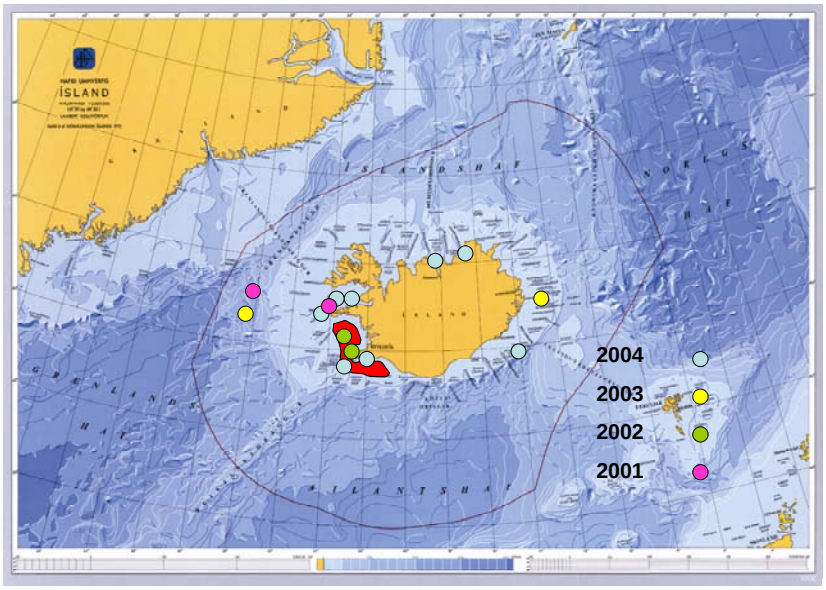

Figure 12. Recent records of snake pipe fish in Icelandic waters.