



## *Status of Marine Mammals in the North Atlantic*

# **THE LONG-FINNED PILOT WHALE**



*(Pilot whale drive in the Faroes. Photo: D. Bloch)*

*This series of reports is intended to provide information on North Atlantic marine mammals suitable for the general reader. Reports are produced on species that have been considered by the NAMMCO Scientific Committee, and therefore reflect the views of the Council and Scientific Committee of NAMMCO.*

### **North Atlantic Marine Mammal Commission**

Polar Environmental Centre N-9296 Tromsø, Norway

Tel.: +47 77 75 01 80, Fax: +47 77 75 01 81 Email: [nammco-sec@nammco.no](mailto:nammco-sec@nammco.no), Web site:

[www.nammco.no](http://www.nammco.no)

## **LONG-FINNED PILOT WHALE (*Globicephala melas*)**

The long-finned pilot whale is a medium-sized toothed whale that is found in the North Atlantic and in mid-latitudes throughout the northern and southern hemisphere. Males are larger than females, reaching a length of 6.3 m and a weight of 2.5 tonnes, compared to 5.5 m and 1.5 tonnes for females (Bloch *et al.* 1993b). They are dark brown to black in colour, with a light anchor-shaped pattern on the belly, and on some a whitish stripe extending towards the tail along the back and sometimes also behind dorsal fin. The pilot whale is a very social species, and is invariably found in groups of 10's to 100's of animals.

### **Distribution and Stock Definition**

The pilot whale is an oceanic species and occurs far offshore as well as in coastal areas (Buckland *et al.* 1993, NAMMCO 1998a). They are very widely distributed in the North Atlantic, from about 35° - 65° N in the west and from about 40° - 75° N in the east (ICES 1996; NAMMCO 1998a,b) (Fig.1). There appears to be a gap in distribution in the area south of Greenland in the Irminger Sea, however this area has not been surveyed extensively so the gap may be an artefact. There is no indication that they undertake extensive seasonal migrations, however their distribution does change on a seasonal basis, probably in relation to the abundance of their principle prey (Payne and Heinemann 1993; Zachariassen 1993).

Genetic studies have indicated that there is very little variability in mitochondrial DNA in pilot whales throughout the North Atlantic, and no significant differences between those sampled from the western Atlantic, Iceland and the eastern Atlantic. This can be considered as evidence that there is only one stock of pilot whales in the North Atlantic. However, this uniformity may be related to the social structure of pilot whales, which occur in schools of closely-related animals (ICES 1996, NAMMCO 1998b). Andersen (1993) found that schools captured in the Faroes differed in their allozyme composition, suggesting that genetic differences between schools do exist. To date, no studies of stock delineation using nuclear DNA have been published.

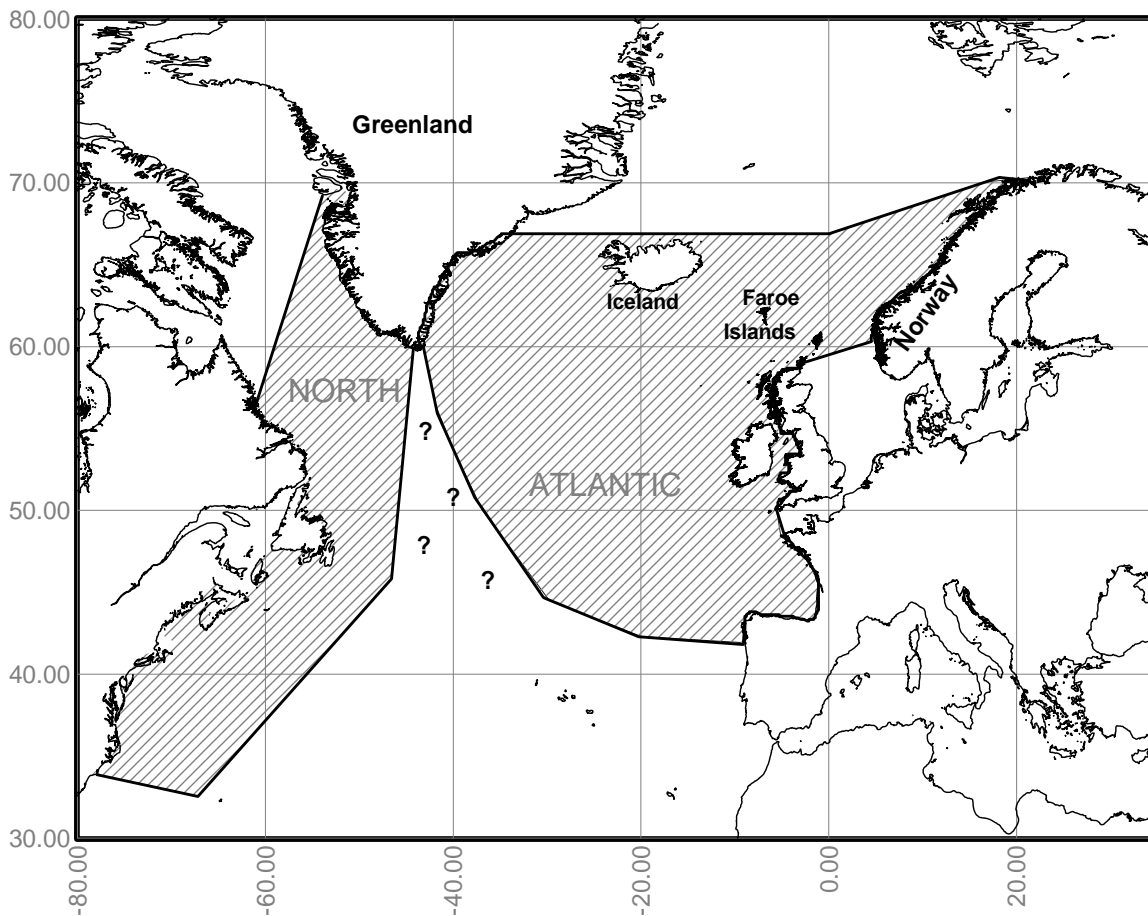
Other lines of evidence suggest that there are at least 2 stocks in the North Atlantic. There are morphometric (body shape) differences between pilot whales caught in the Northwest and Northeast Atlantic (Bloch and Lastein 1993, ICES 1996). This indicates that pilot whales from the two areas are unlikely to be from the same stock. In addition, the depletion of pilot whales off Newfoundland from 1947 to 1972 apparently had no effect on pilot whale abundance elsewhere, indicating that there is probably little or no exchange between this area and others (Mercer 1975, Nelson and Lien 1996). There may also be differences over smaller spatial and temporal scales. There were significant differences in pollutant concentrations (Aguilar *et al.* 1993, Caurant *et al.* 1993) and parasite burdens (Balbuena *et al.* 1995) between schools of whales landed in the Faroe Islands at different times and locations. This suggests that these schools spend different proportions of their time in different areas, which again may be indicative of stock differences.

In 1997, the Scientific Committee of NAMMCO concluded that, based on the evidence noted above, it was likely that there was more than one stock of pilot whales in the North Atlantic, and more than one stock subject to harvesting in the Faroe Islands (NAMMCO 1998b). It is apparent that further research is required to resolve the stock delineation of pilot whales in the North Atlantic.

### **Ecology**

Male pilot whales reach sexual maturity at age 10 to 15 (Desportes *et al.* 1993), while females do so at age 5 to 15 and both sexes reach physical maturity at age 25 to 30 (Bloch *et al.* 1993b, Martin and Rothery 1996). Gestation lasts about 12 months (Martin and Rothery 1993). The fertility of females declines with age, and whales older than 40 years rarely become pregnant (Martin and Rothery 1993, ICES 1996).

Fig. 1. Approximate North Atlantic distribution of the long-finned pilot whale. Based on ICES (1996).



Like many species of toothed whales, pilot whales are highly social animals and usually occur in pods of 10 to 200 whales, with larger pods occurring more rarely. Pods generally consist of related females with offspring of both sexes and all ages, with adult females outnumbering adult males. Male-only pods and pods consisting mainly of males have been observed however (Desportes *et al.* 1992). Genetic evidence indicates that, while males remain in their natal pod, they do not father calves in that pod. Therefore mating must occur when 2 or more pods meet (Amos *et al.* 1993).

Pilot whales are opportunistic feeders that may exploit any locally abundant prey, but they are primarily consumers of squid. In the Northeast Atlantic, they feed mainly on the squids *Gonatus* spp. and *Todarodes sagittatus*, but fish such as greater argentine (*Argentina silus*), blue whiting (*Micromisistius poutassou*), Greenland halibut (*Reinhardtius hippoglossoides*) and pandalid shrimp are also consumed (Desportes and Mouritsen 1993). The squids *Illex illecebrosus* and *Loligo peulei* dominate the diet of pilot whales in the Northwest Atlantic, but they also eat Atlantic mackerel (*Scomber scombrus*) and Atlantic herring (*Clupea harengus*) (Mercer 1975, Gannon *et al.* 1997a, 1997b). While pilot whales are clearly squid specialists, they can diversify their diet according to prey availability, and may feed exclusively on fish when squid are not readily available (Desportes and Mouritsen 1993).

As one of the most abundant cetaceans in the North Atlantic, pilot whales are important consumers in the marine ecosystem. They may be one of the most important marine mammal predators in the offshore waters of northwestern North America (Gannon *et al.* 1997a, 1997b). In the central North Atlantic around Iceland, pilot whales are likely the 4<sup>th</sup> most important marine mammal predator in the marine ecosystem, consuming 200 to 300 thousand tonnes of fish, and 900 to 1100 thousand tonnes of squid per year (Sigurjónsson and Víkingsson 1997). Much of this consumption is concentrated on

species presently of little importance to commercial fisheries, so direct competition with fisheries is probably minimal.

Pilot whales have few predators besides humans, but may be preyed upon by killer whales (*Orcinus orca*) and large sharks.

### **Abundance and Trends:**

Estimates of the abundance of pilot and other species of whales in the North Atlantic have been based largely on sighting surveys conducted from ships and airplanes. The surveys are conducted by cruising along preset transect lines, with observers counting the number of whales seen out to a certain distance from the ship or plane. These counts are translated into estimates of abundance by applying the observed density to areas not counted directly, while correcting (as far as possible) for distance from the trackline, whales below the surface not visible to the observers, and whales visible but missed by the observers. Because of the relatively small area in which whales are actually counted compared to the large survey area, and the uncertainties associated with correction factors, there is always a high degree of variance in these estimates.

The most recent survey in the Northeast and Central Atlantic from which abundance estimates are available, the North Atlantic Sightings Survey (NASS), was conducted co-operatively by Norway, Iceland and the Faroe Islands in 1995, and covered much of the eastern North Atlantic north of 50° and west to Greenland. The NASS-95 survey was conducted primarily from ships, but coastal Iceland was surveyed by plane. Other NASS surveys were conducted in 1987 and 1989.

The three NASS surveys covered substantially different areas and, not surprisingly, yielded different population estimates. However, when the estimates are restricted to the areas covered by all three surveys, the estimates are not significantly different and therefore do not indicate any trend in abundance (NAMMCO 1998a,b). However, year-to-year shifts in distribution are apparent. The 1989 survey covered the largest area of potential pilot whale habitat, yielded the most reliable total estimate of 778,000 (CV=0.295) for the eastern North Atlantic (Buckland *et al.* 1993).

An indication of long term historical trends in the abundance of pilot whales around the Faroe Islands can be gained from analysis of catch data. Catch records from the Faroes go as far back as 1584, and are unbroken since 1709 (Bloch 1994). Catch, corrected for hunting effort, shows a cyclic pattern with a period of 100-120 years, with peaks in catch occurring in 1720-1730, 1840-1850, and 1935-1985 (Hoydal and Lastein 1993). There is no long-term indication of declining or increasing abundance over the period (Bloch and Lastein 1995). The local availability of pilot whales to the Faroese may be related to changes in sea temperature and the abundance of their favoured prey (Hoydal and Lastein 1993).

There is little current information on the abundance of pilot whales in the Northwest Atlantic. Pilot whales were subject to an intensive drive fishery in Newfoundland from 1947 to 1972, and this fishery apparently reduced the stock to very low levels (Mercer 1975, Hay 1982, Nelson and Lien 1996). Abundance at the onset of the fishery was likely about 60,000 animals (Mercer 1975). Hay (1982) conducted an aerial survey in eastern Newfoundland and Labrador waters, and estimated 13,167 whales (95% C.I. 6,731 to 19,602, not corrected for diving whales or whales missed by observers). The population has likely not yet recovered to its pre-exploitation size (Nelson and Lien 1996).

Pilot whales are also abundant in the offshore waters of the northeastern USA (Nelson and Lien 1996, Gannon *et al.* 1997a, 1997b, Waring *et al.* 1999). A sighting survey conducted in 1995 covered the area between Virginia to the Gulf of St. Lawrence from the coast to the 1000 fathom depth contour line (Waring *et al.* 1999). A total of 8,176 (C.V.=0.65) pilot whales were estimated to be present in the survey area. However, this estimate may include both long-finned and short-finned (*G. macrorhynchus*) pilot whales, and is negatively biased because it is not corrected for diving whales and did not cover all pilot whale habitat in the area. Although there is no information on abundance

trends, abundance is likely increasing because human-induced mortality has declined in recent years (Waring *et al.* 1999).

### **Current Management and Utilisation:**

Pilot whales have a long history of utilisation by humans in the North Atlantic. In the 20<sup>th</sup> century, they have been harvested in the Faroe, Shetland and Orkney Islands, Iceland, Greenland, the eastern USA and Newfoundland in Canada (Martin *et al.* 1990, Nelson and Lien 1996). They continue to be harvested in the Faroe Islands and Greenland.

In the Faroes, harvesting of pilot whales has been an important source of food for the inhabitants since the islands were colonised. Pilot whales are taken in an organised drive hunt, or *grind*. When whales are sighted, local fishing vessels co-operate to drive the whales into designated beaches. Once ashore, they are killed by severing the neck arteries and veins using a specialised knife. The catch is then evaluated by designated officials who measure and mark the whales. The catch is divided into shares following specified rules and distributed free of charge to hunt participants and all adult residents in the district (Bloch *et al.* 1990).

Regulation of the Faroese pilot whale hunt is based on old Norse laws, and deals with all aspects of the hunt, including driving procedures, beaching, killing methods, valuation, distribution and beach cleanup. There are no quotas, but certain beaches or entire whaling districts can be closed when harvests are considered sufficient. The hunt is supervised by elected *grindforemen*, who are themselves under the supervision of the *sýslumaður*, or district sheriff. The *sýslumaður* also oversees the valuation and division of the catch, and is responsible for keeping records of the harvest (Bloch *et al.* 1990).

In recent years, the pilot whale catch at the Faroes has ranged between 228 and 2909 (Table 1). From 1709 to 1999, a total of 246,434 pilot whales have been caught in 1,766 pods. There have been an average of 6.1 *grinds* per year in that period, and *grind* size has ranged from 1 to 1200 whales, with a mean of 139.5 whales per *grind* (Zachariassen 1993, Bloch 1994).

Levels of PCB's and mercury are relatively high in the blubber and meat of pilot whales taken in the Faroes (Borrell and Aguilar 1993, Caurant *et al.* 1993)). In some cases, the level of consumption of pilot whale by Faroese may lead to intake of these substances that exceeds recommended levels. This is of particular concern given the documented neurotoxicity of methylmercury to the developing foetus (Weihe *et al.* 1996). Consequently, the Faroese health authorities have recently provided recommendations for the consumption of pilot whale meat and blubber.

Pilot whales are taken in southwest Greenland on an opportunistic basis. They are usually hunted from small boats using rifles and hand harpoons. There are no quotas for pilot whales in Greenland, however regulations pertain to hunting methods and equipment. Recent catches have ranged between 0 and 132 animals (Table 1).

### **Threats:**

Pilot whales are taken as bycatch in some fisheries on both sides of the Atlantic. They were taken in significant numbers in the Mediterranean driftnet fishery for swordfish (*Xiphias gladius*) in the 1980's, however limitations on net size imposed in 1990 have probably ameliorated this problem (Notarbartolo-di-Sciara 1990, Natale and Notarbartolo-di-Sciara 1994). Currently, bycatch of pilot whales in the eastern Atlantic appears to be insignificant.

Table 1. Recent harvests of long-finned pilot whales. Catch data compiled from the NAMMCO Catch Database. NA – Not available, NR – No catch reported.

YEAR	FAROES	GREENLAND
1978	1192	100
1979	1674	50
1980	2775	10
1981	2909	2
1982	2649	2
1983	1685	NR
1984	1926	NR
1985	2596	25
1986	1676	10
1987	1450	NR
1988	1738	NR
1989	1260	NR
1990	917	NR
1991	722	NR
1992	1572	NR
1993	808	100
1994	1201	NR
1995	228	132
1996	1524	67
1997	1162	208
1998	815	365
1999	608	115

In the western Atlantic, pilot whales have been taken as bycatch in several types of fisheries, including squid traps (Lien 1994), pelagic drift gillnets, trawls, purse seines and longlines (Waring *et al.* 1999). Bycatches were highest in the pelagic drift gillnet fishery for swordfish, ranging from 9 to 135 whales per year between 1989 and 1996. However this fishery was closed in 1997. Bycatches in trawl fisheries for squid, mackerel and butterfish were estimated as 45 in 1996 and 0 in 1997. Bycatch of pilot whales in the western Atlantic is not considered to be presently causing stock decline or significantly impeding stock recovery (Nelson and Lien 1997, Waring *et al.* 1999).

Pilot whales prey on some commercially important fish and invertebrate species such as squid, shrimp, mackerel, blue whiting and herring. The availability of these prey might therefore be reduced by commercial fisheries. However, pilot whales feed on a wide variety of prey, and appear to be able to adjust their diet in response to changes in prey abundance (Desportes and Mouritsen 1993). They are therefore less vulnerable to prey depletion than more specialised species.

In addition to their direct toxicity, anthropogenic contaminants may affect the resilience and increase susceptibility to disease in marine mammals (Reijnders and de Ruiter-Dijkman 1995). Pilot whales have concentrations of organic contaminants in their blubber which are roughly in the mid-range of such concentrations in other species of toothed whales in the North Atlantic (Borrell and Aquilar 1993). It is not known if these contaminants are affecting pilot whales in the North Atlantic.

Pilot whales have a tendency to mass-strand throughout their range in the North Atlantic (*e.g.* Sergeant 1982, Bloch *et al.* 1993a, Sigurjónsson *et al.* 1993, Waring *et al.* 1999), however it is not known if human activity influences these occurrences. At present, such strandings must be considered a component of the natural mortality of the species.

### **Status and Outlook:**

Pilot whales are likely one of the most abundant odontocetes in the North Atlantic. The harvesting of pilot whales that continues today in the Faroe Islands has proven sustainable over a period of more than 300 years, and in 1997, NAMMCO concluded that the drive hunt was sustainable (NAMMCO 1998c). The population off Newfoundland is likely recovering after a period of excessive harvesting. In some other areas, bycatch of pilot whales in fisheries continues, but apparently at relatively low and decreasing levels. While there is no indication at present that pilot whales are being affected by contaminants, their occupation of a relatively high trophic level does make them susceptible to this threat.

### **References:**

- Aguilar, A., Jover, L. and Borrell, A. 1993. Heterogeneities in organochlorine profiles of Faroese long-finned pilot whales: indication of segregation between pods? *Rep. int. Whal. Commn.* (special issue 14):359-368.
- Amos, B., Bloch, D., Desportes, G., Majerus, T.M.O., Bancroft, D.R., Barrett, J.A. and Dover, G.A. 1993. A review of molecular evidence relating to social organisation and breeding system in the long-finned pilot whale. *Rep. int. Whal. Commn.* (special issue 14):209-217.
- Andersen, L.W. 1993. Further studies on the population structure of the long-finned pilot whale, *Globicephala melas*, of the Faroe Islands. *Rep. int. Whal. Commn.* (special issue 14):219-231.
- Balbuena, J.A., Aznar, F.J., Fernández, M. and Raga, J.A. 1995. Parasites as indicators of social structure and stock identity of marine mammals. In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds.); *Whales, seals, fish and man*. Elsevier Science B.V., Amsterdam, 133-139.
- Bloch, D. 1994. Pilot whales in the North Atlantic. Age, growth and social structure in Faroese grinds of the long-finned pilot whale, *Globicephala melas*. Doctoral dissertation, Lund University, Sweden.
- Bloch, D. and Lastein, L. 1993. Morphometric segregation and long-finned pilot whale in the eastern and western North Atlantic. *Ophelia* 38:55-68.
- Bloch, D., and Lastein, L. 1995. Modelling the school structure of pilot whales in the Faroe Islands, 1832-1994. In: Blix, A.S., Walløe, L. and Ulltang, U. (eds.). *Whales, seals, fish and man*: 499-508.
- Bloch, D., Desportes, G., Hoydal, K. and Jean, P. 1990. Pilot whaling in the Faroe Islands: July 1986 – July 1988. *North Atlantic Studies* 2:36-44.
- Bloch, D., Desportes, G., Mouritsen, R., Skaaning, S. and Stefansson, E. 1993a. An introduction to studies on the ecology and status of the long-finned pilot whale (*Globicephala melas*) off the Faroe Islands, 1986-1988. *Rep. int. Whal. Commn.* (Special Issue 14): 1-32.
- Bloch, D., Lockyer, C. and Zachariassen, M. 1993b. Age and growth parameters of the long-finned pilot whale off the Faroe Islands. *Rep. int. Whal. Commn.* (Special Issue 14):163-208.
- Borrel, A. and Aguilar, A. 1993. DDT and PCB pollution in blubber and muscle of long-finned pilot whales from the Faroe Islands. *Rep. int. Whal. Commn.* (special issue 14):351-358.
- Buckland, S.T., Bloch, D., Cattanach, K.L., Gunnlaugsson, T., Hoydal, K., Lens, S. and Sigurjónsson, J. 1993. Distribution and abundance of long-finned pilot whales in the North Atlantic, estimated from NASS-1987 and NASS-89 data. *Rep. int. Whal. Commn.* (Special Issue 14): 33-50.
- Caurant, F., Amiard-Triquet, C. and Amiard J.-C. 1993. Factors influencing the accumulation of metals in pilot whales (*Globicephala melas*) off the Faroe Islands. *Rep. Int. Whal. Commn.* (special issue 14):369-390.
- Desportes, G. and R. Mouritsen. 1993. Preliminary results on the diet of long-finned pilot whales off the Faroe Islands. *Rep. int. Whal. Commn.* (special issue 14):305-324.
- Desportes, G., Andersen, L.W., Aspholm, P.E., Bloch, D. and Mouritsen, R. 1992. A note about a

- male-only pilot whale school observed in Faroe Islands. *Fróðskaparrit* 40 (1992): 27-33.
- Desportes, G., Saboureaux, M. and Lacroix, A. 1993. Reproductive maturity and seasonality of male long-finned pilot whales, off the Faroe Islands. *Rep. int. Whal. Commn (special issue 14)*: 233-262.
- Gannon, D.P., Read, A.J., Craddock, J.E., Fristrup, K.M. and Nicolas, J.R. 1997a. Feeding ecology of the long-finned pilot whale in the western North Atlantic. *Mar. Ecol. Progr. Ser.* 148:1-10.
- Gannon, D.P., Read, A.J., Craddock, J.E., and Mead, J.G. 1997b. Stomach contents of long-finned pilot whales (*Globicephala melas*) stranded on the US mid-Atlantic coast. *Mar. Mam. Sci.* 13:405-413.
- Hay, K. 1982. Aerial line-transect estimates of abundance of humpback, fin, and long-finned pilot whales in the Newfoundland-Labrador area. *Rep. int. Whal. Commn* 32:475-486.
- Hoydal, K. and Lastein, L. 1993. Analysis of Faroese catches of pilot whales (1709-1992), in relation to environmental variations. *Rep. int. Whal. Commn.* (special issue 14):89-106.
- [ICES] International Council for the Exploration of the Sea. 1996. Report of the study group on long-finned pilot whales. ICES CM 1996/A6.
- Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979-1990). *Rep. int. Whal. Commn.* (special issue 15):149-157.
- Martin, A.R. and Rothery, P. 1993. Reproductive parameters of female long-finned pilot whales (*Globicephala melas*) around the Faroe Islands. *Rep. int. Whal. Commn* (special issue 14): 263-304.
- Martin, A.R., Donovan, G.P., Leatherwood, S., Hammond, P.S., Ross, G.J.B., Mead, J.G., Reeves, R.R., Hohn, A.A., Lockyer, C.H., Jefferson, T.A. and Webber, M.A. 1990. *Whales and dolphins*. Bedford Editions Ltd., London. 192pp.
- Mercer, M.C. 1975. Modified Leslie-Delury population models of the long-finned pilot whale (*Globicephala melas*) and annual production of short-finned squid (*Illex illecebrosus*) based upon their interaction in Newfoundland. *J. Fish. Res. Bd Can.* 32:1145-54.
- [NAMMCO] North Atlantic Marine Mammal Commission. 1998a. Report of the Scientific Committee Working Group on Abundance Estimates. In: *NAMMCO Annual Report 1997*, NAMMCO, Tromsø, Norway, 173-202.
- [NAMMCO] North Atlantic Marine Mammal Commission. 1998b. Report of the fifth meeting of the Scientific Committee. In: *NAMMCO annual report, 1997*, NAMMCO, Tromsø, Norway, 85-202.
- [NAMMCO] North Atlantic Marine Mammal Commission. 1998c. Report of the Management Committee. In: *NAMMCO annual report, 1997*, NAMMCO, Tromsø, Norway, 63-82.
- Natale, A.D. and Notarbartolo-di-Sciara, G. 1994. A review of the passive fishing nets and trap fisheries in the Mediterranean Sea and of the cetacean bycatch. *Rep. int. Whal. Commn.* (special issue 15):189-202.
- Nelson, D. and Lien, J. 1996. The status of the long-finned pilot whale, *Globicephala melas*, in Canada. *Can. Field Nat.* 110:511-524.
- Notarbartolo-di-Sciara, G. 1990. A note on the cetacean incidental catch in the Italian driftnet swordfish fishery, 1986-1988. *Rep. int. Whal. Commn.* 459-460.
- Payne, P.M. and Heinemann, D.W. 1993. The distribution of pilot whales (*Globicephala spp.*) in shelf/shelf-edge and slope waters of the northeastern United States, 1978-1988. *Rep. int. Whal. Commn.* (special issue 14):51-68.
- Reijnders, P.J.H. and de Ruiter-Dijkman, E.M. 1995. Toxicological and epidemiological significance of pollutants in marine mammals. In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds.); *Whales, seals, fish and man*. Elsevier, Amsterdam, 575-587.



- Sergeant, D.E. 1962. The biology of the pilot or pothead whale *Globicephala melaena* (Traill) in Newfoundland waters. *Bull. Fish. Res. Board Can.* 132:1-84.
- Sigurjónsson, J. and Víkingsson, G.A. 1997. Seasonal abundance of and estimated food consumption by cetaceans in Icelandic and adjacent waters. *J. Northwest Atl. Fish. Sci.* 22:271-287.
- Sigurjónsson, J., Víkingsson, G. and Lockyer, C. 1993. Two mass strandings of pilot whales (*Globicephala melas*) on the coast of Iceland. *Rep. int. Whal. Commn.* (special issue 14):407-423.
- Waring, G.T., Palka, D.L., Clapham, P.J., Swartz, S., Rossman, M.C., Cole, T.V.N., Hansen, L.J., Bisack, K.D., Mullin, K.D., Wells, R.S., Odell, D.K. and Baros N.B. 1999. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 1999. NOAA Technical Memorandum NMFS-NE-153.
- Weihe, P., Grandjean, P., Debes, F., and White, R. 1996. Health implications for Faroe Islanders of heavy metals and PCB's from pilot whales. *The Science of the Total Environment* 186:141-148.
- Zachariassen, P. 1993. Pilot whale catches in the Faroe Islands, 1709-1992. *Rep. int. Whal. Commn.* (special issue 14):69-88.