Kusakabe, T.; Abe, T. 1995. Research on wide area migratory resources and natural resources (sand lances). Osaka Furitsu Suisan Shikenjo Jigyo Hokoku. 1993: 71-74.

"The above research for operation of boat trawling fishery was started jointly with a Hyogo prefecture organization, to make a management model adaptable for sand lances fishery in Osaka Bay and the east area in the Inland Sea, and to collect parameters needed for fishing simulation based on the above model. 'Catch quantity and cost model program,' 'catch quantity calculation result printing program' as a peripheral program and 'past stock biomass estimation model' were prepared in fiscal 1993."

Keywords: *A. personatus*; Japan; catch; fisheries; model.

Kusakabe, T.; Nakajima, M. 1995. Ecological research on sand lance as natural resources. Osaka Furitsu Suisan Shikenjo Jigyo Hokoku. 1993: 109-116.

"To contribute to fishing forecast and to collect knowledge of proper resource management, through clarification and grasp of ecological conditions of sand lance, which was placed as one of important aquatic resources by the Osaka prefectural government, horizontal and vertical distribution survey was conducted at 12 points in the Osaka Bay, for three times during the term from January to February. In 1993, young fish appeared early unusually, in larger quantities compared with the previous year. It was also known that sand lance ranged mainly in water area of 5-10 m in depth."

Keywords: *A. personatus*; Japan; distribution; habitat; fisheries; larvae.

Kusakabe, T.; Nakajima, M. 1996. Sandeel resource ecological research. Osaka Furitsu Suisan Shikenjo Jigyo Hokoku. 1994: 130-134.

Keywords: *A. personatus*; Japan; distribution; habitat; fisheries; larvae.

Laakso, P.; Christie, W.W.; Pettersen, J. 1990. Analysis of North Atlantic and Baltic North Atlantic ocean fish oil triacylglycerols by high-performance liquid chromatography with a silver ion column. Lipids. 25(5): 284-291.

"Triacylglycerols from Atlantic herring (*Clupea harengus*), sandeel (*Ammodytes* sp.) and Baltic herring (*Clupea harengus membras*) have been fractionated by silver ion high-performance liquid chromatography. An ion exchange column loaded with silver ions was the stationary phase, and a gradient in the mobile phase from 1,2—dichloroethane/dichloromethane (1:1, v/v) to acetone and then to acetone/acetonitrile 2:1, v/v) was used to effect the separation with light-scattering (i.e., mass) detection. Fractions were collected via a stream-splitter, and fatty acid methyl esters were prepared by transesterification in the presence of an internal standard for identification and quantification by gas liquid chromatography. Triacylglycerols were separated according to the number of double bonds in the fatty acyl residues. Resolution was excellent at first, when the least unsaturated molecules eluted (trisaturated to dimonoene-monodiene fractions). Base-line resolution could no longer be achieved when molecules containing trienoic or more highly-unsaturated fatty acids began to elute because of overlapping components. Nonetheless, some valuable separations of species containing two saturated and/or monoenoic fatty acids and one polyenoic fatty acid were achieved. Double bond indices (average number of double bonds in each triacylglycerol molecule) were calculated to estimate the separations possible. Fractions containing at least 11-14 double bonds per molecule were obtained."

Keywords: *Ammodytes*; composition; oil; tryglycerol.

Labetskij, A.S. 1981. *Ammodytes hexapterus* in the northern part of the Sea of Okhotsk. Rybnoe Khozyaistvo. 1981(4): 40.

Keywords: *A. hexapterus*; Japan; abundance; density; distrbution; sex ratio.

Ladle, M. 1985. Fish**.** Dorset Natural History and Archaeological Society Proceedings. 107: 197.

Keywords: *A. tobianus*; English Channel; annual variation.

Lagardere, F.; Chaumillon, G. 1988. Effects of delayed initial feeding on the growth of sole, *Solea vulgaris* larvae, and on the incremental pattern of their otoliths. C R Academy of Science III. 306(20): 601-607.

Keywords: *Ammodytes*; larvae; starvation.

Lagler, K.F.; Wright, A.T. 1962. Predation of the Dolly Varden, *Salvelinus malma*, on young salmon *Oncorhynchus* spp., in an estuary of southeastern Alaska. Transactions of the American Fisheries Society. 91: 90-93.

It was found in one southeastern Alaskan estuary that Dolly Varden char fed mostly on capelin, sand lance, and herring.

Keywords: *A. hexapterus*; Alaska; predators (fish, Dolly Varden).

Lahn-Johannessen, J.; Jakupsstovu, S.H.; Thomassen, T. 1978. Changes in the Norwegian mixed fisheries in the North Sea. In: Symposium on North Sea fish stocks–recent changes and their causes; [dates of meeting unknown]; Århus, Denmark. [Place of publication unknown]: [publisher unknown]. 172: 31-38.

“The resources exploited by the Norwegian mixed trawl fisheries in the North Sea, including the Skagerrak, may be divided into 4 categories: deep-water prawn, herring, Norway pout, and sand-eel. This paper describes the development of the mixed fisheries and discusses the main changes in number and size of fishing vessels and in quantities landed, as well as fishing power, fishing effort and catch per unit effort. It further deals with the species composition in industrial landings of Norway pout and shows how new year classes of Norway pout and blue whiting have entered the fishery in recent years.”

Keywords: *Ammodytes*; Norway; annual variation; catch; fisheries.

Lamb, A.; Edgell, P. 1986. Coastal fishes of the Pacific Northwest. [City unknown], BC: Harbour Publishing.

Keywords: *A. hexapterus*.

Lambert, T.C. 1987. Duration and intensity of spawning in herring *Clupea harengus* as related to the age structure of the mature population. Marine Ecology–Progress Series. 39(3): 209-220.

Keywords: *Ammodytes*; spawning.

Langham, N.P.E. 1968. The comparative biology of terns, *Sterna* spp. Durham, [Country unknown]: University of Durham. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (birds).

Langham, N.P.E. 1971a. The distribution and abundance of larval sand-eels (Ammodytidae) in Scottish waters. Journal of the Marine Biological Association of the United Kingdom. 51: 697-707.

Keywords: *A. lanceolatus; A. marinus; Gymnammodytes immaculatus; Gymnammodytes lancea; Gymnammodytes semisquamatus*; Scotland; abundance; distribution; larvae; spawning.

Langham, N.P.E. 1971b. Sandeels. Scottish Fisheries Bulletin. 35: 29-31.

“Sandeels or ‘sile’ are amongst the most abundant fish in the seas around Britain, yet their life history is not very well known. Until the 1950’s, sandeels were looked upon as suitable bait for angling and line fishing, or as a rather obscure continental dish for less conservative palates that the British. Yet, the advent of industrial fishing by various

European countries, notably Denmark, Norway and Germany has dramatically changed the importance of sandeels. In recent years, landings of sandeels, taken mostly by Danish boats over a two to three months season, have exceeded 200,000 tons annually.

“The various species of sandeel have distinctive spawning times, with *Ammodytes marinus* spawning in February and *Gymnammodytes semisquamatus*, the smooth sandeel, in May to July; the inshore species *A. lancea*, has two spawning season, one in spring and one in the autumn; and of the greater sandeels, *A. immaculatus* spawns mainly in May and *A. lanceolatus* in July. It appears that the eggs of all five species are attached to sand grains since they are rarely caught in plankton nets. When the eggs hatch, the young larvae move up into the plankton before their yolk sac is used up. In march, the larvae of *A. marinus* are the dominant fish larvae in the plankton, often with several hundred per cubic metre. The young larvae consitute an important food item for various pelagic species, especially the herring.

“After metamorphosis, the young sandeels assume a diurnal feeding and migration pattern feeding during the daylight and spending the night burrowed into the sea bed, safe from predation. However, in the northern North Sea, during June and July, the period of darkness is very short, so that young sandeels are, on occasion, caught in midwater even at midnight.

“Adult sandeels are an important link in many marine food chains. Most of the important fish caught by Scottish fishermen for human consumption feed on sandeels at some stage of their life history and they often form a major item in their diet.”

Keywords: *A. immaculatus; A. lancea; A. lanceolatus; A. marinus; Gymnammodytes semisquamatus*; Britain; commercial fishery; behavior; illustration; importance; predators (fish, cod, haddock, herring, whiting, saithe, plaice); spawning.

Lapin, Y.E. 1978. Ecology of the White Sea fishes. Nauka; Moskva (USSR). 199: [pages unknown].

“The monograph deals with theoretical and methodological problems of the study of the population structure and dynamics of herring, sand lance, gobies, stickleback and whitefish during ontogenesis. Adaptations of these species to the widely fluctuating hydrological conditions of the White Sea are shown, and the fish producing capacity of this arcto-boreal basin is discussed.”

Keywords: *A. hexapterus*; USSR; White Sea; distribution; ecology.

Larimer, S. 1992. Aspects of the bioenergetics and ecology of sand lance of Georges Bank. [City unknown], Rhode Island: University of Rhode Island. 300 p. Ph.D. dissertation.

“The sand lance, *Ammodytes dubius*, occupies the critical niche of planktivore off the northeast United States. Recent fluctuations of their population size raise the question of what the bioenergetic impact of these changes might be in a highly productive ecosystem like Georges Bank. An energy budget of the adult sand lance was developed to address this question. The individual energy budget was extrapolated to Georges Bank sand lance population levels from 1977 through 1986. Sand lance consumed 0.79 to 19.24% of the production of the major copepod species on Georges Bank during this period. There was a significant inverse relationship between sand lance and copepod population abundances. Sand lance have an ecological efficiency of 20%, considerably higher than the herring and mackerel populations they were thought to replace on Georges Bank.”

Keywords: *A. dubius*; Georges Bank; bioenergetics; ecology.

Larsen, F.; Kapel, F.O. 1983. Further biological studies of the West Greenland minke whale, Brighton, (UK), 19 July 1982. Report of the International Whaling Commission. 33: 329-332.

“Examination of stomach contents confirms that the sand eel (*Ammodytes* sp.) is an important food item for minke whales in the offshore waters of West Greenland.”

Keywords: *Ammodytes*; Greenland; importance; predators (mammals, minke whale).

Larson, K.W.; Moehl, C.E. 1990. Entrainment of anadromous fish by hopper dredge at the mouth of the Columbia River. In: Effects of dredging on anadromous Pacific fishes. Seattle, WA: [publisher unknown]: report Washington Sea Grant; Simenstad, C.A.: 102-112.

“Studies were conducted at the mouth of the Columbia River, USA, to determine the number and types of estuarine organisms entrained by hopper dredging. As part of the study, information was obtained on the number and types of fish species entrained. Fourteen species or species groups of fish were collected during the four study [sic]. Number of individuals entrained were low for all species except Pacific sand lance (*Ammodytes hexapterus*), which were collected in moderate numbers throughout the study. None of the species collected showed any seasonality except Pacific sand lance, which were slightly more abundant in the late summer.

Keywords: *A. hexapterus*; Washington; anthropogenic impacts; dredging.

Last, J.M. 1989. The food of herring *Clupea harengus* in the North Sea 1983-1986. Journal of Fish Biology. 34(4): 489-501.

“The stomach contents of 5762 herring caught during North Sea trawl surveys in February 1983, February 1984 and February, May and August 1986 were analysed. The principal prey organisms were the copepods *Calanus finmarchicus* and *Temora longicaudata*, but Euphausiacea and the post-larval stages of *Ammodytes* spp. and clupeoids contributed a large percentage of the weight. Fish eggs were eaten, chiefly those of plaice, *Pleuronectes platessa*, but not in large numbers.”

Keywords: *Ammodytes*; North Sea; importance; predators (fish, herring).

Laur, D.; Haldorson, L. 1996. Coastal habitat studies: the effect of the *Exxon Valdez* oil spill on shallow subtidal fishes in Prince William Sound. American Fisheries Society Symposium. 18: 659-670.

“The bull kelp community is rare in Prince William Sound, and its fishes were dominated by occasional large schools of pelagic fishes (Pacific herring, Pacific sand lance, young walleye pollock), resulting in extremely high variances in abundance estimates. Other fishes were quite rare.”

Keywords: *A. hexapterus*; Alaska; Prince William Sound; distribution; habitat.

Lawson, J.W.; Stenson, G.B. 1995. Historic variation in the diet of harp seals (*Phoca groenlandica*) in the northwest Atlantic. In: Blix, A.S.; Walloe, L.; Ulltang, O., eds. Whales, seals, fish and man: Proceedings of the international symposium on the biology of marine mammals in the north east Atlantic; 1994 Nov. 29-Dec. 1; Tromsø, Norway. [Place of publication unknown]: [publisher unknown].

Keywords: *A. dubius*; Atlantic (northwest); importance (mammals, harp seal).

Lawson, J.W.; Stenson, G.B. 1997. Diet of northwest Atlantic harp seals (*Phoca groenlandica*) in offshore areas. Journal of Zoology. 75: 2095-2106.

Keywords: *A. dubius*; Atlantic (northwest); importance (mammals, harp seal).

Lear, W.H. 1972. Food and feeding of Atlantic salmon in coastal waters and over oceanic depths. ICNAF Research Bulletin. 9: 27-39.

The main food items were found to be capelin, launce, and herring.

Keywords: *Ammodytes*; Newfoundland; West Greenland; importance; predation (fish, Atlantic salmon).

Lear, W.H. 1980. Food of Atlantic salmon in the West Greenland—Labrador Sea area. Rapports et Procès-Verbaux des Reunions Conseil International pour l’Exploration de la Mer. 176: 55-59.

Launce comprised 50 to 80 percent of the diet of Atlantic salmon sampled during autumn in the West Greenland area.

Keywords: *Ammodytes*; Greenland; predators (fish, Atlantic salmon).

LeBrasseur, R.J. 1959. Marine ecology of Pacific salmon. A: A description of the food. Nanaimo, BC: Fisheries Research Board of Canada, Biology Station.

Keywords: *A. hexapterus*; predators (fish, Pacific salmon).

LeBrasseur, R.J.; Barraclough, W.E.; Kennedy, O.D.; Parsons, T.R. 1969. Production studies in the Strait of Georgia. Part III: Observations on the food of larval and juvenile fish in the Fraser River plume, February to May, 1967. Journal of Experimental Marine Biology and Ecology. 3: 51-61.

Presents information on food of *Ammodytes hexapterus*. Individuals less than 20 millimeters in length, were taking prey of less than 500 micons in diameter (copepod eggs and nauplii), and fish greater than 40 millimeters were feeding mainly on zooplankton between 500 and 1000 microns. Some indication is given that the concentration of small zooplankton species may restrict the survival of larval fish.

Keywords: A*. hexapterus*; food and feeding habits.

Lehnhausen, W.A. 1980. Nesting habitat relationships of four species of alcids at Fish Island, Alaska. Fairbanks, AK: University of Alaska. M.S. thesis.

Keywords: *A. hexapterus*; Alaska; predators (birds).

Lehtonen, L. 1970. Biology of the black-throated diver G*avia arctica*. Annales Zoologica Fennica. 7: 25-60. English summary.

Keywords: *Ammodytes*; predators (birds, black-throated diver).

Leim, A.H.; Scott, W.B. 1966. Fishes of the Atlantic Coast of Canada. Bull. 155. [Place of publication unknown]: Fisheries Research Board of Canada.

“American sand lance *Ammodytes americanus* DeKay 1842. Other common names: sand launce, sand eel, lance, lant, equille. Northern sand lance *Ammodytes dubius* Reinhardt 1838. Other common names: Greenland launce, arctic sand lance. Report contains descriptions of these two species. American sand lance are eaten by many fishes, but cod, haddock, and hake feed on them so extensively that their indirect value to the commercial fisheries is considerable. Over half of the food of haddock on the Sable Island Bank consists of sand lance. They are also an important food for some whales and porpoises. The northern sand lance has only been found in depths up to 17 fathoms, but within these limits where both occur in the salme locality, it tends to be farther offshore than the American sand lance, suggesting a preference for colder water.”

Keywords: *A. americanus*; *A. dubius*; description; predators (fish, cod, haddock, hake, mammals).

Leopold, M.F.; Grunsky, B.; Huppop, O. [and others]. 1995. How large an area of sea do Helgoländ seabirds use for foraging during the breeding season? Helgoländer Meeresuntersuchungen. 49(1-4): 603-604.

Keywords: *Ammodytes*; Germany; predators (birds).

Leopold, M.F.; Wolf, P.A.; Huppop, O. 1992. Food of young and colony attendance of adult guillemots *Uria aalge* on Helgoländ. Helgoländer Meeresuntersuchungen. 46(2): 237-249.

“The guillemot colony on Helgoland, Germany, was visited from June 5th to 21st 1990. The presence of adults and food delivery to chicks was studied on a ledge holding abut 50 breeding pairs. Attendance varied through the day with most birds present at mid-day. Food consisted only of fish, 94.6% Clupeidae (herring and sprat) and 5.4% sand-eel. On average, a chick received 2.72 fish per day. After a marked early morning peak of feeding, the number of feeds per hour levelled off to a constant rate during the rest of the day until dusk. At sea, high numbers of guillemots were present in front of the colony, with densities dropping steeply with stance. The birds are thought to forage at distances of more than 5 km away from the colony.”

Keywords: *Ammodytes*; Germany; predators (birds, guillemot).

LeSauvage, M. 1824. Note sur une espèce nouvelle du genre Ammodytidae. Bulletin de la Societe Scientifique. Philomathique de Paris. 1824: 140-141.

Keywords: Ammodytidae; taxonomy.

Leschner, L.L. 1976. The breeding biology of the rhinoceros auklet on Destruction Island. Seattle, WA: University of Washington. M.S. thesis.

Keywords: *A. hexapterus*; predators (birds, rhinoceros auklet).

Leschner, L.L.; Burrell, G. 1977. Populations and ecology of marine birds on the Semidi Islands. In: Environmental assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators 4. Boulder, CO: National Oceanic and Atmospheric Administration, Environmental Research Laboratory: 13-109.

Keywords: *A. hexapterus*; Alaska; Semidi Islands; predators (birds).

Levasseur, M.E. 1990. Phytoplankton dynamics and the distribution of fish larvae and their nutritional resources across an estuarine plume front. [City unknown], BC: University of British Columbia. 270 p. Ph.D. dissertation. Available from: Dissertation Abstracts Int. B Sci. Eng. 52(10): 5122. 1992. Order no. DANN63982. FR 37(3) .

Keywords: *A. hexapterus*; distribution; estuaries; larvae; recruitment.

Levasseur, M.E.; Michaud, S.; Bonneau, E. [and others]. 1996. Overview of the August 1996 red tide event in the St. Lawrence: effects of a storm surge. In: 5th Canadian workshop on harmful marine algae: [dates of meeting unknown]; St. John’s, NF. Tech. Rep. 76. [Place of publication unknown]: [publisher unknown].

Keywords: *A. hexapterus*; Gulf of Saint Lawrence; mortality; predators (birds, herring gull); poisoning; red tide; toxins.

Licciardello, J.J.; Ravesi, E.M.; Allsup, M.G. 1985. Keeping quality of fresh and frozen sand lance, *Ammodytes* sp. Marine Fisheries Review. 47(1): 78-82.

“In 1978, the New England Fishery Development Program sponsored a study to determine the feasibility of catching sand lance off southern New England (Stellwagen Bank) and the results were reported by Smith and Testaverde. The NMFS Northeast Fisheries Center’s Gloucester Laboratory participated in that study by comparing methods of holding the sand lance on board the fishing vessel, and also by determining the species’ fresh and frozen storage characteristics with regard to its potential as a human food. This paper reports the results of that investigation.”

Keywords: *Ammodytes*; New England; fisheries.

Lid, G. 1981. Reproduction of the puffin on Rost in the Lofoten Islands in 1964-1980. Fauna norv. Ser. C, Cinclus. 4: 30-39.

“The high chick mortality has been caused by food shortage but the reason why the adult Puffins cannot find food for the chicks has not been established. It is suggested that it may be due to man’s over-fishing of Herring and Sandeels.”

Keywords: *Ammodytes*; importance; predators (birds, puffin).

Lidster, W.W.; Lilly, G.R.; Dawe, E.G. 1994. Otoliths of Arctic cod (*Boreogadus saida*), small Atlantic cod (*Gadus morhua*), and three other fish species from Newfoundland waters: description and relationship of body length to otolith length. Journal of Northwest Atlantic Fishery Science. 16: 33-40.

Descriptions are also provided for otoliths of northern sand lance, Atlantic herring, and capelin, three other locally and seasonally abundant fish species at Newfoundland. Regressions of body length on otolith length are presented for each of these fish species to aid in the estimation of the sizes of prey consumed by major fish predators, such as short-finned squid, in coastal Newfoundland waters.

Keywords: *A. dubius*; Newfoundland; age; morphology; otoliths.

Lie, K. 1979. Fish catches in 1978 for reduction to fishmeal and oil. Meld. SSF. 2: 17-21.

“The article gives an account of the industrial fish catches in Norway in 1978. 1.8 mill. tons of pelagic fish were landed for reduction to fishmeal and oil. This is 30% less than the catch record from 1977, and is due both to increasing regulations both national and international, and to a sharp drop in the capelin stock. Even so, capelin represents 74% of the landings, the rest are Norway pout, blue whiting, sandeel, sprat and mackerel, 250 purse seiners and 150 trawlers participated in the different fisheries, and 47 fishmeal factories produced 318,000 tons of fishmeal and 156,000 tons of fishoil.”

Keywords: *Ammodytes*; Norway; catch; fisheries.

Lie, K. 1980. Fish catches in 1979 for reduction to fishmeal and oil. Meld. SSF. 1: 8-12.

“The article gives an account of the industrial fish catches in Norway 1979. 1.85 mill tons of pelagic fish were landed for reduction to fishmeal and oil. This is a slight increase compared with last year’s catch. Capelin represents 67% of the landings, the rest are Norway pout, blue whiting, sandeel, sprat and mackerel. 250 purse seiners and 140 trawlers participated in the different fisheries, and 44 fishmeal factories produced 322,000 tons of fishmeal and 185,000 tons of fishoil.”

Keywords: *Ammodytes*; Norway; catch; fisheries.

Lilly, G.R. 1982. Influence of the Labrador current on predation by cod on capelin and sand lance off eastern Newfoundland. Northwest Atlantic Fisheries Organization Scientific Council Studies. 3: 77-82.

“Catches of Atlantic cod, *Gadus morhua*, capelin, and sand lance, during bottom-trawl research surveys of eastern Grand Bank were examined with respect to depth and temperature. Capelin and sand lance appeared to be associated with the cold core (<0 °C) of the Labrador Current, whereas cod were most abundant in the underlying warmer, more saline water. It is postulated that cod can prey on sand lance throughout the year by migrating into the cold water. A similar vertical stratification of cod and capelin appears to exist on the northern slope of Grand Bank, particularly in winter, and along the coastal shelves of northeastern Newfoundland and southern Larador in summer and autumn. The apparent association of capelin and sand lance with the Labrador Current has implications for the seasonal feeding behavior and growth of cod and other piscivores in the region.”

In 1968, stomachs were collected from 52 cod caught at 148, 185, and 223 meters. Although no sand lance were retained by the trawl at these depths, they were the major prey of cod, occurring in 27 percent of the stomachs and constituting 64 percent of the total stomach contents by weight. Furthermore, 32 percent of the food was unidentified fish, and much of this may have been sand lance, as no other fish was identified in the stomach contents.

Keywords: *A. dubius*; Newfoundland; distribution; importance; predators (fish, Atlantic cod).

Lilly, G.R.; Fleming, A.M. 1981. Size relationships in predation by Atlantic cod, *Gadus morhua*, on capelin, *Mallotus villosus*, and sand lance, *Ammodytes dubius*, in the Newfoundland area. Northwest Atlantic Fisheries Organization Scientific Council Studies. 1: 41-45.

"The minimum length of cod which can prey on adult capelin and sand lance is about 35 cm, but cod as small as 20 cm in length can prey on juveniles of both species. The length range of cod which prey intensively on adult capelin and sand lance is approximately 40-70 cm, the upper limit being imprecise. Intensity of predation is highly variable."

Keywords: *A. dubius*; predators (fish, Atlantic cod).

Lin, J. 1994. On the ecological character and resources of the capelin, myctophids and sand launces. Marine Science (Qingdao): 23-25.

Keywords: *A. personatus*; distribution; ecology.

Lindberg, G.U. 1937. On the classification and distribution of sandlances genus *Ammodytes* (Pisces). Bulletin of the Far East Branch Academy of Sciences USSR. 27: 85-93. In Russian, with English translation.

Keywords: *Ammodytes*; distribution; taxonomy.

Lindroth, A. 1962. Baltic salmon fluctuations. 2: Porpoise and salmon. Report of the Institute of the Freshwater Research at Drottingham. 44: 105-112.

Keywords: *Ammodytes*; predators (mammals, harbor porpoise).

Lindsay, S.T.; Thompson, H. 1932. Biology of the salmon (*Salmo sala*r L.) taken in Newfoundland waters in 1931. Report of the Newfoundland Fisheries Research Committee. 1(2): 1-80.

Keywords: *Ammodytes*; Newfoundland; predators (fish, Atlantic salmon).

Lindsey, C.C. 1975. Pleomerism the widespread tendency among related fish species for vertebral number to be correlated with maximum body length. Journal of the Fisheries Research Board of Canada. 32(12): 2453-2469.

Keywords: *Ammodytes*; meristics; taxonomy.

Linnaei, C. 1758. Systema naturae. I. 123. *Ammodytes*: 10: 247-248.

Keywords: *Ammodytes*; taxonomy.

Litvinenko, N.M.; Shibaev, Y.V. 1987. The ancient murrelet—*Synthliboramphus antiquus* (Gm.): reproductive biology and raising of young. In: Litvinenko, N.M., ed. Rasprostranenie i biologiya morskikh ptits Dal'nego Vostoka: Distribution and biology of seabirds of the Far East. Vladivostok, USSR: Far Eastern Science Centre of the USSR Academy of Sciences: 72-84.

Keywords: *Ammodytes*; predators (birds, ancient murrelet).

Livingston, P., ed. 1991. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1984 to 1986. (Alaska Fisheries Science Center.) NTIS PB92-104710.

Keywords: *Ammodytes*; Bering Sea; predators (fish).

Lloyd, C.S. 1976. The breeding biology and survival of the razorbill *Alca torda* L. Oxford, England: Oxford University. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (birds, razorbill).

Lloyd, C.S. 1979. Factors affecting breeding of razorbills *Alca torda* on Skokholm. Ibis. 12(2): 165-176.

“The small amount of information available on the razorbills’ main food species *Ammodytes* (Cameron 1959) suggests that the start of laying on Skokholm coincided with an increase in the abundance of both larvae and adults in the surface waters of the south Irish Sea.”

Keywords: *Ammodytes*; Irish Sea; importance; predators (birds, razorbill).

Lloyd, D.S. 1985. Breeding performance of kittiwakes and murres in relation to oceanographic and meteorologic conditions across the shelf of the southeastern Bering sea. Fairbanks, AK: University of Alaska. M.S. thesis.

Keywords: *A. hexapterus*; Bering Sea; predators (birds).

Lock, A.R. 1973. A study of the breeding biology of two species of gulls nesting on Sable Island, Nova Scotia. Halifax, NS: Dalhousie University. Ph.D. dissertation.

Keywords: *Ammodytes*; Nova Scotia; predators (birds).

Lock A.R. 1986. Changes In distributions of black-legged kittiwakes and Arctic terns which reflect recent increases in the abundance of *Ammodytes* sp. in the western North Atlantic Ocean. Pacific Seabird Group Bulletin. 13(2): 106.

“Shortly before 1970, notable increases in the abundance of *Ammodytes* sp occurred in Europe and in North America. Contemporaneous changes in distributions of black-legged kittiwakes and Arctic terns in North America are attributed to this change in food abundance. Kittiwakes were first found breeding in Nova Scotia, south of their traditional breeding range; in 1971 and since that time the number of kittiwake colonies has increased to five, and the number of breeding pairs has increased at a mean rate of 16 percent per annum. At the same time, immature Arctic terns, which usually summer south of the breeding range, began appearing at colonies in increasing numbers. These immatures, which had previously made up less than 1 percent of birds at colonies, now often constitute one-third of the birds present.”

Keywords: *Ammodytes*; Atlantic (north); abundance; predators (birds, arctic tern, black-legged kittiwake).

Lock, A.R. 1987. Recent increases in the breeding population of black-legged kittiwakes, *Rissa tridactyla*, in Nova Scotia. Canadian Field-Naturalist. 101(3): 331-334.

“Black-legged kittiwakes (*Rissa tridactyla*) began breeding in Nova Scotia around 1970. Since that time they have increased at a mean rate of 16% per annum to a 1983 population of 570 pairs. Their increase in Nova Scotia is related to a contemporaneous increase in the abundance of the sandlance (*Ammodytes* sp.).”

Keywords: *Ammodytes*; Nova Scotia; predators (birds, black-legged kittiwake).

Locke, A.; Courtenay, S.C. 1995. Effects of environmental factors on ichthyoplankton communities in the Miramichi Estuary, Gulf of St. Lawrence. Journal of Plankton Research. 17(2): 333-349.

“Ichthyoplankton in 20 taxa (17 identified to species, three to genus) representing 14 families were collected in 10 surveys of the Miramichi estuary between May and September 1992. The taxonomic composition was typical of other estuaries in the Gulf of St Lawrence and Gulf of Maine. The species composition of the lower estuary (Miramichi Bay) was dominated by typically marine forms and probably serves as a nursery ground for winter flounder (*Pleuronectes americanus*), smooth flounder (*Pleuronectes putnami*), sculpin (*Myoxocephalus* sp.) and sand lance (*Ammodytes* sp). Of the environmental factors investigated, salinity was the most useful predictor of larval distribution in the estuary.”

Keywords: *Ammodytes*; Gulf of Saint Lawrence; abundance; larvae; salinity; temperature.

Lockley, R.M. 1934. On the breeding habits of the puffin: with special reference to the incubation and fledging period. British Birds. 27: 214-223.

“In the first weeks it is fed with small sand-eels and the minute freshly-hatched fry of fishes (including at least that of herring and pollock) which swarm close inshore in June and July.”

Keywords: *Ammodytes*; predators (birds, puffin).

Loder, J.W.; Ross, C.K.; Smith, P.C. 1988. A space-scale and time-scale characterization of circulation and mixing over submarine banks, with application to the northwestern Atlantic continental-shelf. Canadian Journal of Fisheries and Aquatic Sciences. 45(11): 1860-1885.

Keywords: *Ammodytes*; Atlantic (northwest); fisheries.

Loh-Lee, Low, ed. 1991. Status of living marine resources off Alaska as assessed in 1991. [Place of publication unknown]: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; Tech. Memo.; contract F/NWC-211. [pages unknown].

Keywords: *A. hexapterus*; Alaska.

Longbottom, M.R. 1968. Biological observations associated with the toxic phytoplankton bloom off the east coast. Nature. 220(5162): 24-25.

Keywords: *A. marinus*; mortality; plankton bloom; toxicity.

Lonnberg, E. 1896. Linnaen type-specimens of birds, reptiles, batrachians and fishes in the zoological museum of the R. University in Upsala: list of reptiles, batrachians and fishes. No. 54. *Ammodytes tobianus* Bihang till K. Svenska Vet.-Akad. Handl. 22(4): 41.

Keywords: *A. tobianus*; description.

Lonning, S.; Kjorsvik, E.; Falkpetersen, I.B. 1988. A comparative-study of pelagic and demersal eggs from common marine fishes in northern Norway. Sarsia. 73(1): 49-60.

Keywords: *Ammodytes*; Norway; eggs.

Loughlin, T.R.; Livingston, P.A. 1986. Summary of joint research on the diets of northern fur seals and fish in the Bering Sea during 1985. [Place of publication unknown]: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Proc. Rep.; contract 86-19. 92 p.

Keywords: *A. hexapterus*; Bering Sea; predators (fish; mammals, northern fur seal).

Love, R.M. 1970. The chemical biology of fishes. London: Academic Press.

Keywords: *Ammodytes*; composition.

Love, R.M. 1991. Probably more than you want to know about the fishes of the Pacific coast. Santa Barbara, CA: Really Big Press.

The following are noted as feeding on sand lance: Pacific cod, black rockfish, yelloweye rockfish, Atka mackerel, and Pacific halibut.

Love’s account of the Pacific sand lance: “A very wide ranging, schooling species, this sand lance inhabits waters from the Sea of Japan to the Bering Sea and southward to Balboa, southern California. They are common from Tomales Bay, northern California, northwards. Pacific sand lances have been reported from the intertidal zone to

depths of at least 330 feet and probably down to 908 feet. While primarily a marine species, they are also found near freshwater inputs. Most live in waters less than 300 feet deep, over sand or sand-gravel bottoms. These fish spend much of their time burrowed in the substrate; underwater observations imply that this species buries itself throughout the night. While they are commonly encountered in spring and summer they seem to disappear in fall and winter; probably, the little dears are dug in during this time of cold water.

“How big do they get? Oh, about 10.5 inches. And they live to at least 8 years. Based on studies off Japan, this species matures at 1-3 years and at lengths greater than 5 inches. Female Pacific sand lances are oviparous and probably spawn once per year. Sand lance spawning season may be variable and depend on location, ranging from as early as October to as late as May, perhaps peaking from January to March. Around Kodiak Island, Alaska, sand lances spawn on October high tides in the intertidal zone. Sand lance eggs are adhesive, sticking to the bottom, and take about 3-4 weeks to hatch. Larvae are generally found in shallow surface waters (less than about 90 feet), descending at night into slightly deeper waters (to about 260 feet). In a study off Auke Bay, Alaska, sandlance larvae were most abundant just before the spring phytoplankton bloom. Larvae metamorphose into juveniles in anywhere from 100 to 131 days. Juveniles are often found with adults, particularly in shallow waters; they may also school with other fishes, such as Pacific herring. Zooplankton are always on the menu for both juveniles and adults, particularly calanoid copepods, but also including such items as mysid shrimps, crustacean larvae, gammarid amphipods and chaetognaths. Everyone and their dog eats this species; they are chewed by just about everthing that swims or flies in the vicinity. Much of the predation occurs in the late afternoon, when the fish begin to seek out sediment for their evening slumber. Among the eager eaters are various fishes (such as Pacific cod, Pacific halibut, Pacific whiting, various soles, rockfishes, salmons), seabirds (pigeon guillemots, puffins, auklets, murres, kittiwakes, cormorants) and marine mammals (fur seals, harbor seals, Steller sea lions, spotted seals, minke whales, sei whales, humpback whales).

“FISHERY: There is no recreational fishery for these skinnies, though rumor has it that they are yummy. And, except for a small bait fishery in Washington and British Columbia, there is no commercial fishery either, at least on this side of the Pacific. The Japanese fishery takes about 100,000 tons per year, using a variety of nets.”

Keywords: *A. hexapterus*; behavior; commercial fishery; distribution; habitat; predators (fish; birds; mammals).

Lowry, L.F. Frost, K.J. 1981. Feeding and trophic relationships of phocid seals and walruses in the eastern Bering Sea. In: Hood, D.W.; Calder, J.A., eds. The eastern Bering Sea shelf: oceanography and resources, National Oceanic and Atmospheric Administration, Office of Marine Pollution Assessment. 2: 813-824. [Distributed by University of Washington Press, Seattle].

Keywords: *A. hexapterus*; Bering Sea; predators (mammals).

Lowry, L.F.; Frost, K.J.; Burns, J.J. 1981. Trophic relationships among ice-inhabiting phocid seals and functionally related marine mammals in the Chukchi Sea. [Place of publication unknown]: National Oceanic and Atmospheric Administration; Bureau of Land Management; Environment Assessment of the Alaskan Continental Shelf, Biological Studies; final report, Vol. II. [pages unknown].

Keywords: *A. hexapterus*; Chukchi Sea; predators (mammals, bearded seal, ringed seal).

Lowry, L.F.; Frost, K.J.; Burns, J.J. 1986. Assessment of marine mammal-fishery interactions in the western Gulf of Alaska and Bering Sea: consumption of commercially important fishes by Bering Sea pinnipeds. Juneau, AK: Alaska Department of Fish and Game; National Oceanic and Atmospheric Administration, National Marine Fisheries Service; final report; contract NA-85-ABH-00029. 26 p.

Keywords: *A. hexapterus*; Bering Sea; predators (mammals).

Lowry, L.F.; Frost, K.J.; Galkins, D.G. [and others]. 1982. Feeding habits, food requirements, and status of Bering Sea marine mammals. Doc. 19. Anchorage, AK: North Pacific Fishery Management Council.

Keywords: *A. hexapterus*; Bering Sea; predators (mammals, bearded seal, belukha whale, Dall's porpoise, harbor seal, humpback whale, minke whale, northern fur seal, ribbon seal, ringed seal, spotted seal, Steller sea lion).

Lucas, M.C.; Johnstone, A.D.F. 1990. Observations on the retention of intragastric transmitters, and their effects on food consumption, in cod, *Gadus morhua* L. Journal of Fish Biology. 37(4): 647-649.

"A group of 20 tank-adapted cod (*Gadus morhua*) maintained on a diet of sandeels were starved for 3 days and randomly divided into equal numbers of control and experimental fish. A dummy transmitter of the size used in many acoustic tracking studies (length, 56 mm; diameter, 16 mm; weight in water, 5 g) was inserted via the oesophagus into the stomach of each experimental fish. Fish were first fed at 09.00 hours, 2 days after tagging, and subsequently every other weekday. The experiment was ended when only one fish retained its transmitter. This period was 35 days, the approximate life for acoustic transmitters of the size described. The presence of transmitters did not appear to affect food intake."

Keywords: *Ammodytes*; predators (fish, cod).

Luhmann, M. 1957. Über jahreszeitliche Veranderungen des Fettgehaltes und des Gehaltes an Trockensubstanz und Asche bei Sandspierlingen *Ammodytes* sp. Archiv für Fischereiwissenschaft. 8(3): 198-203.

Keywords: *Ammodytes*.

Luhmann, M. 1965. Über Sandspierlinge und Sandspierlings–Fischerei in der sudlichen Nordsee. Archiv für Fishchereiwissenschaft. 16(2): 182-197.

Keywords: *Ammodytes*; composition; fat; fisheries; spawning.

Lumsden, W.H.R.; Haddow, A.J. 1946. The food of the shag *(Phalacrocorax aristotelis*) in the Clyde Sea area. Journal of Animal Ecology. 15: 35-42.

Keywords: *Ammodytes*; importance; predators (birds, shag).

Lyndon, A.R.; Houlihan, D.F.; Hall, S.J. 1992. The effect of short-term fasting and a single meal on protein synthesis and oxygen consumption in cod *Gadus morhua*. Journal of Comparative Physiology [B]. 162(3): 209-215.

"Rates of protein synthesis and oxygen consumption (.ovrhdot.MO2) in cod were compared in both fasted and refed animals. During a 14-day fast both protein synthesis and respiration rates fell to stable values after 6 days. When a meal of whole sandeel at 6% body weight was fed to fish fasted for 6 days, protein synthesis and .ovrhdot.MO2 increased to a maximum at between 12 and 18 h after feeding. Peak .ovrhdot.MO2 was about twice the pre-feeding values, while whole animal protein synthesis increased four-fold. There were differences between tissues in the timing of maximum protein synthesis; the liver and stomach responded faster than the remainder of the body. Maximum protein synthesis rates in the liver and stomach occurred at 6 h after feeding, at which time their calculated contribution to total .ovrhdot.MO2 was 11%. Similar calculations suggested that the integrated increment in whole animal protein synthesis contributed between 23% and 44% of the post-prandial increase in .ovrhdot.MO2. It was concluded that protein synthesis is an important contributor to increased .ovrhdot.MO2 after feeding in cod."

Keywords: *Ammodytes*; predators (fish, cod).

Macaulay, M.C.; Wishner, K.F.; Daly, K.L. 1995. Acoustic scattering from zooplankton and micronekton in relation to a whale feeding site near Georges Bank and Cape Cod. Continental Shelf Research. 15(4/5): 509-537.

“Euphausiids (predominantly *Meganyctiphanes* sp.) were found in a layer above the bottom, and a mid-water layer may have been due to sand lance (*Ammodytes americanus*).”

Keywords: *A. americanus*; Atlantic (northwest); distribution; hydroacoustics.

MacDonald, K.B. 1979. Environmental assessment of the Alaskan Continental shelf, Kodiak interim synthesis report. Boulder, CO: Science Applications, Inc. 215 p.

Keywords: *A. hexapterus*; Alaska.

MacDonald, P.R.N.; Austin-Smith, P.J. 1989. Bald eagle, *Haliaeetus leucocephalus*, nest distribution on Cape Breton Island, Nova Scotia. Canadian Field-Naturalist. 103 (2): 293-296.

Keywords: *Ammodytes*; Nova Scotia; predators (birds, bald eagle).

Macer, C.T. 1965. The distribution of larval sandeels (Ammodytidae) in the southern North Sea. Journal of the Marine Biological Association of the United Kingdom. 45: 187-207.

“The distributions of four species of larval Ammodytidae in the Southern North Sea are described. Two separate broods of *Ammodytes lancea* larvae were found, in spring and autumn. The spring larvae occurred in the areas of the Thames and Wash, and autumn type mainly off the French and Dutch coasts. A description of these larvae is given. Larvae of *Gymnammodytes semisquamatus* were found in the Southern Bight area and in several areas off the Humber. Few larvae of *Ammodytes lanceolatus* were taken: they occurred in the Southern Bight and Downsing areas. *A. marinus* larvae were found in two areas off the Humber and in the Southern Bight. There is evidence for a spawning area some distance to the west of the Dover Strait.

“A brief review of previous identifications is given and the larval distributions are discussed in relation to those of the adults.”

Keywords: *A. lancea; A. lanceolatus; A. marinus; Gymnammodytes semisquamatus*; North Sea; description; distribution; larvae.

Macer, C.T. 1966. Sand eels (Ammodytidae) in the south-western North Sea; their biology and fishery. Fishery Investigations, Ministry of Agriculture, Food and Fisheries (Great Britain) Series 2. 24(6): 1-55.

“Five species of sand eels have been recorded from the North Sea—*Ammodytes marinus* Raitt, *A. lanceolatus* Lesauvage, *Gymnammodytes semisquamatus* Jourdain, *A. lancea* Cuvier and *A. immaculatus* Corbin. The first three species are common offshore and, in the area investigated, they were concentrated on the south-western edge of the Dogger Bank and, except for *G. semisquamatus*, on the tops of the Norfolk Banks. *A. marinus* comprised 94.5% of all sand eels caught and it is on the large concentrations of this species that the fishery depends.

“On the Dogger Bank growth rate of sand eels is higher than on the Norfolk Banks and Dowsing areas. Marked variations in annual growth and year-class strength were found to occur, expecially in *A. marinus*. The fish are short-lived, the oldest found being IX group, *A. marinus*; VIII-group, *A. lanceolatus*; and VII-group, *G. semisquamatus*.

“Data on maturity confirm previous findings that *A. marinus* is a winter spawner, and *A. lanceolatus* and *G. semi-squamatus* summer spawners. First maturity is reached at one or two years of age, depending on the species. Spawning areas of all three species were found in the Southern Bight and Downsing areas. A feature of sex ratio analyses was the preponderance of males, at spawning time only, in *A. marinus*. Fecundity estimates were made for the latter species only and number of eggs was found to be proportional to a power (3.055) of the length of the fish. Egg measurements showed that *A. marinus* has a short spawning period, and *A. lanceolatus* and *G. semisquamatus* prolonged ones.

“Stomach content analyses show that *A. marinus, A. lancea* and *G. semisquamatus* are plankton feeders (taking chiefly copepods), whilst *A. lanceolatus* and probably *A. immaculatus* are, except for the juveniles, predators on other fish, often sand eels, though not their own species.

“The industrial fishery for sand eels started in 1953. Denmark, Germany, Norway and the Netherlands have taken part and they fish along their own coasts and also in the south-west Dogger area.

“Annual landings have been about 100,000 tons or more, though in 1962 and 1963, sharp increases led to a figure of 183,863 tons. Over 80% of the total is usually taken by Denmark. The fishery is seasonal (March-August). The fish cannot be caught at night in a bottom trawl. Mortality estimates indicate a value of between 70 and 80% annually. The possible effects of the fishery on stocks of sand eels and other fish are discussed.”

Keywords: *A. immaculatus; A. lancea; A. lanceolatus; A. marinus; G. semisquamatus*; North Sea; abundance; age and growth; commercial fisheries; distribution; food and feeding habits; life history; predators (fish); sex ratio; spawning; weight/length relationship.

Macer, C.T. 1967. Ammodytidae. International Council for the Exploration of the Sea, Fiches d’identification des œufs et larves de poissons (Rèdige par J.H. Fraser et V. Kr. Hansen) No. 2.

Keywords: Ammodytidae; larvae; taxonomy.

Macer, C.T. 1969. Variation in catch-rates in the fishery for sandeels (Ammodytidae) in the North Sea. C.M. 1969, International Council for the Exploration of the Sea Demersal Fish (Northern) Committee, Document.

Keywords: *Ammodytes*; North Sea; fisheries.

Macer, C.T. 1970. The fishery for sand eels off the English east coast in 1970. Annales Biologiques. 27: 189-190.

Keywords: *A. marinus*; North Sea; fisheries.

Macer, C.T. 1973. The fishery for sand eels off the English east coast in 1971. Annales Biologiques. 28(1971): 210-211.

Keywords: *A. marinus*; North Sea; fisheries.

Macer, C.T. 1974. The fishery for sand eels off the English east coast in 1972. Annales Biologiques. 29(1972): 176.

Keywords: *A. marinus*; North Sea; fisheries.

Macer, C.T.; Boon, T.W. 1969. The fishery for sandeels off the English east coast in 1969. Annlales Biologiques. 26: 265-267.

Keywords: *A. marinus*; North Sea; fisheries.

Macer, C.T.; Burd, A.C. 1970. Fishing for sandeels. Lab. Leaf. 21. [Place of publication unknown]: Fisheries Laboratory Lowestof. 9 p.

Keywords: *Ammodytes*; fisheries.

MacKenzie, B.R.; Leggett, W.C.; Peters, R.H. 1990. Estimating larval fish ingestion rates: Can laboratory derived values be reliably extrapolated to the wild? Marine Ecology Progress Series. 67(3): 209-225.

“Larval dry weight, temperature and food density explained 85% of the variance in laboratory derived ingestion rates of 11 species. After removing the effects of larval size and water temperature on ingestion rates, larval functional response was steepest at food densities < 185 g/l; beyond this level, ingestion rates were independent of food density. A comparison of the lab functional response with natural mivroplankton densities shows that (2) larvae are

unlikely to feed at maximal rates in the sea; (2) larvae feeding rates are most sensitive to changes in food abundance across the range of food densities that are most likely to occur in nature. However, in situ ingestion rates estimates for 8 species of marine fish larvae indicate that these larvae fed at rates independent of the food density and near-maximally, despite relatively low food densities. We conclude that this difference between in situ and laboratory estimates of ingestion rates as a function of prey density result primarily from the failure of most integrated census estimates of prey density to adequately represent the real contact rate of larvae with their prey and the failure of most lab expt designs to incorporate relivant variables known to influence prey encounter rates and selection."

Keywords: *Ammodytes*; food; ingestion; larvae.

Maclean, S.A.; Morrison, C.M.; Murchelano, R.A. [and others]. 1987. Cysts of unknown etiology in marine fishes of the northwest Atlantic and Gulf of Mexico. Canadian Journal of Zoology. 65(2): 29-303.

"CUEs were found also in gills and viscera of winter flounder, Atlantic croaker, spot, windowpane flounder, and sand lance. CUEs measured 15-400 µm in diameter and consisted of an external fibrous cuticle, usually a thick median band, and a central core that frequently contained eosinophilic vesicles. Structures resembling mitochondria were found in the band and in vesicles of the core, but no other organelles were apparent. Cytochemical staining and ultramicroscopy revealed aggregates of glycogen in the core ground substance; no structural components were stained with Sudan black B or by the Feulgen technique. Extensive encapsulation of CUEs by fibroblasts was typical."

Keywords: *Ammodytes*; disease.

Macy, P.T.; Wall, J.M.; Lampsakis, N.D.; Mason, J.E. 1978. Resources of non-salmonid pelagic fishes of the Gulf of Alaska and eastern Bering Sea. [Place of publication unknown]: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Outer Continental Shelf Environmental Assessment Program; final report; task A-7; parts I and II. 714 p.

Keywords: *A. hexapterus*; Alaska; Bering Sea; Gulf of Alaska; abundance; distribution; life history; literature review.

Mahon, T.E.; Kaiser, G.W.; Burger, A.E. 1992. The role of marbled murrelets in mixed-species feeding flocks in British Columbia. Wilson Bulletin. 104: 738-743.

"Between 6 June and 8 August 1991, we conducted 27 surveys along a 72.4 km transect route to determine the composition and density of mixed feeding flocks. Marbled Murrelets feeding singly or in small groups (<5) initiated the flocks by driving a school of sand lances (*Ammodytes hexapterus*) to the surface where they thrashed briefly in a tightly packed "boil." This attracted one or two Glaucous-winged Gulls to the site, and if the sand lances kept resurfacing more gulls quickly arrived. Diving by murrelets appeared to keep the school of fish near the surface and accessible to gulls. First-year sand lances (6-10 cm) were the only prey identified in feeding flocks."

Keywords: *A. hexapterus*; British Columbia; predators (birds, glaucous-winged gull, marbled murrelet).

Mahoney, S.P. 1979. Breeding biology and behaviour of the common murre (*Uria aalge aalge* Pont.) on Gull Island, Newfoundland. [City unknown], NF: Memorial University. M.S. thesis.

Keywords: *Ammodytes*; Newfoundland; predators (birds, common murre).

Mair, H. 1988. Seabird populations take a dive. Marine Pollution Bulletin. 19(10): 502.

"The RSPB suspects that overfishing for sand-eels, the basic diet of many seabirds, is causing the observed decline in bird numbers. Sand-eels are harvested by local fishermen and most are sold to two processing plants in Shetland for production of fish-meal."

Keywords: *Ammodytes*; Shetland; catch; fisheries; predators (birds, arctic tern, great skua, guillemot, kittiwake, puffin, red-throated diver).

Maksimenkov, V.V. 1984. Pishchevye otnosheniya lichinok nekotorykh ryb v zal. Korfa: Feeding relationships between larvae of some fishes in the Korf Bay of the Bering Sea. Voprosy Ikhtiologii. 24(6): 972-978.

“A study was made of food habits of larval *Theragra chalcogramma*, *Ammodytes personatus*, *Eleginus gracilis*, Cottidae, Pleuronectidae and Agonidae as related to a decline in the abundance of the Korfa population of *Clupea pallasi pallasi* Val. The competitive pressure of the cooccuring larvae of the herring in the beginning of exogenous feeding is shown to be inconsiderable, which is confirmed by the calculated rations and by the absence of correlation between mortality and food availability in the herring larvae on the one hand, and by the fact that the total amount of food consumed by larval herring is lower than that by other larvae.”

Keywords: *A. personatus*; Bering Sea; food and feeding habits; larvae.

Malyshev, V.I. 1980. Evaluation of food requirements of whiting *O. dontogadus merlangus* in the North Sea. Voprosy Ikhtiologii. 20(1): 86-93.

“Food components of North Sea whiting consisted of algae, Polychaeta, Amphipoda, Euphausiacea, Decapoda, Echinodermata, Chaetognatha, Appendicularia, *Ammodytes* sp., *Sprattus sprattus* L., *Clupea harengus* L., *Melanogrammus aeglefinus* L., *Odontogadus merlangus* (L.), *Trisopterus esmarki*i Nilsson, *Argentina* sp., *Callionymus lyra* L., Gobiidae, Pleuronectidae and digested fish. Its food consisted mainly of fish. Calculation of the daily and annual rations revealed that the magnitude of the latter was 478% of the weight of the fish or 819 kcal. The quantity of food required by the entire whiting population was considered over the course of a year in the North Sea and equalled 2.2 million tons.”

Keywords: *Ammodytes*; North Sea; predators (fish, whiting).

Mammershoj, M. 1995. Effects of dietary fish oil with natural content of carotenoids on fatty acid composition, n-3 fatty acid content, yolk colour and egg quality of hen eggs. Archiv für Geflügelkunde. 59(3): 189-197.

“In an experiment with 384 White Lohmann LSL layers the effect of fish oil upon rate of lay, egg weight, albumen height, shell weight, yolk weight, yolk colour, fat content, fatty acid composition, and sensory quality were analysed. The diets were composed as a control diet – A – with 3% animal fat +1.15 mg/kg canthaxanthin, diet B with 1.5% animal fat +1.5% fish oil with a natural content of astaxanthin of 34.8 mg/kg oil, diet C with 3% fish oil with 34.8 mg/kg oil of astaxanthin, and diet D with 3% fish oil containing 6.6 mg astaxanthin/kg oil. The fish oil type was two different lots of sand eel oil (*Ammodytes* spp.) and the astaxanthin originates from Crustacea, being the main feed of sand eel. The experiment lasted 16 weeks from 29 to 45 weeks of age. The diets were iso-energetic and fulfilled the NRC (1984) requirements. A significant effect of fish oil on egg weight, shell weight, yolk weight, and yolk colour was found. A content of 3% fish oil resulted in lower egg weight, shell weight, and yolk weight compared to the diet without fish oil. The yolk colour measured by the Roche Yolk Colour Fan, 15-grade, was significantly higher in diet A compared to diets B and D, but did not differ from diet C. A linear correlation between ppm pigment in the diet and the yolk colour was obtained with r–2 = 0.938. There was a significant increase of n–3 fatty acids in the yolks, especially eicosapentanoic acid (EPA) which is characteristic of fish oil. The fat content expressed as g fat per 60 g egg decreased significantly with increasing fish oil content. The composition changed from 0% to 3% fish oil by a relative increase in saturated fatty acids, decrease in monounsaturated fatty acids, and an increase in polyunsaturated fatty acids. The sensory evaluation of taste of yolk and general impression differed with lower grades for eggs from diets with fish oil, although still above the acceptability limit.”

Keywords: *Ammodytes*; composition.

Manuwal, D.A.; Boersma, D. 1977. Dynamics of marine bird populations on the Barren Islands, Alaska. In: Environmental assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators 4. Boulder, CO: National Oceanic and Atmospheric Administration, Environmental Research Laboratory: 294-420.

Keywords: *A. hexapterus*; Alaska; predators (birds).

Manuwal, D.A.; Boersma, D. 1978. Dynamics of marine bird populations on the Barren Islands, Alaska. In: Environmental assessment of the Alaskan Continental Shelf: annual reports of principal investigators for the year ending March 1978. Volume III: Receptors—birds. Ann. Rep. 3. [Place of publication unknown]: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program; contract RV0341: 575-679.

On East Amatuli Island, the most important food items in number, weight, and frequency of occurrence brought to the young by two puffin species were capelin and sand lance. Sand lance did not appear in the tufted puffin nestling diet in 1976; however, it comprised 30 percent of tufted puffin bill loads in 1977. Similarly, sand lance, comprising 16 percent of horned puffin bill loads in 1976, increased in occurrence to 52 percent of the bill loads in 1977.

Keywords: *A. hexapterus*; Alaska; Barren Islands; predators (birds, tufted puffin, horned puffin).

Manzer, J.I. 1968. Food of the Pacific salmon and steelhead trout in the northeastern Pacific Ocean. Journal of the Fisheries Research Board of Canada. 25: 1085-1089.

Keywords: *A. hexapterus*; predators (fish, Pacific salmon, steelhead trout).

Manzer, J.I. 1969. Stomach contents of juvenile Pacific salmon in Chatham Sound and adjacent waters. Journal of the Fisheries Research Board of Canada. 26: 2219-2223.

Keywords: *A. hexapterus*; predators (fish, Pacific salmon).

March, B.E. 1974. Nutrient composition of experimentally produced meals from whole argentine, capelin, sand lance, and from flounder and red fish filleting scrap. Journal of the Fisheries Research Board of Canada. 31(2): 141-146.

Keywords: *A. americanus*; *A. marinus*; composition.

Marcogliese, D.J.; Mcclelland, G. 1992. *Corynosoma wegeneri*, *Acanthocephala polymorphida* and *Pseudoterranova decipiens* nematoda ascaridoidea larvae in Scotian shelf groundfish. Canadian Journal of Fisheries and Aquatic Sciences. 49(10): 2062-2069.

“We examined larvae of the seal parasites *Corynosoma wegeneri* and *Pseudoterranova decipiens* in various fish species collected from Western and Sable Island banks between February 1989 and October 1990. Neither parasite was found in northern sand lance (*Ammodytes dubius*) or capelin (*Mallotus villosus*).”

Keywords: *A. americanus*; *A. dubius*; Atlantic (northwest); parasites.

Markevich, A.I. 1994. Artificial habitats in Peter the Great Bay, Sea of Japan, USSR: fish communities and prospects of fisheries. In: 5th international conference on aquatic habitat enhancement; 1991 Nov. 3-7; Long Beach, CA. In: Bulletin of Marine Science; 55: 1345.

Keywords: *Ammodytes*; Pacific Ocean; artificial habitat; fisheries.

Mårtensson, P.; Lager Gotaas, A.R.; Norday, E.S.; Blix, A.S. 1996. Seasonal changes in energy density of prey of northeast Atlantic seals and whales. Marine Mammal Science (Lawrence). 12(4): 635-640.

Keywords: *Ammodytes*; energetics; lipids; predators (mammals).

Martin, A.R. 1989. The diet of Atlantic puffin *Fratercula arctica* and northern gannet *Sula bassana* chicks at a Shetland colony during a period of changing prey availability. Bird Study. 36: 170-180.

“The food of young puffins and gannets was examined between 1973 and 1988 on Hermaness, Unst. No prey other than fish was found in any year; 10 species were taken by gannets and at least 13 by puffins during this study period. Sandeel *Ammodytes marinus* was found to be the dominant prey species for puffins in every sampling year except the last 2, comprising over 90% of the diet by weight in many annual samples. Sandeel formed 90% of the diet of young gannets in 1981 but declined steadily in importance thereafter, falling to 6% in 1988 by which time herring *Clupea harengus* and mackerel *Scomber scrombrus* were the 2 most common prey species. In a successful breeding season, the Hermaness colonies of puffins and gannets consume about 3000 tonnes and 2500 tonnes, respectively, during their attendance at the colony. The mean weight of food loads delivered by puffins to their young declined significantly after 1980, as did the size of sandeel captured. Observation of the colonies reinforces the evidence from diet sampling that sandeel had been less available to both seabird species in the latter years of the study. Gannets were able to switch to other prey with no loss of breeding success, but puffins probably suffered a severe breeding failure between 1986 and 1988. Available data on Shetland sandeel stocks provide evidence of a probable link between this species’ abundance within the seabirds’ foraging range and the quantity of sandeels brought ashore to chicks by adult puffins and gannets.”

Keywords: *A. marinus*; Shetland; importance; predators (birds, Atlantic puffin, northern gannet).

Mashiko, T. 1992. Decrease catch of cold water species and management of the fishery household. Suisan Kaiyo Kenkyu. 56(2): 158-162.

Keywords: *Ammodytes*; Japan; fisheries.

Mason, J.C.; Kennedy, O.D.; Phillips, A.C. 1981a. Canadian Pacific coast ichthyoplankton survey: 1980. Ichthyoplankton, Cruise Three, 1980 (March 12-20). Canadian Data Report Fisheries and Aquatic Science. 277.

Keywords: *A. hexapterus*; Canada; abundance; distribution; larvae.

Mason, J.C.; Kennedy, O.D.; Phillips, A.C. 1981b. Canadian Pacific coast ichthyoplankton survey: 1980. Ichthyoplankton, Cruise Two, 1980 (February 13-20). Canadian Data Report Fisheries and Aquatic Science. No. 276.

Keywords: *A. hexapterus*; Canada; abundance; distribution; larvae.

Massmann, W.H. 1960. Additional records for new fishes in Chesapeake Bay. Copeia. 1: 70.

Keywords: *Ammodytes*; Chesapeake Bay; distribution.

Masterman, A.T. 1895. The life-history and growth rate of the lesser sandeel *Ammodytes tobianus*. Annals and Magazine of Natural History. 6 (16): 282-288.

An amazingly detailed account, considering the date of publication, of the life history and behavior of the lesser sand eel.

Keywords: *A. tobianus*; growth rate; life history.

Masuda, H.; Araga, C.; Yoshino, T. 1975. Coastal fishes of southern Japan. Tokyo: Tokai University Press.

“Family Bleekeriidae. *Embolichthys mitsukurii* (Jordan et Evermann). Distinguished by the presence of ventral fins. Found on sandy bottoms in shallow water. Dives into the sand when threatened. Total length 16 cm. Range: Sagami Bay southward; Taiwan.”

Keywords: Bleekeriidae; general.

Matarese, A.C.; Kendall, A.W., Jr.; Blood, D.M.; Vinter, B.M. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. Tech. Rep. 80. Seattle, WA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest and Alaska Fisheries Science Center.

Keywords: *A. hexapterus*; eggs; larvae.

Mathews, E.A. 1996. Distribution and ecological role of marine mammals. [Place of publication unknown]: [publisher unknown], AJ Mine Projec; supplemental environmental impact statement; task report; task 3.1.

Harbor seal, Steller sea lion, harbor porpoise, humpback whale, and killer whale feed on Pacific sand lance. For humpback whale, the sand lance is considered to be a secondarily important prey species.

Keywords: *A. hexapterus*; Alaska; predators (mammals, harbor seal, Steller sea lion, harbor porpoise, humpback whale, killer whale).

Mathisen, O.A. 1959. Studies on the Steller sea lion (*Eumetopias jubata*) in Alaska. Transaction of the North American Wildlife Conference. 24: 346-356.

Keywords: *A. hexapterus*; Alaska; predators (mammals, Steller sea lion).

Mathisen, O.A.; Baade, R.T.; Lopp, R.J. 1962. Breeding habits, growth and stomach contents of the Steller sea lion in Alaska. Journal of Mammology. 43: 469-477.

The stomach contents of 114 sea lions contained 1 percent frequency of occurrence of Pacific sand lance.

Keywords: *A. hexapterus*; Alaska; Shumagin Islands; predation (mammals, Steller sea lion).

Matsubara, K.; Ochiai, A. 1965. Ichtyology, part II. Koseisha-Koseikaku, Tokyo: 864-870.

Matsumura, S.; Karakawa, J.; Mitani, I. 1978. Larvae of sand-eel, (*Ammodytes personatus*) in Bisan-Seto of the Seto-Inland Sea (1978). Bulletin of the Fisheries Experimental Station, Okayama Prefect. 1977: 21-26.

Keywords: *A. personatus*; Japan; larvae.

Matsumura, S.; Tsuchiya, Y. 1982. Catch of sand-eel *Ammodytes personatus* by the sample boats of Fukuromachiami, one kind of hoop net, 1978-'81. Bulletin of the Fisheries Experimental Station, Okayama Prefect. 1981: 45-55.

Keywords: *A. personatus*; Japan; catch; fisheries.

Matthews, D.R. 1983. Feeding ecology of the common murre, *Uria aalge*, off the Oregon coast. Eugene, OR: University of Oregon. M.S. thesis.

Keywords: *A. hexapterus*; Oregon; predators (birds, common murre).

Matthews, J.B.I.; Heimdal, B.R. 1980. Pelagic productivity and food chains in fjord systems. In: Freeland, H.J.; Farmer, D.M.; Levings, C.D., eds. Fjord oceanography. New York: Plenum Press: 377-398.

Keywords: *Ammodytes*; food chain.

Mattson, C.R.; Wing, B.L. 1978. Ichthyoplankton composition and plankton volumes from inland coastal waters of southeastern Alaska, April-November 1972. Juneau, AK: National Oceanic and Atmospheric Administration, National Marine Fisheries Service; tech. rep.; contract SSRF-723.

Keywords: *A. hexapterus*; Alaska; distribution.

Maurer, R. 1976. A preliminary analysis of inter-specific trophic relationships between the sea herring, *Clupea harengus* Linnaeus, and the Atlantic mackerel, *Scomber scombrus* Linnaeus. Res. Doc. contract 76/VI/121. [Place of publication unknown]: International Commission for the Northwest Atlantic Fisheries.

McAlister, W.B. 1981. Estimates of fish consumption by marine mammals in the eastern Bering Sea and Aleutian Island area. Seattle, WA: National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Center, National Marine Fisheries Service; draft report. 29 p.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (mammals).

McAllister, D.I. 1960. List of marine fishes of Canada: Ammodytidae-Sandlances. Bulletin of the National Museum of Canada. 168: 35-36.

Keywords: *Ammodytes*; Canada; distribution.

McClelland, G.; Misra, R.K.; Martell, D.J. 1990. Larval anisakine nematodes in various fish species from Sable Island Bank and vicinity Nova Scotia Canada. In: Bowen, W.D., ed. Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts: workshop; [dates of workshop unknown]; Halifax, NS. In: Canadian Bulletin of Fisheries and Aquatic Sciences; 222: 83-118.

Keywords: *A. americanus*; *A. dubius*; Canada; Nova Scotia; parasites.

McGraw, K.A.; Armstrong, D.A. 1990. Fish entrainment by dredges in Grays Harbor, Washington. In: Simenstad, C.A., ed. Proceedings of a workship on effects of dredging on anadromous Pacific coast fishes in Seattle; [year unknown Sept. 8-9; [location of meeting unknown]. [Place of publication unknown]: [publisher unknown]: 113-131.

Mentioned that Pacific sand lance were entrained at the highest rate, 594 per 1,000 cubic yards, observed in all the studies.

Keywords: *A. hexapterus*; Washington; abundance; habitat.

McGurk, M.D. 1986. Natural mortality of marine pelagic fish eggs and larvae–role of spatial patchiness. Marine Ecology–Progress Series. 34(3): 227-242.

Keywords: *A. hexapterus*; mortality.

McGurk, M.D. 1987a. Age and growth of Pacific herring larvae based on length-frequency analysis and otolith ring number. Environmental Biology of Fishes. 20(1): 33-47.

Keywords: *A. hexapterus*; Alaska; growth; larvae.

McGurk, M.D. 1987b. Natural mortality and spatial patchiness-reply to Gulland. Marine Ecology–Progress Series. 39(2): 201-206.

Keywords: *A. hexapterus*; mortality.

McGurk M.D. 1987c. The spatial patchiness of Pacific herring larvae. Environmental Biology of Fishes. 20(2): 81-89.

Keywords: *A. hexapterus*; Alaska; distribution; larvae.

McGurk, M.D.; Edinger, J.E.; Buchak, E.M. 1993. Fisheries oceanography of the southeast Bering Sea: simulated dispersal of herring and sand lance larvae in Port Moller, Alaska, using a three-dimensional hydrodynamic model. [Place of publication unknown]: U.S. Minerals Management Service, Alaska Outer Continental Shelf Study; final report; contract MMS 92–0055: 1-42.

Reports development of numerical model to determine physical and biological mechanisms involved in retention of herring and sand lance larvae within Port Moller estuary on assumption that such retention may be important for successful year-class formation.

Keywords: *A. hexapterus*; Alaska; Bering Sea; distribution; larvae; model.

McGurk, M.D.; Warburton, H.D. 1992a. Fisheries oceanography of the southeast Bering Sea: relationships of growth, dispersion and mortality of sand lance larvae to environmental conditions in the Port Moller estuary. OCS Report of the U.S. Minerals Management Service. 43 p.

"The objective of the study was to describe the early life history of Pacific sand lance, *Ammodytes hexapterus*, in the southeastern Bering Sea so as to assess the potential impact of oil and gas development in the area of forage fishes. A fisheries oceanography program in the Port Moller Estuary from April to July, 1990, collected 473 samples of ichthyoplankton. Analysis of these samples showed that three waves of adult Pacific sand lance entered the Port Moller estuary from mid-January to late May, 1990, and laid their eggs on sand banks in the shallow, well-mixed outer portion of the estuary. After an incubation period of 41 to 63 days, newly-hatched larvae moved at an average speed of about .3 km/day towards a fjord-like basin in upper Herendeen Bay about 20 km southwest of the center of hatch. The basin develops a spring-summer zooplankton community with greater biomass than any other part of the estuary. The fate of the stock depends on maintenance of undisturbed spawning beds and a productive larval rearing area."

Keywords: *A. hexapterus*; Alaska; Bering Sea; anthropogenic impacts; environmental impact; growth; larvae; migration; mortality; population dynamics.

McGurk, M.D.; Warburton, H.D. 1992b. Pacific sand lance of the Port Moller estuary, southeastern Bering Sea: an estuarine-dependent early life history. Fisheries Oceanography. 1(4): 306-320.

"Three waves of spawning Pacific sand lance (*Ammodytes hexapterus*) entered the Port Moller estuary from mid-January to late May 1990. Each wave laid its eggs on sand in lower Moller Bay with the center of egg distribution about 14 km inside the estuary. After incubation for 45 to 94 d, each cohort of eggs hatched out over a 41- to 63-d period. Larvae moved at a rate of 0.21 km•d^{-1} toward a deep fjordlike basin at the head ofr Herendeen Bay inside the estuary about 20 km southwest of the center of hatch. The basin has the lowest flushing rate of the estuary, and unlike the rest of Port Moller, it is vertically stratified, which allows the development of a spring-summer zooplankton community with greater biomass than any other location in the estuary. Larvae may have moved to the basin to enhance growth or to avoid offshore transport to areas of low food abundance, but we cannot demonstrate a direct link between growth and habitat. We conclude that the Port Moller sand lance stock has an estuarine early life history that evolved in response to the unique physical conditions of the Port Moller estuary—a shallow, well-mixed site with sandy substrate that is suitable for incubation of demersal eggs next to a deep, vertically stratified fjord with a rich zooplankton community that is suitable for rearing of larvae."

Keywords: *A. hexapterus*; Alaska; Bering Sea; advection; early life history; growth; habitat; larvae; mortality; spawning.

McGurk, M.D.; Warburton, H.D.; Galbraith, M.; Kusser, W.C. 1992. RNA-DNA ratio of herring and sand lance larvae from Port Moller, Alaska: comparison with prey concentration and temperature. Fisheries Oceanography. 1(3): 193-207.

"A key assumption of hypotheses that link the production of prey for larval fish with year-class strength of fish is that larval growth and condition is food-limited. We tested this assumption by comparing whole-body RNA-DNA ratios of individual Pacific herring larvae and Pacific sand lance larvae from Port Moller, a subarctic Alaskan estuary, with prey concentration and temperature. RNA-DNA ratios were correlated with larval length, but not with prey concentration or temperature. Ratios were not significantly different between a warm, well-mixed station with low prey concentrations and a colder, stratified station with higher prey concentrations. Using RNA-DNA ratios, we classified

as starving 45% of first-feeding (less than 7 mm long) sand lance larvae. However, starvation could not have been caused by low concentrations of prey because microzooplankton prey concentrations were high enough (16 to 84 prey/L) to support relatively high rates of growth. Therefore, starving larvae were either abnormal or they were still learning to forage."

Keywords: *A. hexapterus*; Alaska; Bering Sea; food and feeding habits; larvae; RNA-DNA ratios.

McIntosh, W.C. 1889. On the pelagic fauna of the Bay of St Andrews during the months of 1888: Part I. Report of the Fisheries Board of Scotland. 1888: 259-310.

Keywords: *Ammodytes*; abundance; distribution.

McIntosh, W.C. 1891. Further observations on the life-histories and development of food and other fishes. Report of the Fisheries Board of Scotland. 1890: 317-342.

Keywords: *Ammodytes*; life history.

McIntosh, W.C.; Masterman, A.T. 1897. The life-histories of the British marine food fishes. London: C.J. Clay and Sons: 303-314.

Keywords: *Ammodytes*; British Isles.

McIntosh, W.C.; Prince, E.E. 1890a. On the development and life-histories of the teleostean food and other fishes. Transactions of the Royal Society of Edinburgh. 35: 665-944.

Keywords: *Ammodytes*; life history.

McIntosh, W.C.; Prince, E.E. 1890b. On the eggs and early stages of the sand-eels. 9th Annual Report of the Fisheries Board of Scotland. Part III.

Keywords: *Ammodytes*; eggs; larvae.

McIntyre, A.D. 1953. The food of halibut from the North Atlantic fishing grounds. Marine Research. 1952(3): 1-20.

Keywords: *Ammodytes*; Atlantic (north); predators (fish, halibut).

McKown, K.A. 1983. Growth and feeding of the sand lance (*Ammodytes americanus*) in coastal waters. Estuaries. 6: 270-271.

Keywords: *A. americanus*; growth; feeding.

Meek, A. 1916. The migrations of fish. London: [publisher unknown].

Keywords: *Ammodytes*; migration.

Mehner, T. 1990. Estimation of prey fish species based on spine fragments during food analysis osteichthyes teleostei. Zoologischer Anzeiger. 225(3-4): 210-222.

"Besides other skeletal structures it is possible to use parts of the spine for the identification of the prey fish species from stomachs of piscivorous fish. Species differences of 13 important prey species *Clupea harengus, Esox lucius. Abramis brama, Gynocephalus cernua, Ammodytes tobianus, Pomatoschistus microps, P. minutus, Osmerus esperlanus, Rutilus rutilus, Perca fluviatilis, Stizostedion lucioperca, Zoarces viviparus, Gasterosteus aculeatus, Pugitius*

pungitius, of the inner coastal waters of the GDR with regard to the morphology of the spine are described and presented. Regressions between length of vertebra and fish length have been determined for 6 species in order to enable a backcalculation of prey length. The results can also be helpful during food analysis of birds and mammals."

Keywords: *A. tobianus*; predators (fish); skeleton.

Meidinger, D.; Pojar, J., eds. 1991. Ecosystems of British Columbia. Spec. Rep. Series 6. Victoria, BC: British Columbia Ministry of Forests.

Keywords: *A. hexapterus*; British Columbia; ecology.

Melville, D. 1974. Analysis of herring gull pellets collected in C. Antrim. Seabird Report. 4: 40-46.

Keywords: *Ammodytes*; predators (birds, herring gull).

Menzel, H. 1980. The fish fauna from the upper oligocene of Astrup near Osnabrueck lower Saxony West Germany. Abhandlungen Naturwissenschaftlichen Vereins zu Bremen. 39: 263-282.

Keywords: *Ammodytes*; Germany; fossils.

Mercille, B.; Dagenais, J. 1987. A literature review of the biology and exploitation of the American sand lance (*Ammodytes americanus*). Canadian Manuscript Report no. 1927. Fisheries and Aquatic Sciences. 49 p.

"The authors reviewed the literature on the American sand lance (*Ammodytes americanus*). Several aspects concerning the biology and the exploitation of *A. americanus* are discussed. An annotated bibliography is also presented."

Keywords: *A. americanus*; bibliography; biology; exploitation.

Mergardt, N.; Temming, A. 1997. Diel pattern of food intake in whiting (*Merlangius merlangus*) investigated from the weight of partly digested food particles in the stomach and laboratory determined particle decay functions. International Council for the Exploration of the Sea Journal of Marine Science. 54(2): 226-242.

"The daily periodicity of the food intake of North Sea whiting feeding on sandeels was investigated by means of analysing the weight of partly digested prey particles found in the stomachs. The digestion times corresponding to the weights of partly digested sandeels were estimated from the assumed weight at ingestion as derived from the length-weight relationship of the prey and a gastric evacuation model that was based on experimental data with whiting fed on sandeels . The results indicated a single feeding peak with a maximum feeding between 2200 and 2400 h and minimal food intake between 0800 and 1000 h. Additional simulation exercises were performed to investigate the precision of the back-calculation method. These simulations revealed that the scatter of individual weights around the mean weight at a given length is transformed into a corresponding scatter in the estimated times of food intake. The main conclusion from the analysis that whiting appear to feed during the night hours was found to be robust against changes of the actual parameters of the particle decay function within the range of the most likely values."

A local population of adult whiting was found to feed almost exclusively on sandeels.

Keywords: *Ammodytes*; North Sea; importance; predators (fish, whiting).

Merrick, R.L.; Loughlin, T.R.; Calkins, D.G. 1987. Decline in abundance of the northern sea lion, *Eumetopias jubata*, in Alaska 1956-86. Fishery Bulletin. 85: 351-365.

Keywords: *A. hexapterus*; Alaska; predators (mammals, Steller sea lion).

Merriman, D. Sclar, R.C. 1952. Hydrographic and biological studies of Block Island Sound: the pelagic fish eggs and larvae of Block Island Sound. Bulletin of the Bingham Oceanography College. 13(3): 165-219.

Keywords: *Ammodytes*; abundance; distribution; eggs; larvae.

Meschkat, A. 1936. Untersuchungen über den Aufbau der Kabeljau-nahrung im Bereich der Vestmannainseln. Rapports et Procès-Verbaux des Reunions Conseil International pour l'Exploration de la Mer. 99(3): 3-19.

Keywords: *Ammodytes*; Iceland; predators (fish, cod).

Meyer, R.M.; Johnson, T.M. 1990. Fisheries oceanography–a comprehensive formulation of technical objectives for offshore application in the Arctic. In: Outer Continental Shelf Report 132 of the U.S. Mineral Management Service. Anchorage, AK: [publisher unknown].

"In the Beaufort Sea, fish resources include Arctic char, Arctic cisco, broad whitefish, Arctic cod, least cisco, and fourhorn sculpin. In the Chukchi Sea, fish resources include Arctic char, pink and chum salmon, Arctic and saffron cod, Pacific sand lance, capelin, and Pacific herring."

Keywords: *A. hexapterus*; Alaska; Chukchi Sea; distribution.

Meyer, T.L.; Cooper, R.A.; Langton, R.W. 1979. Relative abundance, behavior, and food habits of the American sand lance, *Ammodytes americanus*, from the Gulf of Maine. Fishery Bulletin. 77(1): 243-253.

"Meristic characteristic of sand lance taken from Stellwagen Bank indicated the species to be the American sand lance *Ammodytes americanus.* Bottom trawl data, ichthyoplankton surveys, and diver and submersible observations demonstrated a significant increase in relative abundance of sand lance since about 1975 on Stellwagen Bank; this trend was typical of the Northwest Atlantic from Cape Hatteras, N.C., to the Gulf of Maine. School shapes were constant in appearance, vertically compressed, tightly compacted, and bluntly linear from a dorsal and ventral view. School strength varied from about 100 to tens of thousands of individuals with the nearest-neighbor distance ranging from ¼ to 1½ body lengths. The swimming motion is sinusoidal in form and eellike in appearance. Swimming speeds varied from 15 to over 120 cm/s. Copepods were the most important food source, constituting 41% of the total weight of food consumed; sand lance feed in school formation between midwater and the surface. Sand lance bury themselves totally or partially in clean sandy substrates when not schooling."

Substrates of mud, mud and silt, medium to coarse gravel, and rock and boulder were avoided. This preference for loose porous substrate facilitates entry and exit and may relate to a sufficient supple of dissolved oxygen within at least the first few centimeters of interstitial water. Oxygen is continually replenished by tidal currents of 32 to 47 centimeters per second measured at 1 meter above the bottom on Stellwagen Bank.

Keywords: *A. americanus*; northwest Atlantic; abundance; behavior; food and feeding habits; swimming speed.

Meyer-Waarden, P.F. 1959. German sandeel investigations in 1957. Annales Biologiques, Copenhagen. 14: 83.

Keywords: *Ammodytes*; Germany.

Meyer-Waarden, P.F. 1960. The German fishery for sandeels in 1958. Annales Biologiques, Copenhagen. 15: 77.

Keywords: *Ammodytes*; Germany; fisheries.

Meyer-Waarden, P.F. 1961-65. The German sandeel fishery in 1961-65. Annales Biologiques, Copenhagen. 16: 22.

Keywords: *Ammodytes*; Germany; fisheries.

Meyer-Waarden, P.F. 1963. The German sandeel fishery in 1963. Annales Biologiques, Copenhagen. 20: 109.

Keywords: *Ammodytes*; North Sea; catch; fisheries; length frequency.

Meyer-Warden, P.F. 1964. The fish: other fishes–redfish, picked dogfish, sand-eels, and rare fish. Annales Biologiques, Copenhagen. 21: 172-179.

Keywords: *Ammodytes*; general.

Meyer-Waarden, P.F. 1967. The German sandeel fishery in 1965. Annales Biologiques, Copenhagen. 22: 182.

Keywords: *A. lancea; A. marinus*; North Sea; catch; fisheries; length frequency.

Miller, D.S. 1980. Hydroacoustic assessment of pelagic fish stocks in the Newfoundland and Labrador areas. Council meeting of the International Council for the Exploration of the Sea 1980/H: 51; [dates of meeting unknown]; [location unknown]. [Place of publication unknown]: [publisher unknown]. 10 p.

Keywords: *A. dubius*; Labrador; Newfoundland; distribution.

Miller, T.J.; Crowder, L.B.; Rice, J.A.; Marschall, E.A. 1988. Larval size and recruitment mechanisms in fishes–toward a conceptual framework. Canadian Journal of Fisheries and Aquatic Sciences. 45(9): 1657-1670.

Keywords: *Ammodytes*; fisheries; larvae; recruitment.

Mills, S. 1981. Graveyard of the puffin. New Scientist. 91:10-13.

Keywords: *Ammodytes*; predators (birds, puffin).

Minami, H.; Aotsuka, M.; Terasawa, T. [and others]. 1995. Breeding ecology of the spectacled guillemot (*Cepphus carbo*) on Teuri Island. Journal of the Yamashina Institute for Ornithology. 27(1): 30-40.

“Chick growth and parental feeding behavior of the spectacled guillemot (*Cepphus carbo*) were studied on Teuri Island, Hokkaido in 1989. Increase in chick body weight was closely fitted to the von Bertalanffy equation. Chick growth rate peaked at a maximum of 22.1 g/day at 15.3 days after hatching; being highest among the Alcidae. Its weight was 620 g at fledging, 91.2% of the average adult weight. Lengths of wing, culmen and tail for two chicks grew to 60-79% of adult lengths at fledging, with only the tarsus attaining the full length. Chick diets in the nestling period consisted of three species of benthic fishes, *Sebastes minor, Ammodytes personatus,* and *Blennioidei* sp. Feeding frequency was 9.8 times/day for one chick brood, and 9.3 times/day for two chick broods. These figures are remarkably high compared to other Alcidae. High feeding ability of the parents may account for high growth rates and large body sizes at fledging for the chicks.”

Keywords: *A. personatus*; Japan; predators (birds, spectacled guillemot).

Minami K.; Nishimura, S.; Yamada, H. [and others]. 1993. Biochemical research on sandeel aestivation: preliminary tests. Mie–Ken Suisan Gijutsu Senta Jigyo Hokoku. 1992: 86-89.

Keywords: *A. personatus*; aestivation; biological rhythm; dormancy; fatty acid.

Minami, K.; Yamada, H.; Hagita, K. 1994. Role of the lipid of a sand lance in the periods of aestivation and maturity. Mie–Ken Suisan Gijutsu Senta Jigyo Hokoku. 1993: 79-81.

Keywords: *A. personatus*; aestivation; biological rhythm; dormancy; lipids; maturation; metabolism.

Mitchell, E. 1974. Trophic relationships and competition for food in northwest Atlantic whales. In: Burt, M.B.D., ed. Proceedings of the Canadian Society of Zoologists annual meeting; [year unknown] June 2-5; [location unknown]. [Place of publication unknown]: [publisher unknown]: 123-133.

Keywords: *Ammodytes*; predators (mammals, whales).

Mitsano, D.A. 1977. Species composition and relative abundance of larval and post-larval fishes in the Columbia River estuary, 1973. U.S. Fishery Bulletin. 75: 218-222.

Keywords: *A. hexapterus*; Washington; abundance; distribution; larvae.

Mitton, J.B.; Odense, P.H. 1985. Muscle esterase variation and size variation in the sand launce *Ammodytes dubius.* Marine Biology (Berlin). 87(3): 279-284.

“Esterase variation detected in homogenates of muscle tissue taken from the sand launce *A. dubius* in April, 1970 and 1971 is described. Eight alleles were found segregating at a single locus, and the frequencies of these alleles were homogenous in population samples taken on the Emerald Bank, off Nova Scotia, Canada, in successive years. When ordered by their electrophoretic mobility, the profile of the frequencies of these alleles was unimodal and symmetric. In both of the population samples, there were significant excesses of homozygotes and deficiencies of heterozygotes. There was an association between genotype and size of individuals among homozygous genotypes: individual homozygous for the most common, intermediately-migrating allele were larger than homozygotes bearing alleles with relatively fast or slow mobilities.”

Keywords: *A. dubius*; Canada; Nova Scotia; genetics.

Miyake, H.; Kaneda, Y. 1996. Survey and research on fish resources: biological survey and research on regional bottom fish resources—sand lance. Hokkaidoritsu Wakkanai Suisan Shikenjo Jigyo Hokokusho. 1994: 22-27.

Keywords: *A. personatus*; Japan; age; catch; fisheries; length.

Miyamura, M.; Sugino, T. 1959. On the sand eel (*Ammodytes personatu*s Girard) in Ise Bay. I: Spawning ground, spawning season and migration of larvae. Contribution of the Ise-wan Regional Fisheries Research Laboratory. 1: 1-9.

Keywords: *A. personatus*; larvae; migration; spawning.

McGilvrey, F.B. 1967. Food habits of sea ducks from the northeastern United States. Wildfowl Trust Annual Report (1965-1966). 18: 142-145.

Keywords: *Ammodytes*; predators (birds).

Moe, R.A.; Baird, P.A. 1978. Some notes on the feeding ecology of the tufted puffin *Lunda cirrhata* in the Sitkalidak Strait Region of Kodiak Island, Alaska, during the 1977 breeding season. Pacific Seabird Group Bulletin. 5: 42.

Keywords: *A. hexapterus*; Alaska; Kodiak Island; predators (birds, tufted puffin).

Moe, R.A.; Day, R.H. 1979. Populations and ecology of the seabirds of the Koniuji Group, Shumagin Islands, Alaska. In: Environmental assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators 4. Boulder, CO: National Oceanic and Atmospheric Administration, Environmental Research Laboratory: 395-491.

“Pacific sand lance were frequently found in the bill loads brought to horned puffin chicks at the Koniuji Strait colony in 1976. Sand lance occurred by weight in 70.3% and by frequency of occurrence in 68.8% of the bill loads brought to horned puffin chicks. Pacific sand lance occurred in the diet of tufted puffins collected in the Yukon Harbor area, 1976. Sand lance occurred in 12.5% of food items in regurgitations of glaucous-winged gull chicks on Hall Island, 1976.”

Keywords: *A. hexapterus*; Alaska; Shumagin Islands; importance; predators (birds, horned puffin, tufted puffin, glaucous-winged gull).

Molloy, J. 1967. Irish sprats and sandeels *Ammodytes marinus* fishery. Irish Fisheries Investigations, Series B. (Marine). 2: 5-18.

Keywords: *A. marinus*; fisheries.

Monaghan, P. 1992. Seabirds and sandeels: the conflict between exploitation and conservation in the northern North Sea. Biodiversity and Conservation. 1: 98-111.

“Sandeels, especially *Ammodytes marinus* are a major component of the diet of many predatory fish, seabirds and seals. The industrial fishery for sandeels is now the largest of the North Sea fisheries. A sandeel fishery in the Shetland area began in 1974 but has recently declined. This change was accompanied by dramatic declines in the breeding success of certain seabirds, particularly Arctic terns and kittiwakes. Current information on seabirds and sandeels in the Shetland area is reviewed and areas where further research is needed, highlighted. The Shetland problem illustrates the difficulities of reconciling conservation and exploitation when fundamental ecological and behavioral knowledge is lacking, and also the need to obtain further information on the ecological impact of industrial fisheries.”

Keywords: *A. marinus*; Shetland; commercial fishery; importance; predators (birds, fish, mammals).

Monaghan, P. 1996. Relevance of the behaviour of seabirds to the conservation of marine environments. Oikos. 77: 227-237.

“Catastrophic declines in prey populations are often accompanied by pronounced seabird breeding failures, as recently occurred for example with lesser sandeels *Ammodytes marinus* in the Shetland area of the North Sea.

“Seabirds in Shetland feed almost entirely on lesser sandeels. Sandeels spawn in January, and the fish of the year (0-group) are first caught by the fishery in late June/early July. By this time they have also reached a large enough size to be taken by seabirds. The industrial fishery for sandeels is now the largest of the North Sea fisheries, approaching 109 kg per year. A sandeel fishery started in Shetland in 1974; landings peaked in 1982 and then declined rapidly, as did the breeding success of several species of seabird. Shetland contained over 33 thousand breeding pairs of Arctic terns *Sterna paradisaea* in 1980, 40% of the British and Irish breeding population, yet the shetland population produced no young between 1984 and 1990. Productivity of kittiwakes *Rissa tridactyla* was similarly very poor from 1985 to 1990. It was established that the poor breeding success of the Arctic tern resulted from a shortage of sandeels, but considerable controversy arose over the extent to which stocks had actually declined, and the extent to which overfishing was involved. It was noted that, whole surface feeding seabirds were badly affected, diving species such as shags *Phalacrocorax aristotelis* and guillemots (also dependent on sandeels) continued to breed reasonably successfully.”

Keywords: *A. marinus*; importance; predators (birds, arctic tern, kittiwake, shag, guillemot).

Monaghan, P.; Uttley, J.D.; Burns, M. [and others]. 1989. The relationship between food supply, reproductive effort, and breeding success in arctic terns *Sterna paradisea*. Journal of Animal Ecology. 58: 261-274.

“This study compares the foraging performance, adult body condition and breeding success of Arctic terns (*Sterna paradisaea* Pontoppidan) in a successful (Coquet Island) and an unsuccessful (Shetland) breeding colony. During courtship feeding, males in Shetland brought larger fish to their mates than did the birds on Coquet. However, the latter brought more energy-rich fish, made more foraging trips per hour and their rate of energy transfer to their mates was higher. There was no difference between the two colonies in clutch or eggs size, or in hatching success. During chick-rearing, birds in both areas concentrated on sandeels as prey. In contrast to Coquet, the Shetland birds brought their young a very high proportion of small fish, and lost a high proportion of their large prey to conspecific kleptoparasites; they also foraged at a higher rate and brought less energy per chick per hour. The chicks in the Shetland colony grew at a slower rate than those on Coquet and the majority died in the first week of life. Breeding success on Coquet was good. In both areas, adults lost weight during the breeding period. The birds on Shetland were lighter than those on Coquet, but their subsequent rate of weight loss was less. During the chick-rearing period on Coquet, birds fledging two young remained heavier than those where one young died of starvation in the first

week after hatching. The data suggest that the birds in Shetland had difficulty in finding sandeels of the 4-8 cm size-class to feed their young, and that the adults themselves were in poor condition prior to the chicks hatching. Adult arctic terns appear to adjust their breeding effort in response to body condition. These findings are discussed in relation to the life-history strategy of arctic terns and factors influencing their food availability."

Keywords: *A. marinus*; Coquet Island; Shetland; importance; predators (birds, arctic tern).

Monaghan, P.; Uttley, J.D.; Burns, M.D. 1991. The influences of changes in prey availability on the breeding ecology of terns. International Ornithology Congress. 20: 2257-2262.

In the Shetland area, the lesser sand eel is the main prey of arctic terns. Very few young terns were produced for 7 successive years. The sand eel fishery is near the main seabird colonies, and the fishery may have caused the collapse of the sand eel stock. Arctic terns use 1 age group sandeels in courtship and 0 age group sand eels when feeding young. In Shetland, there is a very good correlation between the production of 0 age group sand eels and the number of young terns ringed each year.

Keywords: *A. marinus*; Shetland; fisheries; importance; 0 age; predator (birds, arctic tern).

Monaghan, P.; Uttley, J.D.; Burns, M.D. 1992. Effects of changes in food availability on reproductive effort in arctic terns *Sterna paradisea*. Ardea. 80: 71-81.

"The breeding effort of Arctic terns *Sterna paradisaea* in two conditions of low food availability in Shetland (A: poor food supply during courtship and very poor during chick rearing, B: very poor during courtship and poor during chick rearing) was compared with that of Arctic terns breeding in two areas of good food supply elsewhere. In Shetland situation B courtship prey were small and males provisioned females at a comparatively high rate. Neither the onset of laying nor egg size appeared to be affected; clutch size was slightly reduced in Shetland B, and a significantly higher proportion of birds deserted during incubation. Sandeels (*Ammodytes marinus*) were the main chick prey and feeding rates were highest when prey were small. No young fledged in the Shetland situations. Adults at the good food supply sites were heavier than those in Shetland and there was a significant positive relationship between adult weight at the time of hatching and the time to nest failure. These data are discussed in relation to the proximate role of food supply in influencing reproductive decisions and a model is proposed suggesting that individual Arctic terns have a critical threshold body weight below which they abandon breeding."

Keywords: *A. marinus*; Shetland; importance; predators (birds, arctic tern).

Monaghan, P.; Uttley, J.D.; Okill, J.D. 1989. Terns and sandeels: seabirds as indicators of changes in marine fish populations. Journal of Fish Biology. 35: 339-340.

Keywords: *Ammodytes*; importance; predators (birds).

Monaghan, P.; Walton, P.; Wanless, S. [and others]. 1994. Effects of prey abundance on the foraging behaviour, diving effeciency and time allocation of breeding guillemots *Uria aalge*. Ibis. 136: 214-222.

The main prey of the common murre is the lesser sand eel.

"These data demonstrate that breeding guillemots have the capacity to adjust their foraging behaviour and time budgets in response to changes in food abundance, but this flexibility was not sufficient to compensate fully for the very low food abundance experienced by birds in this study."

Keywords: *A. marinus*; Shetland; importance; predators (birds, common murre).

Monaghan, P.; Wright, P.J.; Bailey, M.C. [and others]. 1996. The influence of changes in food abundance on diving and surface feeding seabirds. In: Montevecchi, W.A., ed. Studies of high-latitude seabirds. 4: Trophic relationships and energetics of endotherms in cold ocean systems. Occas. Pap. 91. [Place of publication unknown]: Canadian Wildlife Service: 10-19.

“Breeding parameters of black-legged kittiwakes *Rissa tridactyla* and common murres *Uria aalge* breeding in Shetland in 1990 and 1991 were examined in conjunction with studies on the distribtuion, abundance, and age composition of sand lance (*Ammodytes* spp.), their main prey in the area. There was a 40-fold difference in sand lance density between years, and the distribution and age composition of the fish also differed markedly. Although the diet compostion of the birds did not differ between years, differences were found in the breeding success, colony attendance, foraging trip durations, and overall activity budgets. These findings are discussed in relation to the differing foraging strategies of the two seabird species and the use of seabirds as indicators of changes in marine fish populations.”

Keywords: *Ammodytes*; Shetland; age; abundance; distribution; predators (birds, black-legged kittiwake, common murre).

Monaghan, P.; Zonfrillo, B. 1986. Population dynamics of seabirds in the Firth of Clyde. Proceedings of the Royal Society of Edinbergh. 90B: 363-375.

Keywords: *Ammodytes*; predators (birds).

Monaghan, P.A.; Uttley, J.; Burns, M.D. 1988. The relationship between food supply, reproductive effort and breeding success in arctic terns. In: Tasker, M.L., ed. Seabird food and feeding ecology: Proceedings of the International Conference of the Seabird Group. 3: 35-36.

Keywords: *Ammodytes*; importance; predators (birds, arctic tern).

Monteleone, D.M. 1983. Feeding ecology of sand lance, *Ammodytes* sp. larvae. Estuaries. 6: 270.

Keywords: *Ammodytes*; food and feeding habits; larvae.

Monteleone, D.M. 1992. Seasonality and abundance of ichthyoplankton in Great South Bay New York. Estuaries. 15(2): 230-238.

“Other dominant larvae were winter flounder (*Pleuronectes americanus*) and American sand lance (*Ammodytes americanus*). Their combined density reached 8 m-3 and accounted for the winter peak in larvae. The seasonality of abundance of larval fish was strongly correlated with reported densities of copepod nauplii prey.”

Keywords: *A. americanus*; New York; abundance; eggs; larvae; seasonal variation.

Monteleone, D.M.; Peterson, W.T. 1986. Feeding ecology of American sand lance *Ammodytes americanus* larvae from Long Island Sound. Marine Ecology Progress Series. 30(2-3): 133-143.

Keywords: *A. americanus*; Long Island Sound; food and feeding habits.

Monteleone, D.M.; Peterson, W.T.; Williams, G.C. 1985. Interannual fluctuations in density of sand lance, *Ammodytes americanus*, larvae In Long Island Sound. Estuaries. 8(2B): 101A.

Keywords: *A. americanus*; Long Island Sound; annual variation; environmental effects.

Monteleone, D.M.; Peterson, W.T.; Williams, G.C. 1987. Interannual fluctuations in the density of sand lance *Ammodytes americanus* larvae in Long Island Sound USA 1951-1983. Estuaries. 10(3): 246-254.

“Enumeration data from over 2,300 ichthyoplankton samples collected during 17 yr, spanning a 32-yr interval (1951-1983), were compiled to determine interannual variations in density of sand lance larvae. Years of relatively high densities were noted during the winters of 1965-1966 and 1978-1979 and low densities in 1971-1974. A regular increase in numbers during the late 1970’s and the peak in 1978-1979 coincided with increases in population size found throughout the coastal northwest Atlantic Ocean. Densities in Long Island Sound began to decline in 1980 and

this continued through 1983. In contrast, densities throughout coastal Atlantic areas during the 1980's remained at least as high as they were 1976-1978. Interannual fluctuations in density of sand lance larvae could be partially explained by water temperatures in December. Warm Decembers were associated with low larval densities."

Keywords: *A. americanus*; Long Island Sound; abundance; annual variation; larvae; temperature.

Montevecchi, W.A. 1993. Birds as indicators of change in marine prey stocks. In: Furness, R.W.; Greenwood, J.J.D., eds. Birds as monitors of environmental change. New York: Chapman and Hall: 215-266.

Keywords: *Ammodytes*; predators (birds).

Montevecchi, W.A.; Myers, R.A. 1992. Monitoring fluctuations in pelagic fish availability with seabirds. Canadian Atlantic Fisheries Scientific Council. 92.

Keywords: *Ammodytes*; predators (birds).

Montevecchi, W.A.; Ricklefs, R.E.; Kirkham, I.R.; Gabaldon, D. 1984. Growth energetics of nestling northern gannets (*Sula bassanus*). Auk. 101: 334-341.

Keywords: *A. hexapterus*; energy value; predators (birds, northern gannet); organic composition.

Morgan, R.; Greenstreet, S.P.R.; Thorpe, J.E. 1986. First observations on distribution, food and fish predators of post-smolt Atlantic salmon, *Salmo salar*, in the outer Firth of Clyde: Council meeting of the International Council for the Exploration of the Sea; [dates of meeting unknown]; Copenhagen, Denmark. [Place of publication unknown]: [publisher unknown]. 12 p.

"Post-smolt salmon, *Salmo salar* L., (16.7-20.0 cm) were caught by pair trawling at night in the surface 10 m off the Kintyre peninsula, Scotland, during Jun. 1986, very shortly after their emigration from the rivers. They were feeding chiefly on 2-6 cm sandeels, *Ammodytes* sp. Demersal trawl surveys in late May had revealed the dogfishes *Squalus acanthias* and *Scyliorhinus caniculus* as the only fish species present in the area which were potential predators on juvenile salmon."

Keywords: *Ammodytes*; Scotland; predators (fish, Atlantic salmon).

Mori, K. 1995. Ecological study on the fishes of Yuya Bay, the Japan Sea. Bulletin of the National Research Institute of Fisheries Science. (7): 277-388.

"In order to clarify the role and function of a semi-closed sea area in the production of fish, a series of research was carried out in Yuya Bay, in the Japan Sea. The bay is geographically sheltered from the open sea by a peninsula, and is under the influence of the warm Tsushima current and has a variety of environmental elements. Quantitative sampling of study materials were made regularly in the bay from April 1975 to November 1977. A small-scale trawl with a beam of 8 m in length was used to catch demersal fish, a pair of boat seine were used to catch pelagic fish and pelagic juveniles of both pelagic and demersal fish. Ichthyoplanktons were collected with step-oblique tows of a plankton net having a mouth diameter of 113 cm. 3. About 91 species and species-groups of larvae were collected by the plankton net tows. The dominant species or species groups in order were as follows: Gobiids, *Aqogon linea-tus,* Callionimids*, Rudarius ercodes, Sebastes inermis, Sebastiscus marmoratus, Engraulis japonicus, Enedrias nebulosus, Sillago japonica, Ammodytes personatus* and *Chromis notatus.*"

Keywords: *A. personatus*; Japan; distribution; growth; larvae; migration; seasonal variation; spawning.

Morin, R.; Dodson, J.; Power, G. 1980. Estuarine fish communities of eastern James-Hudson Bay coast. Environmental Biology Fisheries. 5(2): 135-141.

Keywords: *A. dubius; A. hexapterus*; Hudson Bay; abundance; distribution.

Morse, W. 1982. Spawning stock biomass estimates of sand lance, *Ammodytes* sp., off northeastern United States, determined from MARMAP plankton surveys, 1974-1980: Council meeting of the International Council for the Exploration of the Sea, G; [dates of meeting unknown]; [location unknown]. [Place of publication unknown]: [publisher unknown]. 59 p.

Keywords: *Ammodytes*; Atlantic (northwest); abundance; spawning.

Morse, W.W. 1989. Catchability, growth, and mortality of larval fishes. Fishery Bulletin. 87: 417-446.

Keywords: *Ammodytes*; fisheries; growth; larvae; mortality.

Motoda, S.; Iizuka, A.; Kurohagi, T. 1950. Ecological investigations on the young sand-eel around the coast of Hokkaido. I: Water temperature at fishing season, plankton at fishering ground, burrowing behaviour, body-length composition, and growth rate. Bulletin of the Hokkaido Regional Fisheries Research Laboratory. 7: 46-55.

Keywords: *Ammodytes*; Japan; behavior; ecology; growth.

Motoda, S.; Tanaka, Y. 1950. Ecological investigations on the young sand-eel around the coast of Hokkaido. II: Feeding habit. Scientific Papers of the Hokkaido Fisheries Scientific Institute. 7: 56-67.

Keywords: *Ammodytes*; Japan; ecology; food and feeding habits.

Mukai, R.; Bando, M. 1990. Study of coast important resource (sand lance). Aichi–Ken Suisan Shikenjo Gyomu Hokoku. 1989: 110-114.

Keywords: *A. personatus*; Japan; catch; ecology; habitat; larvae.

Munk, P.; Christensen, V.; Paulsen, H. 1986. Studies of a larval herring (*Clupea harengus*) patch in the buchan area; growth, mortality and drift of larvae. Dana–A Journal of Fisheries and Marine Research. 6: 11-24.

Keywords: *Ammodytes*; fisheries; growth; larvae; mortality.

Munk, P.; Nielsen, T.G. 1994. Trophodynamics of the plankton community at Dogger Bank: predatory impact by larval fish. Journal of Plankton Research. 16(9): 1225-1245.

“The trophodynamics of a coastal plankton community were studied, focusing on fish larvae and their copepod prey. The major objectives were to describe distributional overlap and evaluate the predatory impact by larval fish. The study was carried out across Dogger Bank in the North Sea, August-September 1991.”

Keywords: *A. lancea*; North Sea; competition; food and feeding habits; larvae.

Munro, J.A.; Clemens, W.A. 1939. The food and feeding habits of the red-breasted merganser in British Columbia. Journal of Wildlife Management. 3: 46-53.

Keywords: *A. hexapterus*; British Columbia; predators (birds, red-breasted merganser).

Murawski, S.A. 1993. Climate change and marine fish distributions: forecasting from historical analogy. Transactions of the American Fisheries Society. 122(5): 647-658.

Keywords: *A. americanus; A. dubius*; Atlantic Ocean; distribution; environmental effects; fisheries; seasonal variation; temperature.

Murawski, W.S. 1970. Marine fisheries investigations: study of the ichthyoplankton associated with two of New Jersey’s coastal inlets. [Place of publication unknown]: New Jersey Division of Fish and Game. 35 p.

Keywords: *A. americanus*; New Jersey; abundance; eggs; estuary; larvae; spawning.

Murphy, E.C.; Cooper, B.A.; Martin, P.D. [and others]. 1987. The population status of seabirds on St. Matthew and Hall Islands 1985 and 1986. [Place of publication unknown]: Minerals Management Service; OCS Study MMS 87-0043.

Keywords: *A. hexapterus*; Alaska; predators (birds).

Murphy, E.C.; Day, R.H.; Oakley, K.L.; Hoover, A.A. 1984. Dietary changes and poor reproductive performance in glaucous-winged gulls. The Auk. 101: 532-541.

“In 1979, fishes including sand lance, became prevalent in the diet only when hatching began. When mussels were prominent in the diet they had poor reproductive performance but a predominance of fishes coincided with high survivorship and rapid growth of chicks. Mussels are of low caloric value compared with other intertidal prey and are avoided by GW gulls foraging in intertidal zones. Mussels must be crushed in the gizzard and represent a high cost of digestion to gulls compared with other intertidal prey. Mussels in Alaska may be more difficult to digest because of higher shell thickness.”

Keywords: *A. hexapterus*; Alaska; importance; predators (birds, glaucous-winged gull).

Murphy, E.C.; Springer, A.M.; Roseneau, D.G. 1989. Recent climatic anomalies and the troubled reproduction of kittiwakes at the Alaskan colonies in the Bering and Chukchi Seas. In: Proceedings of the Arctic Science Conference, 40; [dates of meeting unknown]; [location unknown]. [Place of publication unknown]: [publisher unknown]. 27 p.

Keywords: *A. hexapterus*; Alaska; Bering Sea; abundance; environmental effects; predators (birds, black-legged kittiwake).

Murphy, E.C.; Springer, A.M.; Roseneau, D.G. 1991. High annual variability in reproductive success of kittiwakes (*Rissa tridactyla* L.) at a colony in western Alaska. Journal of Animal Ecology. 60: 515-534.

Spring air temperatures were highly correlated with break-up of sea ice, and these factors probably influenced seasonal warming trends in the sea water and the consequent availability of prey such as sandeels (*Ammodytes hexapterus*) near the colony.

Results are presented of a 15-year study at a colony in western Alaska where kittiwakes prey primarily on sand eels (*A. hexapterus*). Sand eels appear to be the primary prey of kittiwakes at Bluff. At Bluff and at colonies in the eastern Chukchi Sea, sand eels were less prevalent in kittiwake diets and size-at-age was smaller in midsummer following cold springs. At Bluff, sand eels comprised a lower percentage of the adult diet in 1976-77 than in 1979-82 and also were uncommon in the diets of chicks in 1983. Sand eels are not commercially harvested in this region, and no stock assessments have been made, but these observations suggest that availability of sand eels has differed considerably among years and was higher throughout the chick period in good reproductive years.

Keywords: *A. hexapterus*; Alaska; Bering Sea; Chukchi Sea; importance; predators (birds, black-legged kittiwake).

Murphy, M.A. 1995. Occurrence and group characteristics of minke whales, *Balaenoptera acutorostrata*, in Massachusetts Bay and Cape Cod Bay. Fishery Bulletin. 93(3): 577-585.

Keywords: *A. americanus*; Cape Cod Bay; Massachusetts Bay; predators (mammals, minke whale).

Murphy, M.L.; Thedinga, J.F.; Koski, K.V. 1988. Size and diet of juvenile Pacific salmon during seaward migration through a small estuary in southeastern Alaska. Fishery Bulletin. 86(2): 213-222.

“To assess competition and predation among juvenile Pacific salmon (*Oncorhynchus* spp.) migrating, through the estuary of Porcupine Creek, a small stream in southeastern Alaska, their size and diet were determined in 1979 and 1981. Mean fork length (FL) during May and June increased from 32 to 73 mm (1.5 mm/day) for pink salmon, *O. gorbuscha*; from 39 to 51 mm (0.4 mm/day) for chum salmon, *O. keta*; and during June and July, from 99 to 165 mm

(1.6 mm/day) for coho salmon, *O. kisutch*. Prey, in order of importance, included larval fish (mostly Gadidae), larval molluscs (Mesogastropoda), and calanoid copepods for pink salmon; larval molluscs, larvaceans, and hyperiid amphipods for chum salmon; and fish (*Clupea harengus* pallasi, *Ammodytes hexapterus*, and Gadidae), insects, and larval decapods (Brachyrhyncha) for coho salmon. No pink or chum salmon were found in the coho salmon stomachs. Prey size for pink and chum salmon was similar (median, 0.4 mm long for both species), and much smaller than that of coho salmon (median, 2.3 mm). Diet overlap was greater between pink and chum salmon than between either species and coho salmon. Pink salmon, however, ate almost exclusively (95%) pelagic prey, whereas chum salmon ate both pelagic (74%) and epibenthic (26%) prey. Rapid early growth and differences in diet probably help minimize predation and competition among salmon during seaward migration."

Keywords: *A. hexapterus*; Alaska; predators (fish, coho salmon).

Murray, J.; Burt, J.R. 1969. The composition of fish. Torry Advisory Note 38. H.M.S.O.

Keywords: *Ammodytes*; composition.

Myers, K.W. 1979. Comparative analysis of stomach contents of cultured and wild juvenile salmonids in Yaquina Bay, Oregon. In: Lipovsky, S.J.; Simenstad, C.A., eds. Gutshop 78: fish food habits studies: Proceedings of the 2d Pacific Northwest technical workshop; [dates of meeting unknown]; [location unknown]. Publ. WSG-WO-79-1. [Place of publication unknown]: Washington Sea Grant: 155-162.

Keywords: *A. hexapterus*; Oregon; predators (fish).

Myers, K.W.W. 1980. An investigation of the utilization of four study areas in Yaquina Bay, Oregon, by hatchery and wild juvenile salmonids. Corvallis, OR: Oregon State University. 233 p. M.S. thesis.

Keywords: *A. hexapterus*; Oregon; abundance; distribution.

Myrberget, S. 1962. Undersokelser over forplantnings biologien til lunde [*Fratercula arctica* (L.)]: egg, ruging og under. Meddelelser fra Statens Viltundersokelser. 2(11): 1-51. English summary.

Keywords: *Ammodytes*; predators (birds, puffin).

Nagashima, H.; Kobayashi, N.; Izumi, Y.; Kodama, J. 1995. Simulation on resource management of the sandeel, *Ammodytes personatus* Girard, in Sendai Bay. Miyagi–Ken Suisan Kenkyu Kaihatsu Senta Kenkyu Hokoku. 14: 51-53.

Keywords: *A. personatus*; Japan; Sendai Bay; fisheries; models; recruitment.

Nagoshi, M.; Kanda, T. 1979. Population studies of sand eel, *Ammodytes personatu*s, in Ise Bay. 2: Estimation of population size and fishing mortality. Bulletin of the Faculty of Fisheries Mie University. 6: 65-726.

Keywords: *A. personatus*; Japan; Ise Bay; abundance; fisheries.

Nagoshi, M.; Sano, M. 1979. Population studies of sand eel, *Ammodytes personatus*, in Ise Bay. I: Growth and its relation to population desnsity. Japan Journal of Ecology. 29: 1-10.

"The annual fluctuation of growth of sand eel collected from 1968 to 1977 was studied in relation to the population density in Ise Bay. There was no apparent sex difference in the growth in the first and second years of life. The population was divided into two groups, age 0 and I groups, based on the distribution of body length. Biweekly mean body length and mean body weight for each year-class remarkably fluctuated every year. A considerable yearly variation occurring in the growth was in close connection with the fluctuation of population density of age 0 group. A highly significant negative correlation existed between the growth in weight and the population density."

Keywords: *A. personatus*; Japan; Ise Bay; age; growth, length, weight.

Nagoshi, M.; Yuba, K. 1988. Variation of individual fish size in relation to population density of sand eel *Ammodytes personatus* in Ise Bay. Nippon Suisan Gakkaishi; Bulletin of the Japan Society of Scientific Fisheries. 54(6): 913-917.

“The chief factors affecting body length-variations of a sand eel *Ammodytes personatus* were studied in Ise Bay, Japan. Mean body size and growth rate of first year sand eel in fourteen year-classes varied considerably among the year-classes. The relative variation in individual fish size, coefficient of variation (CV), in each year-class was inversely related to population density and was thus density-dependent. The causes of density-dependent fluctuation of the variation are discussed.”

Keywords: *A. personatus*; Japan; Ise Bay; abundance; growth; length; weight.

Nairn, R.G.W. 1977. Fox V*ulpes vulpes* feeding on sand eels *Ammodytes*-sp. Irish Naturalists’ Journal. 19(4): 132.

Keywords: *A. tobianus*; predators (mammals, red fox).

Naito, M; Murakami, K.; Kobayashi, T. 1977. Growth and food habit of oceanic squids in the western subarctic Pacific region. In: Fisheries biology productivity in the subarctic Pacific region. Spec. Vol. Hakodate, Japan: University of Hokkaido, Research Institute of North Pacific Fisheries: 339-351.

Keywords: *Ammodytes*; predators (invertebrates, squid).

Nakai, K.; Kakuda, S.; Gushima, K. 1987. On the food habits of *Nibea albiflora* in the Seto Inland Sea Japan. Journal of the Faculty of Applied Biological Science, Hiroshima University. 26(1-2): 89-98.

“The food habits of *Nibea albiflora*, which is one of the most important fishing resources in Bisan–seto of the Seto Inland Sea, were studied through the qualitative and quantitative analysis of their stomach contents. Stomachs of 323 fish collected in the central regions of the Sea during the period from March ‘77 to June ‘79 were examined, although 120 of them were found to be empty. The stomachs of the remaining 203 fish with a standard length ranging from 49 mm to 435 mm were analyzed individually. The most important species of fish consumed was the sand eel (*Ammodytes personatus*). Fishes were the most important prey item in the > 200 mm size group, and sand eel was dominant in the stomachs of N. albiflora greater than 260 mm length. The total length of fish prey in the stomachs was 1/5-1/3 of the standard length of the predator.”

Keywords: *A. personatus*; Japan; Seto Inland Sea; importance; predators (fish, *Nibea albiflora*).

Nakamura, Y.; Nishikawa, T.; Miyahara, K. [and others]. 1995. Seto Inland Sea important aquatic life environment survey: sand lance fry distribution study. Hyogo Kenritsu Suisan Shikenjo Jigyo Hokoku. 1993: 40-44.

Keywords: *A. personatus; Japan*; Seto Inland Sea; catch; distribution; eggs; habitat; larvae; length.

Nakanishi, N. 1976. Feeding, fat deposits, and growth of sand-eels in Ise Bay, central Japan. Nihon Suisan-Gakkai Shi. 42(8): 831-835.

Keywords: *A. personatus*; Japan; Ise Bay; energetics; food and feeding habits; growth.

Nakashima, B.S. 1990. Escapement from a Diamond IX midwater trawl during acoustic surveys for capelin *Mallotus villosus* in the northwest Atlantic. Journal du Conseil, Conseil International pour l’Exploration de la Mer. 47(1): 76-82.

“Escapement from different parts of the Diamond IX midwater trawl was measured using experimental bags made of 6.43–mm–square mesh nylon attached to the outside of the trawl. The objective was to quantify the amount of escapment and to determine its effect on estimating the species composition and length frequency of capelin populations encountered during capelin acoustic surveys. Escapement was restricted primarily to the third and fourth bellies near the cod end. Escapement was not related to the catch weight in the cod end. Differences were observed in length frequencies between the experimental bags and cod end catches of capelin. Length frequencies were skewed to the left towards the smaller lengths for experimental bag catches compared with the cod end regardless

of the size of capelin encountered. In some instances, there were differences in species composition between the cod end and the experimental bags, especially when sand lance and Arctic cod were present. Escapement was greatest from the top of the trawl compared with the bottom and side in the vicinty of the fourth wedge and belly. A bias in the length frequency of the capelin catch or in the catch composition due to escapement is of concern when biomass estimates of capelin are calculated from acoustic airways."

Keywords: *Ammodytes*; Atlantic (northwest); fishing methods; length frequency.

Nakata, H. 1983. Physical processes of the transport of fish eggs and larvae. In: Symposium on review and problem of observation method of environment in the fishing ground Tokyo (Japan). Bulletin of the Japanese Society of Fisheries and Oceanography. 44: 100-104.

"On the basis of investigations in Japanese waters, the transport of fish eggs and larvae is discussed: (1) the differential distribution of eggs and larvae in the Seto Inland Sea corresponds well to the pattern of prevailing winds and, hence, their transport and dispersion from the spawning grounds are mostly subject to the change in the wind stress (2) a temperature front is lying between the Sagami Bay coastal water and off-shore water. The change in this front and an associated inflow of off-shore water strongly influence the coastward recruitment of eggs and larvae and (3) access to the vertical profiles of flows as well as the flow of the surface water on finer tempo-spatial scales is desirable for understanding the transport processes of these small animals."

Keywords: *A. personatus*; Japan; eggs; larvae; spawning.

Nakata, H. 1988. Wind effects on the transport of Japanese sand eel larvae in the eastern part of the Seto Inland Sea. Bulletin of the Japanese Society of Scientific Fisheries. 54(9): 1553-1561.

"The effects of the wind-induced surface drift on the larval transport of the Japanese sand eel *Ammodytes personatus* in the eastern part of the Seto Inland Sea are discussed on the basis of the results of a drift-card experiment and an analysis of the historical data on the distribution of the larval fish. The wind-induced changes in the recovery distribution of the drift-cards released from Shikano-se, one of the main spawning grounds located in the Sea of Harima, suggest that the prevailing wind, particularly its westerly component, affects the drift pattern of the sand eel larvae originating from this spawning ground. The strong westerly wind after the hatching of the larvae also contributed to the eastward transport of the larvae from spawning ground in the Bisan-Seto to the Sea of Harima."

Keywords: *A. personatus*; Japan; Seto Inland Sea; larvae; population dynamics; recruitment; stock assessment.

Nakata, H. 1995. How does the westerly wind in the winter affect sand lance recruitment? Bulletin of the Japanese Society of Fisheries Oceanography. 59(3): 322-324.

Keywords: *A. personatus*; environmental effects; larvae; recruitment.

Nakata, H.; Kimura, S.; Kishi, M.J.; Fujiwara, T. 1991. Environmental constraints on the sand lance population in the eastern Seto Inland Sea. Marine Pollution Bulletin. 23: 195-199.

"The Japanese sand lance is one of the commercially important fish in the coastal waters of Japan. The catch varies considerably due to the recruitment success or failure of the 0-age fish. The main spawning period is in winter (early December-early January). The eggs adhere to bottom sand for about 25 days, then hatch out and spend about 2 month pelagic period. The 0-age fish become a target of the fishery from late March to late June. After this they estivate in the bottom sand until early December, when they are matured and start to spawn."

Environmental contraints include wind-induced currents, water temperature and salinity, competition for prey, available habitat (i.e., sand banks), and adult predation on the larvae.

Keywords: *A. personatus*; Seto Inland Sea; environmental constraints; aestivation; fishery; larvae; spawning.

Narimatsu, Y.; Munehara, H.; Shimazaki, K. 1996. Difference in fishing period of naked sand lance, survival in embryo and larval period, and the relation with growth. Nippon Suisan Gakkai Taikai Koen Yoshishu. 1996: 51.

Keywords: *A. personatus*; eggs; growth; larvae.

Narver, D.W.; Dahlberg, M.L. 1965. Estuarine food of Dolly Varden at Chignik, Alaska. Transactions of the American Fisheries Society. 94: 405-408.

The authors report sand lance, capelin, whitespotted greenling, and silverspotted sculpin in order of frequency of occurrence in stomach contents of Dolly Varden.

Keywords: *A. hexapterus*; Alaska; Chignik; predators (fish, Dolly Varden).

Nash, R.D.M. 1986. Diel fluctuations of a shallow water fish community in the inner Oslofjord Norway. Marine Ecology (Pubbl. Stn. Zool. Napoli I). 7(3): 219-232.

“A shallow water fish community in the inner Oslofjord, Norway, was sampled with a beach seine at 4 h intervals over two 36 h periods (25-26th May and 28-29th September, 1982). Night length varied from 1 h in May to 11 h in September. Differences in the community composition were observed between May and September. The diversity of the fish community changed between the two months although the interpretation of the change was dependent on the method used to analyse the community. The three dominant species (*Gasterosteus aculeatus, Sprattus sprattus, and Ammodytes tobianus*) showed diel variations in catch rate which were out of phase with each other. The percentage of overlap in abundance of the dominant species was low. The summation of the individual periodicities resulted in a periodicity at the community level. There were fluctuations, over a diel cycle, in all the community parameters (number of indiviudals, number of species, species diversity [H’], species richness [D] and evenness [J’]) which affect measures of resource partitioning in fish communities and which should therefore be considered in ecological studies. Diel fluctuations in abundance of some individual shallow water species varied between seasons causing problems in population estimates.”

Keywords: *A. tobianus*; Norway; distribution; seasonal variation.

Natural Environment Research Council. 1985. The impact of grey and common seals on North Sea resources. [Place of publication unknown]: Natural Environment Research Council, Sea Mammal Research Unit; final report; contract no. ENV 665 UK(H) to the EEC.

Keywords: *Ammodytes*; North Sea; predators (mammals, grey seal, common seal).

Naumenko, E.A. 1997. The role of fish predators in pelagic ichthyocenosis of the western Bering Sea. In: Forage fishes in marine ecosystems: Proceedings of the international symposium on the role of forage fishes in marine ecosystems; [dates of meeting unknown]; [location unknown]. Prog. Rep. 97-01. [Fairbanks, AK]: University of Alaska Fairbanks, Alaska Sea Grant College: [pages unknown].

“In the western Bering Sea shelf the common facultative fish predators are pollock, Pacific cod, Pacific halibut, Greenland turbot, Kamchatka flounder, rainbow smelt, some species of sculpins, and others. The frequency of occurrence of fish prey in their stomachs averages 5% to 80%. The most frequent prey species are capelin; sand lance; and juvenile pollock, herring, saffron cod, and flatfishes.”

Pollock and Pacific cod feed rarely on sand lance. Rainbow smelt stomachs are often filled with either larvae or alevins of sand lance. From May to October, smelt consume up to 12 billion fish larvae and alevins (sand lance, capelin, pollock, or herring).

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (fish, rainbow smelt).

Neilson, J.D.; Gillis, D.J. 1979. A note on the stomach contents of adult Atlantic salmon (*Salmo salar* Linnaeus) from Port Burwell, Northwest Territories. Canadian Journal of Zoology. 57(7): 1502-1503.

“Stomach content analyses on 28 Atlantic salmon captured in late Aug. 1977, indicate that invertebrate prey items were the most important by volume. *Parathemisto libellula* dominated the invertebrate prey group, and *Ammodytes* sp. was the most important fish in the diet of the salmon analyzed. A range extension for *Notoscopelus elongtus kroeyeri* was recorded.”

Keywords: *Ammodytes*; Canada; Northwest Territories; importance; predators (fish, Atlantic salmon).

Nelson, B. 1966. The breeding biology of the gannet (*Sula bassana*) on the Bass Rock, Scotland. Ibis. 108: 584-626.

“Four of the principal food fishes of the gannet are probably herring, mackerel, saithe and sand-eels. The latter is not commercially significant and there is therefore little evidence available of any change in its abundance.”

Keywords: *Ammodytes*; Scotland; predators (birds, gannet).

Nelson, G.A. 1990. Population biology and dynamics of northern sand lance (*Ammodytes dubius*) from the Gulf of Maine to the middle Atlantic bight region. Amherst, MA: University of Massachusetts. 210 p. M.S. thesis.

Keywords: *A. dubius*; Atlantic (northwest); life history.

Nelson, G.A.; Ross, M.R. 1991. Biology and population changes of northern sand lance *Ammodytes dubius* from the Gulf of Maine to the middle Atlantic bight. Journal of Northwest Atlantic Fishery Science. 11: 11-28.

“Trends in temporal and spatial abundance, and population size structure of the sand lance, *Ammodytes dubius*, were examined based on trawl survey data from 1963 to 1988. Reproduction, age structure and growth were evaluated in 1986-88 from the Gulf of Maine to Middle Atlantic Bight region off eastern USA. Relative abundance indices which were near zero prior to 1976, increased dramatically (5-10 fold) from 1976 to 1981 in all regions studied. Subsequently, abundance dropped from 1982 to 1987. Gonadal recrudescence of *A. dubius* begins in late July and males appeared to mature earlier in a reproductive season than females. Estimates of fecundity ranged from 1,169 to 22,904 ova per female for sand lance 137 to 213 mm total length. Maximum age estimated for otoliths and vertebrae was 5 years. Age at 50% maturity was age II for all regions in spring. Comparison of Von Bertalanffy growth curves derived for *A. dubius* from the study regions to published values from Newfoundland and Nova Scotia suggests a decline in length and age with declining latitude.”

Keywords: *A. dubius*; Atlantic (northwest); age; fecundity; growth; maturation; meristics; otoliths; reproduction; seasonal variation.

Nelson, G.A.; Ross, M.R. 1992. Estimates of gastric evacuation and consumption rates in little skate (*Raja erinacea*): Council meeting of the International Council for the Exploration of the Sea; [dates of meeting unknown]; Rostock-Warnemuende, Germany. [Place of publication unknown]: [publisher unknown]. 15 p.

“Estimates of prey consumption by fishes are important for understanding predator-prey interactions in multispecies fish communities. Laboratory studies of gastric evacuation and twenty-four hour diel samples of stomachs were used to estimate daily consumption of benthic prey by little skate (*Raja erinacea*) on Georges Bank. Gastric evacuation was determined at 10 °C using polychaetes (*Glycera* spp.), krill (*Meganictiphanes norvegica*), clams (*Spisula solidissima* and *Placopecten magellanicus*) and sand lance (*Ammodytes dubius*), and at 16 °C using polychaetes (*Nereis* spp.) and shrimp (*Palaemonetes* spp. and *Crangon septimspinosus*) as prey. Evacuation data for polychaetes, krill, clams and sand lance at 10 °C are modelled best by linear and square root equations. At 16 °C, exponential and logistic models described the evacuation data for polychaetes and shrimp best. Estimates of seasonal daily ration (expressed as a percentage of body weight (BW)) ranged from 0.47% to 1.74% BW for little skates 10-19 cm in length to 0.08% to 0.77% BW for skates 50-59 cm in length. Annual consumption ranged from 0.085 kg fish^{-1} yr^{-1} for 10-19 cm little skates to 0.860 kg fish^{-1} yr^{-1} for 50-59 cm little skates.”

Keywords: *A. dubius*; Atlantic (northwest); predators (fish, little skate).

Nelson, G.A.; Ross, M.R. 1995. Gastric evacuation in little skate. Journal of Fish Biology. 46(6): 977-986.

“The effects of prey type and prey preparation on the mathematical forms and rates describing gastric evacuation in little skate *Raja erinacea* were examined. Linear and square-root models best described the gastric evacuation of whole, thin-shelled krill *Meganyctiphanes norvegica*, clam feet/muscle *Spisula solidissima/Placopecten magellanicus*, polychaetes *Glycera* spp. and sand lance *Ammodytes dubius*. Evacuation of krill and clams was faster than polychaetes and sand lance. A logistic model best described the evacuation data of thick-shelled benthic shrimp *Crangon septemspinosa/Palaemonetes* spp. Cut polychaetes *Nereis* spp. were digested at an exponential rate and were evacuated faster than would be predicted based upon comparison with live polychaetes and previously published evacuation-temperature relationships. The results of this study suggest that a single equationd [sic] evacuation process for all prey, and that whole prey should be used if laboratory-derived rates of gastric evacuation are to reflect what might occur in wild fishes.”

Keywords: *A. dubius*; Atlantic (northwest); predators (fish, little skate).

Nelson, J.S. 1994. Fishes of the world. 3d ed. New York: John Wiley and Sons.

Sand lances are found in marine waters, both cold and tropical. They occur in the Arctic, Atlantic, Indian, and Pacific Oceans.

“Body elongate; premaxilla protractile (except in *Hyperoplus*); caudal fin forked; dorsal and anal fin spines absent; lower jaw projecting forward beyond upper jaw with symphysial process; scales cycloid, minute, arranged in oblique rows; pelvic fins usually absent (jugular and with one spine and four or five soft rays in *Embolichthys*); lateral line high, close to dorsal fin; no teeth; single long dorsal fin usually with 40-69 soft rays; anal fin rays 14-36; seven branchiostegal rays; gill membranes separate; no swim bladder; vertebrae 52-78. Length up to 30 cm.

“The ammodytids have been added to the trachinoids as a possible sister group to Trachinidae plus Uranoscopidae.

“Five genera, *Ammodytes, Bleekeria* (perhaps = *Ammodytoides*), *Embolichthys, Gymnammodytes*, and *Hyperoplus*, with about 18 species.”

Keywords: *Ammodytidae*; classification; description; distribution.

Nelson, K.S.; Hamer, T.E. 1995. Nesting biology and behavior of the marbled murrelet. In: Ralph, C.J.; Hunt, G.L., Jr.; Raphael, M.G.; Piatt, J. F., eds. Ecology and conservation of the marbled murrelet. Gen. Tech. Rep. PSW-GTR-152. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 57-67.

Chicks are usually fed at least once a day for the 27 to 40 days they are in the nest, although the frequency is variable and sometimes decreases prior to fledging. Feedings occur from 90 minutes before to 71 minutes after sunset. To provide chicks with fish at dawn, adults probably forage at night, perhaps taking advantage of fish that forage near the water surface during darkness. Fish species fed to chicks at nests include Pacific sand lance.

Keywords: *A. hexapterus*; predators (birds, marbled murrelet).

Nemoto, T. 1957. Foods of baleen whales in the northern Pacific. Scientific Reports of the Whales Research Institute, Tokyo. 12: 33-89.

Keywords: *Ammodytes*; predators (mammals, humpback whale, little piked whale).

Nemoto, T. 1959. Food of baleen whales with reference to whale movements. Whales Research Institute Scientific Report. 14: 149-290.

Keywords: *Ammodytes*; predators (mammals, baleen whales).

Nemoto, T. 1993. Reproduction study of the important coastal fish species: sandeel. Ibaraki–Ken Suisan Shikenjo Jigyo Hokoku. 1992: 82-88, 90-113.

Keywords: *A. personatus*; Japan; catch; growth; larvae; maturation.

Nerini, M. 1984. A review of gray whale feeding ecology. In: Jones, M.L.; Swartz, S.L.; Leatherwood, S., eds. The gray whale, *Eschrichtius robustus*. Orlando, FL: Academic Press: 423-450.

Keywords: Ammodytidae; predators (mammals, gray whale).

Nettleship, D.N. 1970. Breeding success of the common puffin (*Fratercula arctica*) on different habitats on Great Island, Newfoundland. [Place or publication unknown]: McGill University. Ph.D. dissertation.

Keywords: *Ammodytes*; Newfoundland; predators (birds, Atlantic puffin).

Nettleship, D.N. 1991. The diet of Atlantic puffin chicks in Newfoundland before and after the initiation of an international capelin fishery, 1967-1984. In: Furness, R.W.; Nettleship, D.N., eds. Proceedings of the symposium on seabirds as monitors of changing marine environments. In: International Ornithological Congress; 20: 2263-2271.

Presents the percentage of sand lance delivered to puffin chicks at Great Island, Newfoundland, 1967-84.

Keywords: *Ammodytes*; Newfoundland; predators (Atlantic puffin).

Nettleship, D.N.; Sanger, G.A.; Springer, P.F. 1984. Winter feeding ecology and trophic relationships of oldsquaws and white-winged scoters on Kachemak Bay, Alaska. In: Sanger G.A.; Jones, R.D., Jr. Marine birds: their feeding ecology and commercial fisheries relationships. Ottawa, ON: Canadian Wildlife Service; Seattle, WA: [publisher unknown]: 20-28.

“The feeding ecology of Oldsquaws (*Clangula hyemalis*) and White-winged Scoters (*Melanitta fusca*) was studied on Kachemak Bay from November 1977 through April 1978. Oldsquaws were extreme generalists, eating at least 61 prey species. The most important were the Pacific sandlance (*Ammodytes hexapterus*), Stimpson’s surf clam (*Spisula polynyma*), and blue mussel (*Mytilus edulis*). Scoters were generalists on molluscs, mostly bivalves. They ate at least 22 prey species; the most important were the common Pacific littleneck clam (*Protothaca staminea*), blue mussel, and puppet margarite snail (*Margarites pupillus*). There was little overlap in kinds of prey between the two ducks, and when it occurred the scoters ate significantly larger prey.”

Keywords: *A. hexapterus*; Alaska; Kachemak Bay; predators (birds, oldsquaw).

Nevinskiy, M.M.; Mokanu, I.D. 1971. Nekotoryye nablyudeniya za peshchankoy u poberezh’ya Zapadnoy Grenlandii osen’yu 1966 g. Materialy rybokhozyaystvennykh issledovaniy Severnogo basseyna: Some observations on the sand lance off the coast of Western Greenland in autumn 1966. Materials from fisheries research in the northern basin. No. 17. [Place of publication unknown]: [publisher unknown].

Keywords: *Ammodytes*, Greenland.

Newman, M.W. 1982. Vertebral anomalies of *Ammodytes* sp., a potential biological indicator of water quality: Council meeting of the International Council for the Exploration of the Sea 49; [dates of meeting unknown]; [location unknown]. [Place of publication unknown]: [publisher unknown]: 1-5.

Keywords: *Ammodytes*; environmental impacts; meristics; morphology; water quality.

Nichols, J.T.; Murphy, R.C. 1944. A collection of fishes from the Panama bight, Pacific Ocean. Bulletin of the American Museum of Natural History (New York). 83(4): 221-260.

“Most species are listed with localities, depth, sizes and remarks on capture. Some with comments on ecology and/or taxonomy.”

Keywords: Ammodytidae; distribution; taxonomy.

Nikiforov, M.I. 1958. Sand lance fishing in the North Sea. Rybnoe kh-vo. 9: [pages unknown].

Keywords: *Ammodytes*; North Sea; fisheries.

Nilssen, K.T. 1995. Seasonal distribution, condition and feeding habits of Barents Sea harp seals (*Phoca groenlandica*). In: Blix, A.S.; Walloe, L; Ulltang, O., eds. Whales, seals, fish and man: Proceedings of the international symposium on the biology of marine mammals in the north east Atlantic; 1994 Nov. 29-Dec. 1; Tromsø, Norway. [Place of publicaton unknown]: [publisher unknown]: 241-254.

Keywords: *Ammodytes*; White Sea; predators (mammals, harp seal).

Nilssen, K.T.; Haug, T.; Potelov, V. [and others]. 1995. Food habits of harp seals (*Phoca groenlandia*) during lactation and moult in March-May in the southern Barents Sea and White Sea. International Council for the Exploration of the Sea Journal of Marine Science. 52(1): 33-41.

“In the White Sea in April-May, moulting harp seals had been feeding mainly on crustaceans, sandeels (*Ammodytes* spp.), capelin and White Sea herring (*Clupea harengus marisalbi*). Feeding of moulting seals in the East Ice and in the White Sea area appeared to have been less intensive than further west.”

Keywords: *Ammodytes*; White Sea; predators (mammals, harp seal).

Nisbet, I.C.T. 1973. Courtship-feeding, egg size and feeding success in common terns. Nature. 241: 141-142.

Keywords: *Ammodytes*; predators (birds, common tern).

Nisbet, I.C.T. 1977. Courtship-feeding and clutch size in common terns *Sterna hirundo*. In: Stonehous, B.; Perrins, C., eds. Evolutionary ecology. London: Macmillan Press: 101-109.

Keywords: *Ammodytes*; predators (birds, common tern).

Nisbet, I.C.T. 1981. Biological characteristics of the roseate terns *Sterna dougallii*. Newton Corner. MA: U.S. Fish and Wildlife Service, Office of Endangered Species. 112 p. [Purchase order 50181-1840-9].

Keywords: *Ammodytes*; predators (birds, roseate tern).

Nisbet, I.C.T. 1983. Paralytic shellfish poisoning effects on breeding terns. Condor. 85(3): 338-345.

“Common terns (*Sterna hirundo*, > 70) and lesser numbers of other terns and gulls were killed on June 11-12, 1978, by paralytic shellfish poisoning (PSP; toxin of the dinoflagellate *Gonyaulax excavata*) at a breeding colony in Massachusetts [USA]. PSP toxin was detected at lethal levels in sand launce (*Ammodytes americanus*), the terns’ principal food. Most terns that died were females in prelaying condition; other birds vomited and survived. Breeding performance of survivors was unaffected. Mortality was greatest in 3 yr old birds; 10-25% of 3 yr old females were killed. Although PSP toxin was present in local shellfish for @ 3 wk, tern mortality was limited to a few hours on 2 days. Much higher levels of toxin were detected in shellfish at other parts of the Massachusetts coast in 1978 and other years, but terns and other susceptible seabirds were unaffected.”

Keywords: *A. americanus*; Massachusetts; paralytic shellfish poisoning; predators (birds, arctic tern, common tern, roseate tern).

Nisbet, I.C.T. 1989. Status and biology of the northeastern population of the roseate tern. Newton Corner, MA: U.S. Fish and Wildlife Service. 74 p. [Purchase order 50181-88-81085].

Keywords: *Ammodytes*; predators (birds, roseate tern).

Nisbet, I.C.T.; Drury, W.H. 1972. Measuring breeding success in common and roseate terns. Bird-Banding. 43: 97-106.

Keywords: *Ammodytes*; predators (birds, common tern, roseate tern).

Nishiyama, T. 1974. Energy requirements of Bristol Bay sockeye salmon in the central Bering Sea and Bristol Bay. In: Hood, D.W.; Kelly, E.J., eds. Oceanography of the Bering Sea with emphasis on renewable resources. Occas. Publ. 2. Fairbanks,AK: University of Alaska, Fairbanks, Institute of Marine Science: 321-343.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (fish, sockeye salmon).

Nizinski, M.S.; Collette, B.B.; Washington, B.B. 1990. Seperation of two species of sand lances, *Ammodytes americanus* and *A. dubius*, in the western North Atlantic. U.S. National Marine Fisheries Service, Fishery Bulletin. 88(2): 241-255.

“Two species of sand lances are recognized in the western North Atlantic, the inshore *Ammodytes americanus* DeKay 1842 and the offshore *A. dubius* Reinhardt 1838. The best separation of the two species is achieved by using the number of plicae (oblique folds of skin on the lateral body surface) singly or in combination with the number of vertebrae. *Ammodytes americanus* has fewer meristic structures than *A. dubius*: number of lateral plicae 106-126, .hivin.x 117.4 vs. 124-147, 132.1; total vertebrae 62-70, .hivin.x 66.4 vs. 68-76, 70.8; dorsal fin rays 52-61, .hivin.x 57.4 vs 56-67, 61.8; anal fin rays 26-33, .hivin.x 29.4 vs. 28-35, 31.1; pectoral fin rays 11-15, .hivin.x 13.2 vs. 12-16, 14.0; gill rakers on first arch 21-28, .hivin.x 24.3 vs. 23-31, 26.6. Meristic differences between species were summarized with principle component analysis. In addition to considerable variation within samples, there is geographic variation in numbers of vertebrae, plicae, and dorsal and anal fin rays, particularly in the offshore *A. dubius*. Specimens from the Scotian Shelf north have higher counts than do specimens from more southern populations. Based on specimens examined, *A. americanus* occurs from southern Delaware north to Labrador in shallow coastal waters as well as in protected bays and estuaries. *Ammodytes dubius* is found in deeper, open waters from North Carolina to Greenland.”

Keywords: *A. americanus*; *A. dubius*; meristics; morphology; taxonomy.

Nolf, D. 1978. Les otolithes des teleosteens du plio–pleistocene belge. Geobios. 11(4): 517-559.

Keywords: *Ammodytes*; fossils; otoliths.

Nolf, D.; Lapierre, H. 1976. Otoliths of teleosts of the shell sands of bois-gouet eocene of Brittany France. Biologisch Jaarboek. 44: 256-268.

“A total of 1622 teleost otoliths were obtained by washing about 1500 kg sediment of the Sables du Bois-Gouet. The presence of 22 spp. was revealed. Among them, 2 are new: *Atherina margereli* and *Ammodytes vasseur*i. The assemblage is indicative of a tropical to subtropical very shallow marine environment, and is rich in Pomadasyidae. The fauna seems to indicate a stratigraphic position nearthe Lutetian-Bartonian limit for the Sables du Bois-Gouet.”

Keywords: *A. vasseuri*; fossils; otoliths.

Norcross, B.L.; Frandsen, M. 1996. Distribution and abundance of larval fishes in Prince William Sound, Alaska, during 1989 after the *Exxon Valdez* oil spill. In: Rice, S.D.; Spies, R.B.; Wolfe, D.A.; Wright, B.A., eds. Proceedings of the *Exxon Valdez* oil spill symposium. In: American Fisheries Society Symposium; 18: 463-486.

Of interest is that Pacific sand lance was one of the least abundant larval fishes recovered after the oil spill. The authors cite other studies in Alaska where sand lance are among the most abundant. Also, numerous studies point to sand lance being a major food of birds in Prince William Sound. The authors do not discuss sand lance but make the statement, “Unfortunately, it is biased as a baseline because it represents the ecosystem following an oil spill.”

Keywords: *A. hexapterus*; Alaska; Prince William Sound; abundance.

Norcross, J.J.; Massmann, W.H.; Joseph, E.B. 1961. Investigations of inner continental shelf waters off lower Chesapeake Bay. Part II: Sand lance larvae, *Ammodytes americanus*. Chesapeake Science. 2(1/2): 46-59.

“Plankton samples were collected monthly from 22 stations in the Atlantic Ocean and 3 in Chesapeake Bay. Numerous larvae of sand lance, *Ammodytes americanus*, were taken from January through April, 1960. Larvae were widely distributed over the survey area but were most abundant beyond 25 miles from shore. Statistical analysis of sample mean lengths indicated movement offshore and a tendency for a group hatched together to remain together. Rate of larval development was approximated at 11.7 mm per month for the first four months. It is believed that spawning occurred at 5-12 fathoms in the study area. Hatching began in late November, reached a peak sometime after mid-December, and continued until mid-March. Few larvae were collected in waters with salinities less than 30%.

“In the summer during high tide, sand lances often swarm onto sandy beaches above the low-water mark where they burrow into the sand and reappear with the next high tide. Sand lances play an important role in the economy of northern seas by providing food for such fishes as cod, halibut, haddock, silver hake, salmon, mackerel, striped bass, bluefish and white marlin. Einarsson (1951) pointed out that areas where these fishes are abundant are extremely fertile fishing grounds and owe their fertility in a high degree to the presence of shoals of these fishes. Flounders *Paralichthys dentatus* also feed on sand lances and trawlers observing traces of sand lance on their echo sounders would trawl almost always catching flounders.”

Keywords: *A. americanus*; Atlantic; Chesapeake Bay; abundance; distribution; larvae; importance; predators (fish); seasonal variation.

Nordoy, E.S.; Folkow, L.P.; Martensson, P.-E.; Blix, A.S. 1995. Food requirements of northeast Atlantic minke whales. In: Blix, A.S.; Walloe, L.; Ulltang, O., eds. Whales, seals, fish and man: Proceedings of the international symposium on the biology of marine mammals in the north east Atlantic; 1994 Nov. 29-Dec. 1; Tromsø, Norway. [Place of publication unknown]: [publisher unknown]: 307-317.

Keywords: *Ammodytes*; Atlantic (northeast); predators (mammals, minke whale).

Nordoy, E.S.; Martensson, P-.E.; Lager, A.R. [and others]. 1995. Food consumption of the northeast Atlantic stock of harp seals. In: Blix, A.S.; Walloe, L; Ulltang, O., eds. Whales, seals, fish and man: Proceedings of the international symposium on the biology of marine mammals in the north east Atlantic; 1994 Nov. 29-Dec. 1; Tromsø, Norway. [Place of publication unknown]: [publisher unknown]: 255-260.

Keywords: *Ammodytes*; Barent’s Sea; predators (mammals, harp seal).

Norman, D. 1992. The growth rate of little tern *Sterna albifrons* chicks. Ringing and Migration. 13(2): 98-102.

“One hundred and six Little Tern chicks have been weighed and had their wing length measured in the colony at Gronant, Clwyd, Wales [UK], in two different years. Forty of them were re-measured on dates at least six days later and growth rates calculated. There were big differences in the weather in the two years of this study but no difference in growth rate. Chicks put on weight quickly and reached close to their full weight at an age of about 10 days. After an initial period of two or three days with little growth, wing length increased approximately linearly at a rate

between 6.5 and 7.5 mm/day, with a mean of 6.8 +/- 0.2 mm/day. Chick could just fly at 14 or 15 days of age, with wing length of about 100 mm, some 70 mm shorter than the mean wing lengths of fully-grown juveniles. They were fed on small fish, mainly sandeels and 'Whitebait', and satiated chicks were frequently seen to refuse food. The growth rate measured here is probably close to the maximum achievable in this habitat and possibily limited only by the birds' metabolism."

Keywords: *Ammodytes*; Wales; predators (birds, little tern).

Nozawa, K. 1997. Sandeel caught in the south of Iwate Prefecture in spring, 1996. Tohoku Sokouo Kenkyu. 17: 3-8.

Keywords: *A. personatus.*

Oakley, K.L. 1981. Determinants of population size of pigeon guillemots on Naked Island, Prince William Sound, Alaska. Fairbanks, AK: University of Alaska. M.S. thesis.

Keywords: *A. hexapterus*; Alaska; Prince William Sound; predators (birds, pigeon guillemot).

Oakley, K.L. 1990. Assessment of injury to waterbirds from the *Exxon Valdez* oil spill: effects on the population and reproductive success of pigeon guillemots in Prince William Sound. Unpublished report. On file with: U.S. Fish and Wildlife Service, Anchorage, AK.

Keywords: *A. hexapterus*; Alaska; Prince William Sound; predators (birds, pigeon guillemot).

Oakley, K.L.; Kuletz, K.J. 1996. Population, reproduction and foraging ecology of pigeon guillemots at Naked Island, Prince William Sound, Alaska, before and after the *Exxon Valdez* oil spill. American Fisheries Society Symposium. 18: 759-769.

Pacific sand lance were the most observed fish being brought to pigeon guillemot chicks at Naked Island before the oil spill. Chick feeding observations suggested changes in the availability of cods, Pacific herring, and Pacific sand lance, prespill to postspill. Cods were used more frequently after the spill, and Pacific sand lance were used less frequently. Whether changes in the apparent availability of these species were caused by the oil spill is unknown.

Keywords: *A. hexapterus*; Alaska; Prince William Sound; oil pollution; predators (birds, pigeon guillemot).

O'Clair, R.M.; Armstrong, R.H.; Carstensen, R. 1992. The nature of southeast Alaska. Seattle, WA: Alaska Northwest Books. 254 p.

Presents an observation of Pacific sand lance behavior and predators on the Mendenhall wetlands in Juneau. Up to 85 bald eagles have been observed at one time feeding on sand lance. Northwestern crows have been observed excavating hiding sand lances from 4-inch-deep pits.

Keywords: *A. hexapterus*; Alaska; southeast; behavior; predators (birds, bald eagle, northwestern crow).

O'Connell, M.; Fives, J.M. 1995. The biology of the lesser sand-eel *Ammodytes tobianus* l. In the Galway Bay area. Biology and Environment. 95b(2): 87-98.

"Two separate spawning components of a population of *Ammodytes tobianus* (Pisces, Ammodytidae) were recorded off the west coast of Ireland. The two groups were distinguished principally by differences in the size of the opaque centre of the otoliths. There was also a significant difference between the mean vertebral number of the spring, and autumn-spawned fish. A sample of 219 spring-spawned and 574 autumn-spawned fish were examined during the period November 1987 to August 1989. The spring spawning period was December to February and the first influx of spring-spawned juveniles occurred in June. The autumn spawning period was in August and September and

autumn-spawned juveniles were captured in January. The most recent year-classes dominated the age structure of the population. Peak feeding intensity for both soups coincided with a peak growing period in April. All guts were empty from mid-December to early March. Copepods, mainly planktonic, formed the major food items but mysids were more important in July and August."

Keywords: *A. tobianus*; Ireland; age; food and feeding habits; otoliths; spawning.

O'Connell, M.; Fives, J.M. 1996. Sandeel species recorded in the Inishmore area, co Galway. Irish Naturalists' Journal. 25(6): 207-209.

Keywords: *A. tobianus*; Ireland; distribution; habitat; meristics.

Ogi, H.; Kudobera, T.; Nakamura, K. 1980. The pelagic feeding ecology of the short-tailed shearwater *Puffinus tenuirostris* in the subarctic Pacific region. Journal Yamashima Institute Ornithology. 12: 157-182.

Keywords: *Ammodytes*; predators (birds, short-tailed shearwater).

Ogi, H.; Tanaka, H.; Tsujita, T. 1985. The distribution and feeding ecology of murres in the northwestern Bering Sea. Journal Yamashina Institute Ornithology. 17: 44-56.

Keywords: *A. hexapterus*; Bering Sea; predators (birds, common murre).

Ogi, H.; Tsujita, T. 1973. Preliminary examination of stomach contents of murres *Uria*-spp from the eastern Bering Sea and Bristol Bay Alaska USA June-August 1970 and 1971. Japanese Journal of Ecology. 23(5): 201-209.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (birds, common murre).

Ohshima, Y. 1950. (*Ammodytes personatus* Girard.) Biological notes on the sand-eel *Ammodytes personatus* Girard. Bulletin of the Japanese Society Scientific Fisheries. 16(3): 99-107.

Keywords: *A. personatus*; biology.

Okaichi, T. 1974. Significance of amino-acid composition of phyto plankton and suspensoid in marine biological production. Bulletin of the Japanese Society of Scientific Fisheries. 40(5): 471-478.

Keywords: *A. personatus*; composition; food and feeding habits.

Okamoto, H. 1989. A genetic comparison of sympatric populations of sand lance genus *Ammodytes* from the region east of Cape Soya Japan. Canadian Journal of Fisheries and Aquatic Sciences. 46(11): 1945-1951.

"Sand lance (Genus *Ammodytes*) collected from four stations off Japan and one station at Kodiak, Alaska [USA], were genetically characterized at 17 protein coding loci using starch-gel electrophoresis. Sand lance in Wakkanai (Cape Soya, Japan) consist of two genetically distinct groups. They are fixed for different alleles at four loci (Ldh–2,–3, G3pdh–2, and Mdhp–2). The genetic structure of one of the groups (Wakkanai–a group, W–a) is similar to that of *A. personatus* around Japan. The other group (Wakkanai–b group, W–b) has different genetic structure from either *A. personatus* or the Alaskan collection, which is presumed to belong to *A. hexapterus*. It is not presently possible to identify the affiliation of the W–b group; however, despite its sympatry with the W–a group, it is reproductively isolated and therefore is probably a distinct species occurring northeast of Hokkaido."

Keywords: *A. hexapterus; A. personatus*; Alaska; Kodiak; Japan; genetics.

Okamoto, H.; Sato, H.; Shimazaki, K. 1989. Comparison of reproductive cycle between two genetically distinctive groups of sand lance (genus *Ammodytes*) from northern Hokkaido. Bulletin of the Japanese Society of Scientific Fisheries. 55(11): 1935-1940.

“Two genetically distinct groups of sand lance *Ammodytes* are distributed sympatrically at the region east of Cape Soya (Japan). Monthly changes of gonosomatic indices and histological characteristics were investigated to understand their reproductive cycles. The spawning period was found to be late November to January in one group and late March to early May in the other group. The difference in their spawning period plays an important role as a mechanism for reproductive isolation between them.”

Keywords: *A. personatus*; Japan; distribution; genetics; spawning.

Okamoto, H.; Yamazaki, F.; Mishima, S. 1988. Genetic divergence among sand-lance *Ammodytes personatus* populations in Japan. Nippon Suisan Gakkaishi. Bulletin of the Japanese Society of Scientific Fisheries. 54(8): 1297-1304.

“Genotypes at 10 enzyme loci were analyzed by horizontal starch gel electrophoresis for each of 11 populations of sand-lance *Ammodytes personatus* in Japan. Allele frequencies at each locus were calculated for each population. There were clear differences of allele frequencies at three loci (alpha –Gpdh, Me–2, Sod) between populations north of Iwate Prefecture and those south of Miyagi Prefecture. A cluster analysis based on genetic similarities calculated from allele frequencies at all 10 loci observed suggests that sand-lance along the Pacific coast of Japan are composed of two population groups northern and southern groups. The boundary exists between Iwate and Miyagi Prefecture.”

Keywords: *A. personatus*; Japan; genetics; stocks.

Okamoto, S.; Tanda, M.; Moriwaki, H. 1989. Predation of larvae of the sand eel *Ammodytes personatus* by parent fish in Harima–Nada (short paper). Hyogo Kenritsu Suisan Shikenjo Kenkyu Hokoku. 26: 65-67.

Keywords: *A. personatus*; Japan; Seto Inland Sea; cannibalism; distribution; habitat; larvae.

Okata, A. 1995. Role of sand lance as prey in the community. Bulletin of the Japanese Society of Fisheries Oceanography. 59(3): 324-326.

Keywords: *A. personatus*; Japan; ecology; predation.

Okawa, M.; Tamura, W. 1992. Study of resources and ecology of sandeel. Aomori–Ken Suisan Shikenjo Jigyo Hokoku. 1990: 116-126.

Keywords: *A. personatus*; Japan; catch; distribution; habitat; larvae.

Okill, J.D.; Fowler, J.A.; Ellis, P.M.; Petrie, G.W. 1992. The diet of cormorant *Phalacrocorax carbo* chicks in Shetland in 1989. Seabird. 14: 21-26.

“Samples of food regurgitated by cormorant chicks (*Phalacrocorax carbo*) in four Shetland colonies comprised thirteen species of fish of a wide range of sizes and a single edible crab. There was considerable variation in diet between colonies, probably reflecting the local availability of the different prey species. It is thought that the catholic diet of the cormorant has enabled it to maintain its breeding success when a number of smaller seabird species in Shetland have had poor breeding success due to a reduction in the availability of sandeels.”

Keywords: *Ammodytes*; Shetland; importance; predators (birds, cormorant).

Olesiuk, P.F.; Bigg, M.A.; Ellis, G.M. [and others]. 1990. An assessment of the feeding habits of harbour seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia, based on scat analysis. Canadian Technical Report of Fisheries and Aquatic Sciences. 1730: 1-135.

Keywords: *A. hexapterus*; Canada; British Columbia; Strait of Georgia; predators (mammals, harbour seal).

Olsen, M.; Bjorge, A. 1995. Seasonal and regional variations in the diet of harbour seal in Norwegian waters. In: Blix, A.S.; Walloe, L.; Ulltang, O., eds. Whales, seals, fish and man: Proceedings of the international symposium on the biology of marine mammals in the north east Atlantic; 1994 Nov. 29-Dec. 1; Tromsø, Norway. [Place of publication unknown]: [publisher unknown]: 271-285.

Keywords: *Ammodytes*; Norway; predators (mammals, harbor seal).

Olson, S.L.; Swift, C.C.; Mokhiber, C. 1979. An attempt to determine the prey of the great auk *Pinguinus impennis.* Auk. 96: 790-792.

Keywords: *Ammodytes*; predators (birds, great auk).

Olsthoorn, H. 1987. Jackdaws stealing food from breeding guillemots. British Birds. 80(3): 117-118.

“On several occasions during 1982-84 at the Bullers of Bachun seabird colonies north of Aberdeen, Grampian, the author saw jackdaws *Corvus monedula* stealing fish, mainly sand-eels *Ammodytes,* from chick-tending guillemots *Uria aalge*. Although the jackdaws concentrated mainly on fish which had been dropped on to the breeding ledges and at the base of the cliffs, they also looked for guillemots carrying fish. Usually, a jackdaw walked up to an adult guillemot and snatched the fish.”

Keywords: *Ammodytes*; Britain; predators (birds, guillemot, jackdaw).

Omori, A.; Sakurai, S. 1987. Characteristics of the sand eel, *Ammodytes personatus*, as raw materials for food processing. Seasonal variation of ingredients of sand eel meat. Ibaraki–Ken Suisan Shikenjo Jigyo Hokokusho. 1986: 198-202.

Keywords: *A. personatus*; composition; fisheries; lipid content.

Ono, K.; Nakamura, Y. 1993. The biology of nesting Japanese murrelets on Biroto Island (Kadokawa-cho, Miyazaki pref.). In: Ono, K., ed. Symposium on the Japanese murrelet: its status and conservation; annual meeting of Japanese Ornithological Society; 1993 Oct. 11: [location unknown]. [Place of publication unknown]: [publisher unknown].

Keywords: *Ammodytes*; Japan; predators (birds, Japanese murrelet).

Ono, K.; Nakamura, Y. 1994. Current status and breeding ecology of Japanese murrelets (abstract). Pacific Seabirds. 21(1): 47.

Keywords: *Ammodytes*; Japan; predators (birds, Japanese murrelet).

Orlova, E.L.; Chumakov, A.K. 1993. Comparative study of the intensity of feeding of cod (*Gadus morhua*) off Newfoundland and of the southern Barents Sea. In: Amaratunga, T., ed. Changes in abundance and biology of cod stocks and and their possible cause symposium; [dates of meeting unknown]; [location unknown]. In: Northwest Atlantic Fisheries Organization Scientific Council Studies; 18: 91-92.

“Food consumption investigations formed the basis for the construction of multi-type models in this study. The Arcto-Norwegian cod distribution is close to that of the Newfoundland cod, and hence similarities in rate of growth and sexual maturing, and also hydrological conditions and food composition, with the exception of sand eel (*Ammodytes* sp.), are known (Popova, 1962//Turuk, 1973, 1976//Lilly, 1987). This permitted the comparison of the intensity of feeding of cod of both stocks. A comparative analysis of the results of calculations of daily rations of the Atlantic cod (*Gadus morhua*) is presented in this paper.”

Keywords: *Ammodytes*; Newfoundland; Barents Sea; predators (fish, Atlantic cod).

Orsi, J.A.; Landingham, J.H. 1985. Numbers, species, and maturity stages of fish captured with beach seines during spring 1981 and 1982 in some nearshore marine waters of southeastern Alaska. Tech. Memo. F/NWC-86. [Place of publication unknown]: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service..

Ninety-five percent of the catch were pink salmon, chum salmon, Pacific sand lance, Dolly Varden, and coho salmon. Findings emphasize the importance of the nearshore marine habitat during the early life history of these fishes. Over 212,000 fish were captured.

Keywords: *A. hexapterus*; Alaska; southeastern Alaska; abundance; distribution.

Oshima, Y. 1950. Biological notes on the sand-eel, *Ammodytes personatus* Girard. Bulletin of the Japanese Society of Scientific Fisheries. 16(3): 99-107.

Keywords: *A. personatus*; biology.

Ostrand, W.D.; Coyle, K.O.; Drew, G.S. 1998. Selection of forage-fish schools by murrelets and tufted puffins in Prince William Sound, Alaska. The Condor. 100: 286-297.

Keywords: *A. hexapterus*; Alaska; Prince William Sound; predators (birds, marbled murrelet, tufted puffin).

Ouellet, P.; Allard, J.P.; St–Pierre, J.F. 1994. The distribution of larvae of invertebrate decapods (Pandalidae, Majidae) and of eggs and larvae of fish species in the northern Gulf of St. Lawrence from May and June of 1985 to 1987 and 1991-1992. Canadian Technical Report Fisheries and Aquatic Science. 2019: 68.

“From 1985 to 1987, and in 1991 and 1992, seven plankton surveys were conducted, between the end of April and early July in the northern gulf of St. Lawrence. These missions provide informations on the species composition and the distribution of larvae of invertebrate decapods and of the eggs and larvae of fish species. A total of 28 species from 13 families (2 families of decapods and 11 families of fishes) were enumerated from these surveys.”

Keywords: *Ammodytes*; Gulf of Saint Lawrence; distribution; eggs; larvae.

Outram, D.N.; Haegele, C. 1972. Food of Pacific hake *Merluccius productus* on an offshore bank southwest of Vancouver Island British Columbia. Journal of the Fisheries Research Board of Canada. 29(12): 1792-1795.

Keywords: *A. hexapterus*; British Columbia; predators (fish, Pacific hake).

Overholtz, W.J.; Murawski, S.M.; Foster, K.L. 1991. Impact of predatory fish, marine mammals, and sea birds on the pelagic fish ecosystem of the northeastern United States. International Council for the Exploration of the Sea Marine Science Symposium. 193: 198-208.

Keywords: *Ammodytes*; Atlantic (northeast); ecology; predators (birds, fish, mammals).

Overholtz, W.J.; Nicholas, J.R. 1979. Apparent feeding of the fin whale, *Balaenoptera physalus*, and humpback whale, *Megaptera novaeanglia* [sic], on the American sand lance. *Ammodytes americanus*, in the northwest Atlantic. Fishery Bulletin. 77(1): 285-287.

“The feeding observations which we made imply that the rorqual whales off New England, particularly fin and humpback whales may be utilizing the high standing stock of American sand lance that is currently available. Additionally noteworthy is that the Atlantic herring, *Clupea h. harengus*, a commonly mentioned rorqual whale food is in low abundance at this time.”

Keywords: *A. americanus*; New England; predators (birds, great black-back gull, herring gull, fish, Atlantic cod, mammals, fin whale, humpback whale).

Oynes, P. 1972. Composition of fish species in purse seine catches obtained by use of artificial light in fjords of western Norway. Fisken og Havet. 3: 52-61.

Keywords: *A. lancea*; Norway; catch; fisheries.

Palenichko, Z.G. 1958. Ammodytidae. In: Ryby Belogo morya=Fishes of the White Sea. Petrozavodsk, USSR: Karelian ASSR.

Keywords: Ammodytidae; White Sea; distribution.

Pallas, P.S. 1831. Zoographia Rosso-Asiatica, sistens omnium animalium in extensio Imperico Rossico et adjacentibus maribus observatorium recensionem, domicilia, mores et descriptiones anatomen atque icones plurimorum. 3. Ed. Guil. Theophil. Tilesius. Ordo III. Branchiata. XXIX *Ammodytes.* Academy of Science Petropoli: 226-227.

Keywords: *Ammodytes*; distribution.

Palsson, O.K. 1980. Biology of juvenile gadoids age groups 0, I, II in Icelandic waters. Meeresforschung. 28(2-3): 101-145.

“The diet of whiting consists mainly of fish (sandeel, capelin) and to some extent of euphausiids and pandalids, benthic animals are of no importance. The dial periodicity in most cases shows periods of intensive feeding, one in the day and the other at night. Durations and feeding intensity of these periods vary considerably. The growth of the gadoids is regulated by seasonal changes. Parameters of trophodynamics, daily coefficient and conversion efficiency vary considerably.”

Keywords: *Ammodytes*; Iceland; predators (fish, whiting).

Parks, N.B.; Zenger, H. 1979. Trawl survey of demersal fish and shellfish resources in Prince William Sound, Alaska. Seattle, WA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest and Alaska Fisheries Center; Process Report 79-2.

Keywords: *A. hexapterus*; Alaska; Prince William Sound; distribution.

Parsons, T.R.; LeBrasseur, R.J. 1970. The availability of food to different trophic levels in the marine food chain. In: Steele, J.H., ed. Marine food chains. Berkeley, CA; Los Angeles: University of California Press: 325-343.

Keywords: *Ammodytes*; food chain.

Partridge, K.E. 1988. Feeding areas for the Berry Head guillemot colony. Devon Birds. 41(4): 66-71.

Keywords: *A. lanceolatus; A. marinus*; English Channel; predators (birds, guillemot).

Paszkowski, C.A.; Olla, B.L. 1985. Foraging behavior of hatchery-produced coho salmon *Oncorhynchus kisutch* smolts on live prey. Canadian Journal of Fisheries and Aquatic Sciences. 42(12): 1915-1921.

“We presented three groups of naive hatchery-produced, pellet-reared coho salmon (*Oncorhynchus kisutch*) with live, natural prey and observed their foraging behavior. Of 26 individuals examined, 20 captured one or more Crangon (sand shrimp) within 1 h of their first exposure to these prey. Six older (< 210 mm TL) accelerated smolts (underyearlings) displayed improved foraging performances with experience, capturing their first Crangon sooner during their second, compared with their first, exposure. Four of five of these fish successfully captured sand lance (*Ammodytes hexapterus*) within 1 h of their first presentation. Two groups of 10 recently smolted fingerlings (< 190 mm TL), one accelerated and one conventionally reared (yearlings), were used in choice experiments and simultaneously offered equal masses of Crangon and pellets. Six of the accelerated and seven of the conventionally reared

fish ate larger amounts of Crangon than pellets, with all 20 fish striking more at Crangon than at pellets. Our results suggest that a majority of hatchery-produced coho salmon smolts readily recognize, capture, and ingest natural prey and seem capable of foraging successfully upon release into the marine environment."

Keywords: *A. hexapterus*; predators (fish, coho salmon).

Patten, S.M., Jr. 1974. Breeding ecology of the glaucous-winged gull in Glacier Bay, Alaska. Seattle, WA: University of Washington. M.S. thesis.

Keywords: *A. hexapterus*; Alaska; Glacier Bay; predators (birds, glaucous-winged gull).

Patten, S.M., Jr.; Patten, L.R. 1983. Evolution, pathology, and breeding ecology of large gulls (*Larus*) in the northeast Gulf of Alaska and effects of petroleum exposure on the breeding ecology of gulls and kittiwakes. In: Environmental assessment of the Alaskan Continental Shelf. Final Report. Boulder, CO: National Oceanic and Atmospheric Administration; Bureau of Land Managment; Outer Continental Shelf Environmental Assessment Program. 18: 1-352.

Keywords: *A. hexapterus*; Alaska; predators (birds).

Patterson, K.R. 1985. The trophic ecology of whiting *Merlangius merlangus* in the Irish Sea and its significance to the Manx herring stock. Journal Du Conseil, Conseil International Pour l'Exploration de la Mer. 42(2): 152-161.

"Whiting (*Merlangius merlangus*) were trawled from a muddy sand trawling ground in the Irish Sea during 1981 and 1982. They had been feeding mainly on Norway pout (*Trisopterus esmarkii*), sprat (*Sprattus sprattus*), sandeels (*Ammodytes marinus*), herring (*Clupea harengus*), and cuttlefish (*Sepiola atlantica*). There was considerable seasonal variation in both the quantity and the type of food eaten. Yearly mean food intake rate was estimated at 1.42, 3.35, and 7.25 grams fresh weight per day for one-, two-, and three-year-old fish, respectively. Gross conversion efficiency during the second, third, and fourth years of life was calculated to be 0.14. Comparison with laboratory data suggests that whiting may use between 10 and 45% of available metabolites for locomotion. Predation on herring seemed to be important, and may have accounted for 45% of the variability in the numbers of recruits to the local stock."

Keywords: *A. marinus*; Irish Sea; predators (fish, whiting).

Paul, A.J.; Paul, J.M.; Coyle, K.O.; Smith, R.L. 1991. Phytoplankton, zooplankton, and ichthyoplankton in Resurrection Bay, northern Gulf of Alaska in 1988. Alaska Sea Grant Rep. AK-SG-91-02. Fairbanks, AK: [publisher unknown].

Keywords: *A. hexapterus*; Alaska; distribution; food; larvae.

Paul, J.M.; Paul, A.J.; Vogeler, T.J; Doyle, J.P. 1997. Biological investigations on Pacific sandfish in the northern Gulf of Alaska. In: Forage fishes in marine ecosystems; Proceedings of the international symposium on the role of forage fishes in marine ecosystems: [dates of meeting unknown]; [location unknown]. Rep. 97-01. [Fairbanks, AK]: University of Alaska Fairbanks, Alaska Sea Grant College Program: 87-94.

"This project was a preliminary examination of the size-weight relationships, length and age, stomach contents, and fecundity of Pacific sandfish, *Trichodon trichodon*. Most of the fish over 150 mm FL were females. Qualitatively, the most common prey items were sand lance (*Ammodytes* sp.), several types of shrimps, crab larvae, cumaceans, and polychaetes. Based on the break and burn method, fish with one annulus on the otolith averaged 71 mm FL and by age two they were 104 mm FL."

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; predators (fish, Pacific sandfish).

Pauly, D.; Pullin, R.S.V. 1988. Hatching time in spherical, pelagic, marine fish eggs in response to temperature and egg size. Environmental Biology of Fishes. 22(4): 261-271.

Keywords: *Ammodytes*; eggs.

Payne, P.M.; Nicolas, J.R.; O'Brien, L.; Powers, K.D. 1986. The distribution of the humpback whale (*Megaptera novaeangliae*) on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel (*Ammodytes americanus*). Fishery Bulletin. 84(2): 271-277.

"In the Gulf of Maine, south of Newfoundland, humpback whale distribution was correlated (r=0.81, df = 13) with sand lance (*Ammodytes americanus*) density as measured in tow samples. However, no such trend was observed over Georges Bank, where sand lance densities reached comparable levels as those observed in the Gulf of Maine."

Keywords: *A. americanus*; Gulf of Maine; predators (mammals, humpback whale).

Payne, P.M.; Selzer, L.A. 1989. The distribution abundance and selected prey of the harbor seal *Phoca vitulina concolor* in southern New England. Marine Mammal Science. 5(2): 173-192.

"The American sandlance *Ammodytes americanus* was the single dominant prey item of harbor seals in waters adjacent to Cape Cod based on the modified frequency of occurrence of each prey species in scat samples collected from three haulout sites on Cape Cod between 1984-1987. During January and February sandlance was the near exclusive prey item at Monomoy (99%, n = 80). During March and April, the frequency of Atlantic herring *Clupea harengus* increased in the scat samples at this site. Regional differences in the diet of seals reflect distinct prey communities throughout the study area. Since 1986, the percent occurrence and importance of sandlance in the diet of seals has decreased, reflecting an overall decrease in abundance of this prey species in waters adjacent to Cape Cod. In spite of fluctuations in abundance, and regional differences in the diet of seals throughout the study area, sandlance still comprised a minimum 55% of the total prey species of harbor seals throughout the study area."

Keywords: *A. americanus*; Cape Cod; importance; predators (mammals, harbor seal).

Payne, P.M.; Wiley, D.N.; Young, S.B. [and others]. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fishery Bulletin. 88(4): 687-696.

"Significant changes in the biomass of sandlance *Ammodytes* spp. and in the abundance of the copepod *Calanus finmarchicus* in the southern Gulf of Maine co-occurred with a shift in the occurrence and abundance of four species of baleen whales in the region. During the years 1982-88 the abundance of sandlance was negatively correlated to the abundance of C. *finmarchicus* (r_s =– 0.883, $P < 0.05$). Peak years of abundance for *C. finmarchicus* during 1982-88 in the study area were the lowest years of abundance for sandlance. The abundance of *C. finmarchicus* and sandlance was at a regional maximum during 1986 and 1988, respectively. The abundance of humpback and fin whales were marginally correlated to each other ($r_s = 0.3338$, $P < 0.08$). The abundance of humpbacks was negatively correlated with right whales ($r_s = – 0.7753$, $P < 0.001$) and sei whales ($r_s = –0.5507$, $P < 0.01$). The patterns of occurrence for right and sei whales were significantly related to each other ($r_s = 0.6842$, $P < 0.001$). Right and sei whales were common in the region only during 1986, when copepod abundance reached a regional maximum and sandlance abundance a regional minimum. These patterns of whale occurrence reflect known prey preferences, and are therefore expected between the pisciverous humpback and fin whales and the highly planktiverous right and sei whales. We hypothesize that the spatial distribution and abundance of baleen whales in the Gulf of Maine can be characterized as a series of ecological responses to human-induced changes in the abundance of planktiverous finfish."

Keywords: *Ammodytes*; Gulf of Maine; abundance; importance; predators (mammals, fin whale, humpback whale).

Pearcy, W.G.; Richards, S.W. 1962. Distribution and ecology of fishes of the Mystic River estuary, Connecticut. Ecology. 43: 248-259.

An account of catching 22 larvae ranging in length from 4.7 to 14.5 mm. The larvae were significantly higher in this range near the bottom than at the surface.

Keywords: *A. americanus*; northwest Atlantic; larvae; size.

Pearson, T.H. 1968. The feeding biology of seabird species breeding on the Farne Islands, Northumberland. Journal of Animal Ecology. 37: 521-552.

“Ammodytidae were found in the stomachs of the following species: 1st percentage = percentages of total number of prey taken, 2nd percentage = percentage of total weight of prey taken. Arctic tern (65 and 22), common tern (44 and 10), sandwich tern (74 and 61), kittiwake *Rissa tridactyla* (81 and 56), lesser black-backed gull *Larus fuscus* (55 and 14), puffin *Fratercula arctica* (85 and 80), guillemot *Uria aalge* (49 and 57), shag *Phalacrocorax aristotelis* (81 and 44), cormorant *P. carbo* (26 and 1).

“All age groups of developing Ammodytidae tend to spend the winter and early spring in mid-water offshore, but migrate to the surface and move inshore in late April and May. The hatching of seabird chicks coincides with the arrival at the surface, and inshore around the islands, of the shoals of juvenile Ammodytidae. Subsequent checks made on fish brought in to the island by terns returning from these fishing flocks showed them to be Ammodytidae (*A. tobianus* or *A. marinus*). The larger *A. lanceolatus* were only rarely positively identified in the diet of the tern and gull species, but were frequently recorded in that of the auks. Thus the birds on the Farne Islands are ensured of an abundant source of food throughout the summer, the Ammodytidae present during the early summer being supplemented by an influx of clupeoides in July.

“Feeding range of seabirds—It is immediately obvious from these values that all of the tern species have a very limited feeding area. This is partly because these species take small fish and do not normally carry more than one fish at a time. The shag has a feeding range comparable to that of the terns but is capable of carrying a much greater amount of fish than the latter group. The kittiwake and puffin have a feeding range three to four times greater than that of the terns and it is clear that these species are potentially able to feed over an area about ten times greater than that utilized by terns breeding in the same locality. The inshore migrations of young Ammodytidae and clupeoids may have differential effects on the various sea-bird species. Since the feeding ranges of the various species differ considerably, those species with the shorter range, i.e. the terns, may be suffering from a scarcity of Ammodytidae and Clupeidae, should the shoals of these fish fail to move into the inshore surface waters for some reason, when the kittiwakes and auks are able to exploit populations in the offshore areas which are beyond the range of the other species.The kittiwakes, lesser black-backed gulls and shags feed their young by regurgitation, and generally feed the whole of the brood after a feeding journey.

“Between October and March there is evidence that the large shoals of juvenile Ammodytidae disappear offshore into deeper waters moreover the calanoid copepods which appear to form their main food supply migrate to deeper water from the surface levels they inhabit during the summer months.

“For the seabirds studied all feed almost exclusively on fish, only the lesser black-backed gull taking more than 10% of any other type of food. Moreover, of the types of fish taken, Ammodytidae composed the greater part of the diet of all but the cormorants, and to a lesser extent the shags, and even in these species they were an important element in the diet.”

Keywords: *A. lanceolatus; A. marinus; A. tobianus*; importance; predators (birds, arctic tern, common tern, sandwich tern, kittiwake, lesser black-backed gull, puffin, guillemot, shag, cormorant).

Pearson, W.H.; Woodruff, D.L.; Sugarman, P.C.; Olla, B.L. 1984. The burrowing behavior of sand lance, *Ammodytes hexapterus*: effects of oil-contaminated sediment. Marine Environmental Research. 11: 17-32.

“Whilst foraging in the water column for zooplankton, sand lance, *Ammodytes hexapterus*, are under heavy predation from marine birds and fish. To avoid predation, sand lance bury in the sand when not foraging and during overwintering. We did two experiments to determine whether oil contamination of the sand would reduce the amount of time that sand lance spent buried. In the first experiment sand lance significantly decreased by 20% the time spent

buried in oiled sand (306 ppm). In the second experiment sand lance did not decrease time spent buried in oiled sand at 28 and 256 ppm but did at 3384 ppm. The higher condition index of the 1981 fish suggested that nutritional state may have influenced how sand lance used the sediment as a refuge and how they responded to contamination of that refuge."

When food is not available and the choice is between burial in contaminated sand or remaining in the water column, sand lance can be expected to have substantial exposure to oil and to suffer the consequences of such exposure.

Keywords: *A. hexapterus*; oil pollution.

Pedersen, J. 1953. Discrimination of fish layers using the three-dimensional information obtained by a split-beam echo-sounder. International Council for the Exploration of the Sea Journal of Marine Science. 2: 371-376.

Keywords: *Ammodytes*; hydroacoustics.

Pellegrini, R. 1976. Aspects of the biology of the American sand lance, *Ammodytes americanus*, from the lower Merrimack River estuary, Massachusetts. Amherst, MA: University of Massachusetts. 44 p. Master's problem.

Keywords: *A. americanus*; Massachusetts; biology.

Pemberton, R. 1976. Sea trout in north Argyll Sea lochs Scotland. Part 2: Diet. Journal of Fish Biology. 9(3): 195-208.

"The diet of sea trout in some of the sea lochs of the West coast of Scotland [United Kingdom] was investigated. The contents of 986 sea trout stomachs from the Loch Etive area (1970-1973) and 291 stomachs from the Loch Eil area (1964-1973) were examined and the composition of the diet, seasonal changes and the effect of trout size were analyzed using frequency of occurrence, dry weight and number of organisms methods. Benthic feeding (crustacea and annelids) was more important in winter while midwater and surface organisms (young fish and insects) were preferred in summer. Young fish (mainly clupeids and sand eels) featured more in the diet of larger trout (≤ 21 cm) than in the smaller size range (≥ 21 cm). Surveys of 24 h completed in June and Sept. 1972 indicated that availability of food was the main factor influencing the presence or absence of trout. Bottom feeding was greatest during the day while the amount of midwater and surface feeding tended to increase between sunset and sunrise."

Keywords: *Ammodytes*; Scotland; predators (fish, sea trout).

Penina, G.K. 1964. Food habits of fur seals in the Sea of Japan. Trudy VINRO. 51: 67-73. In Russian; English abstract.

Keywords: *Ammodytes*; Japan; Sea of Japan; predators (mammals, fur seal).

Pennington, M.G.; Martin, A.R.; Heubeck, M. 1991. The breeding birds of Hermaness Shetland. Scottish Birds. 16(2): 118-130.

Keywords: *Ammodytes*; Shetland; predators (birds).

Penttila, D.E. 1995. Investigations of the spawning habitat of the Pacific sand lance, *Ammodytes hexapterus*, in Puget Sound. In: Puget Sound research-95 conference proceedings; [dates of meeting unknown]; [location unknown]. Olympia, WA: Puget Sound Water Quality Authority: 2: 855-859.

Keywords: *A. hexapterus*; Washington; Puget Sound; habitat; spawning.

Penttila, D.E. 1997. Investigations of intertidal spawning habitats of the surf smelt and the Pacific sand lance in Puget Sound, Washington. In: Forage fishes in marine ecosystems; Proceedings of the international symposium on the role of forage fishes in marine ecosystems: [dates of meeting unknown]; [location unknown]. Rep. 97-01. [Fairbanks, AK]: University of Alaska Fairbanks, Alaska Sea Grant College Program: 395-407.

“The intertidal beach spawning habitats of Pacific sand lance are common and widespread throughout the Puget Sound basin. This paper will summarize current investigations of their spawning habitats and ecology, with observations that may be relevant elsewhere within their ranges around the north Pacific Ocean, undertaken by the Washington Department of Fish and Wildlife. Intertidal spawn deposition/incubation by the Pacific sand lance was discovered in Puget Sound by WDFW in 1989. With the employment of new survey techniques that no longer rely on detection of the visually cryptic eggs in the field, 120 miles (193 km) of sand lance spawning habitat have been mapped on the shores of Puget Sound as of May 1996. Previously unknown details of sand lance spawning ecology can now be characterized.

“An estimated 20% of the shoreline of Puget Sound may be used by surf smelt and/or sand lance as spawning habitat. In spite of their apparent abundance and wide distribution these species appear not to be amenable to sampling by the standard hydroacoustic/trawl survey techniques used routinely by WDFW to assess co-occurring Pacific herring stocks in Puget Sound.

“Surf smelt and sand lance spawn deposition/incubation now appears to be a widespread and important ecological function of upper intertidal sand-gravel beaches in Puget Sound, and possibly elsewhere in the North Pacific basin as well, where these and other shore-spawning forage fishes occur. The occurrence and seasonal usage of these habitats may be poorly known in many regions, and a thorough inventory of them cound be essential to gain a complete picture of regional forage fish populations. A complete knowledge of the distribution and spawning ecology of these lesser-known forage species allows for more effective monitoring and management of their stocks, fisheries, and habitats considered critical for maintenance of local populations.”

Keywords: *A. hexapterus*; Washington; Puget Sound; habitat; spawning.

Pepin, P. 1993. Application of empirical size-dependent models of larval fish vital rates to the study of production: accuracy and association with adult stock dynamics in a comparison among species. Canadian Journal of Fisheries and Aquatic Science. 50(1): 53-59.

Keywords: *Ammodytes*; Atlantic (northwest); age; fisheries; growth; larvae.

Pepin, P. 1995. An analysis of the length-weight relationship of larval fish: limitations of the general allometric model. U.S. National Marine Fisheries Service, Fishery Bulletin. 93(2): 419-426.

Keywords: *A. americanus*; condition factor; larvae; length-weight relationship.

Perez, M.A.; Bigg, M.A. 1981. An assessment of the feeding habits of the northern fur seal in the eastern north Pacific Ocean and eastern Bering Sea. Seattle, WA. 49 p. Unpublished draft report. Seattle, WA: National Marine Fisheries Service. 49 p. On file with: [unknown].

Keywords: *A. hexapterus*; predators (mammals, northern fur seal).

Perez, M.A.; Bigg, M.A. 1986. Diet of northern fur seals *Callorhinus ursinus* off western North America. U.S. National Marine Fisheries Service, Fishery Bulletin. 84(4): 957-972.

“Data recorded from the stomach contents of 18,404 northern fur seals, *Callorhinus ursinus*, mostly females aged 3 years collected off western North America during 1958-74, were analyzed to determine the relative importance of each prey species by region, subregion, and month. When weighted for energy content, the primary food species were small schooling fishes. Between western Alaska and California from December to August the most significant prey species were northern anchovy, *Engraulis mordax* (20%); Pacific herring, *Clupea harengus pallasi* (19%); capelin, *Mallotus villosus* (8%), Pacific sand lance, *Ammodytes hexapterus* (8%); Pacific whiting, *Merluccius productus* (7%); salmon, *Oncorhynchus* spp. (6%); Pacific saury, *Cololabis saira* (4%); and rockfishes, *Sebastes* spp. (4%). Other food species eaten in this area consisted of a wide variety of squids (17%) and other fishes (7%). In the eastern Bering Sea the main prey species from June to October were juvenile walleye pollock, *Theragra chalcogramma*

(35%); capelin (16%); Pacific herring (11%); and squids, *Berryteuthis magister* and *Gonatopsis borealis*, which comprise most (30%) of the remaining diet of northern fur seals in this region. In all areas off western North America, fishes were the main food species of these pinnipeds in neritic waters, while squids were the most important prey in oceantic waters. Typically three prey species comprised 80% of their diet in any one area, although the composition of the diet varied in type and importance by region and month."

Keywords: *A. hexapterus*; predators (mammals, northern fur seal).

Perkins, J.S.; Bryant, P.J.; Nichols, G.; Patten, D.R. 1982. Humpback whales *Megaptera novaeangliae* off the west coast of Greenland. Canadian Journal of Zoology. 60(11): 2921-2930.

"Distribution was unrelated to zooplankton densities, but was positively correlated with large flocks of greater shear-waters. These findings, together with 2 observations of lunge feeding, confirmed that the humpbacks were eating small fish, probably *Ammodytes* sp. The possibility of a discrete feeding stock of humpbacks, probably numbering < 200 whales, off west Greenland which, like other feeding stocks in the northwest Atlantic, breed and calve on Silver and Navidad banks in winter is indicated."

Keywords: *Ammodytes*; Greenland; predators (mammals, humpback whale).

Perlmutter, A. 1940. Variation of American North Atlantic marine fishes correlated with the environment. 7: Sand eels of the genus *Ammodytes.* [City unknown], Michigan: University of Michigan: 16-20. Ph.D. dissertation.

Keywords: *Ammodytes*; North Atlantic; biology; habitat.

Petersen, A. 1981. Breeding biology and feeding ecology of black guillemots. Oxford, England: Oxford University. 378 p. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (birds, black guillemot).

Petersen, G.H. 1977. The occurrence of the sand eel (*Ammodytes dubius*) in 0.1 M2 van veen grab samples taken during winter in Godhavn Havn, Disko Bugt. Journal du Conseil, Conseil International pour l"Exploration de la Mer. 37(3): 309-110.

"An investigation of the marine benthos yielded 11 specimens of the sand eel *A. dubius* Reinhardt, 1838. Sand eels apparently hibernate, buried in the sediment at shallow depths, from late Nov.-May. The temperature at the bottom during this period is about –1.7 °C and there is practically no light. The polar night starts in the 1st wk of Dec. and a layer of sea ice approximately 1 m thick covers the area until late May. The density of sand eels is about 3-6/m^2 in the shallow sand bottom. The material seems to consist of 2 size groups: one of 60-96 mm and another of 123-143 mm. The large unexploited stock of sand eels found in Disko Bugt in Dec. may be suitable for fishery during Nov."

Keywords: *A. dubius*; Atlantic Ocean; aestivation; behavior; burrowing; habitat.

Phillips, A.C.; Barraclough, W.E. 1977. On the early life history of the lingcod (*Ophiodon elongatus*). Technical Report Fisheries Marine Service (Canada). 756: 39.

"They grew rapidly and readily accepted live or frozen juvenile herring, salmon, and sandlance as food."

Keywords: *Ammodytes*; aquaculture; predators (fish, lingcod).

Phillips, A.C.; Mason, J.C. 1986. A towed self-adjusting sled sampler for demersal fish eggs and larvae. Fisheries Research (Amsterdam). 4(3-4): 235-242.

"We describe a sled sampler designed to collect adhesive eggs or non-adhesive eggs of high specific gravity in inner-shelf areas of heterogenous substrate type. A self-adjusting grating controls off-bottom height of entry ramps leading to the sampler and allows sampling over previously inaccessible topographical irregularities. The sampler

was tested in field trials that located and mapped a previously unknown spawning ground of English sole (*Parophrys vetulus*). On a known spawning ground of English sole, the sampler also collected demersal and adhesive eggs of Pacific cod (*Gadus macrocephalus*) and of sand lance (*Ammodytes hexapterus*). Eggs of the cod have not been collected previously with substrate-sampling gear. The semi-quantitative catches are sufficient for location and mapping of spawning grounds."

Keywords: *A. hexapterus*; habitat; fishing methods; spawning.

Phillips, R.A.; Caldow, R.W.G.; Furness, R.W. 1996. The influence of food availability on the breeding effort and reproductive success of arctic skuas *Stercorarius parasiticus*. Ibis. 138(3): 410-419.

"Territorial attendance, chick growth rate and breeding success of Arctic skuas *Stercorarius parasiticus* in Shetland were lowest in the late 1980s when recruitment of sandeels *Ammodytes marinus* in the surrounding waters was poor. The relationships between both fisheries-based and avian indices of food availability and annual variation in Arctic skua chick growth and breeding success between 1976 and 1994 were better described by a threshold effect rather than linear functions. Arctic skuas conform to the model proposed by Cairns, which predicts the responses of seabirds to changes in prey availability. Skua clutch size, egg volume, hatching success and hatching date were not reliable indices of sandeel availability. However, annual fluctuations in Arctic skua breeding numbers may be a useful indicator of changes in prey abundance."

Keywords: *A. marinus*; Shetland; predators (birds, arctic skua).

Phillips, R.A.; Catry, P.; Thompson, D.R. [and others]. 1997. Inter-colony variation in diet and reproductive performance of great skuas *Catharacta skua*. Marine Ecology Progress Series. 152(1-3): 285-293.

"Sustained population growth of great skuas *Catharacta skua* during the current century has been attributed largely to a high abundance of sandeels, principally *Ammodytes marinus*, and a plentiful supply of discards from whitefish trawlers in the vicinity of breeding colonies. A new colony of great skuas was established at St. Kilda, outer hebrides, in 1963 and has since grown rapidly despite an apparent lack of sandeels in the waters surrounding the archipelago and the presence of only a small whitefish fishery. This paper presents an analysis of diet and breeding ecology of great skuas at Hirta, St. Kilda, over 3 seasons, 1994 to 1996, with comparative data from Foula, Shetland, the largest and one of the oldest of the British colonies. At St. Kilda, breeding adults, nonbreeders and chicks all fed extensively upon other seabirds (44 to 65% of pellets over the 3 yr), and to a lesser extent on goose barnacles *Lepas* sp. (18 to 30% of pellets) and fish (16 to 30% of pellets), with sandeel virtually absent from the diet (0.2 to 0.3% of pellets). In contrast, at Foula only 4 to 12% of pellets were of other seabirds, with sandeels and discarded fish together constituting the vast majority (4 to 36% and 55 to 88% of pellets, respectively). Despite the low availability of sandeels and discards at St. Kilda, egg volumes, chick body condition and annual productivity were at least as high as at Foula, and territorial attendance of breeding adults was much higher, indicating considerably lower foraging effort during chick-rearing. Great skuas at St. Kilda are therefore able to make effective use of other seabirds as a food resource during the breeding season, in sharp contrast to Foula where adult mortality increased and chick growth rates and breeding success plummeted during the marked decline in sandeel abundance in the late 1980s."

Keywords: *A. marinus*; importance; predators (birds, great skua).

Phillips, R.A.; Furness, R.W.; Caldow, R.W.G. 1996. Behavioural responses of arctic skuas *Stercorarius parasiticus* to changes in sandeel availability. In: Greenstreet, S.P.R.; Tasker, M.L., eds. Aquatic predators and their prey; Royal Society Of Edinburgh conference: 1994 Aug.; Edinburgh, Scotland. Oxford, England; Cambridge, MA: Blackwell Scientific Publications: 4: 17-25.

Keywords: *A. marinus*; Shetland; Scotland; importance; predators (birds, arctic skua).

Piatt, J.F. 1987. Behavioural ecology of common murre and Atlantic puffin predation on capelin: implications for population biology. St. John's, NF: Memorial University of Newfoundland. 311 p. Ph.D. dissertation.

Keywords: *A. dubius*; predators (birds, Atlantic puffin; common murre).

Piatt, J.F. 1997. Seabird and forage fish interactions in the Gulf of Alaska. In: Forage fishes in marine ecosystems: Proceedings of the international symposium on the role of forage fishes in marine ecosystems; [dates of meeting unknown]; [location unknown]. Prog. Rep. 97-01. [Fairbanks, AK]: University of Alaska Fairbanks, Alaska Sea Grant College: [pages unknown].

“For more than a decade, seabirds in the Gulf of Alaska have shown signs of food stress—population declines, decreased productivity, changes in diet, and large-scale-die-offs. Small-mesh trawls (ca. 12,000) conducted during the past 40 years reveal that a major shift in community composition occurred in the late 1970s—some forage species (e.g. capelin, shrimp) virtually disappeared, while predatory fish populations (e.g. gadids, flatfish) increased dramatically. These changes correlate with long-term cycles in seawater temperature. In 1995 and 1996, productivity, diets, and foraging behavior of 6 seabird species (murre, puffin, guillemot, gull, kittiwake, cormorant) were studied at 3 colonies in lower Cook Inlet. Oceanographic measurements, seabird and hydroacoustic surveys, trawls, and seines were conducted in waters around each colony. Pelagic waters were dominated by juvenile (0+, 1+) pollock and capelin, important prey for puffins and murres. Nearshore waters were dominated by sand lance, which were consumed by all seabirds in proportion to their local abundance. Forage fish school densities ranged from 10s fish/m^3 (pollock) to 100s and 1000s fish/m^3 (sand lance). Correspondingly, seabird productivity ranged from low to moderate to high in areas with low, moderate, and high forage fish densities. Capelin and sand lance had much higher energy loads than gadids, and where they were observed in high densities, seabirds consumed large quantities and had the highest breeding success.”

Keywords: *A. hexapterus*; Alaska, Gulf of Alaska; abundance; importance; predators (birds).

Piatt, J.F.; Anderson, P. 1996. Response of common murres to the *Exxon Valdez* oil spill and long-term changes in the Gulf of Alaska marine ecosystem. American Fisheries Society Symposium. 18: 720-737.

Sand lance in 1988-91 was the most frequently injested item in kittiwake and common murre and important in the diet of marbled murrelet, horned puffin, and tufted puffin. Capelin were the dominant prey of seabirds in the late 1970s but were absent or much reduced in seabird diets in the late 1980s and early 1990s. Capelin were replaced by Pacific sand lance and pollock.

Keywords: *A. hexapterus*; Alaska; Prince William Sound; importance; predators (birds).

Piatt, J.F.; Hatch, S.A.; Roberts, B.D. [and others]. 1988. Populations, productivity, and feeding habits of seabirds on St. Lawrence Island, Alaska. Anchorage, AK: U.S. Fish and Wildlife Service.

Pacific sand lance occurred, but were not common, in the diets of murres around Saint Lawrence Island. This contrasts with obervations of arctic cod, saffron cod, and sand lance, which dominated murre diets at Cape Thompson and Cape Lisburne to the north, and saffron cod and sand lance diets at Bluff, Norton Sound, to the east.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (birds, common murre, thick-billed murre).

Piatt, J.F.; Naslund, N.L. 1995. Abundance, distribution and population status of the marbled murrelet in Alaska. In: Ralph, C.J.; Hunt, G.L., Jr.; Raphael, M.G.; Piatt, J.F., eds. Ecology and conservation of the marbled murrelet. Gen. Tech. Rep. PSW-GTR-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Keywords: *A. hexapterus*; Alaska; predators (birds, marbled murrelet).

Piatt, J.F.; Wells, J.L.; MacCharles, A.; Fadely, B.S. 1991. The distribution of seabirds and fish in relation to ocean currents in the southeastern Chukchi Sea. In: Montevecchi, W.A.; Gaston, A.J., eds. Studies of high-latitude seabirds. 1: Behavioural, energetic, and oceanographic aspects of seabird feeding ecology. Canadian Wildlife Service Occasional Papers. (68): 21-31.

“Sandy substrates maintained nearshore by the Alaska coastal current provide habitat for sand lance *Ammodytes hexapterus*, and the warm nearshore waters stimulate growth and production of sand sand lance and other coastal fishes.

“There are no published estimates for sand lance target strengths, but because they have ‘open’ swimbladders (physostomes), it is likely that target strength are about 5-10 dB lower than those of cod and capelin. This would lead to an underestimate of fish densities where sand lance were recorded (only nearshore).”

Keywords: *A. hexapterus*; Alaska; Chukchi Sea; distribution; predators (birds, thick-billed murre, common murre, black-legged kittiwake, glaucous-winged gull).

Pierce, G.J.; Boyle, P.R.; Diack, J.S.W.; Clark, I. 1990. Sandeels in the diets of seals. Application of novel and conventional methods of analysis to feces from seals in the Moray Firth area of Scotland UK. Journal of the Marine Biological Association of the United Kingdom. 70(4): 829-840.

“Serological methods for prey identification have been applied to detection of residues of sandeel (Ammodytidae) protein in faeces of common seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) from the Moray Firth, north-east Scotland. Antisera raised to muscle protein from *Ammodytes marinus* were evaluated by testing their reactions with protein extracts made from a range of North Sea fish species and protein residues in in vitro digestates, seal digestive tracts and seal faeces. It was concluded that, using fused rocket immuno-electrophoresis, linkage of precipitin peaks from unknown samples with peaks from standard sandeel extract was a reliable indicator of the presence of sandeel in the unknown sample. Seasonal variation in the incidence of sandeels in common seal diet in the Moray Firth was examined by identifying otoliths, bones, and proteins, and all three methods indicated that sandeels occurred in the majority of samples tested in the summer, but were less important during the winter. Proteins were detected in fewer samples than otoliths, particularly in February and March. Possible reasons for this difference are discussed. Serological identification of sandeel proteins is potentially applicable to dietary studies on all marine predators.”

Keywords: *A. marinus*; Scotland; otoliths; predators (mammals, common seal, grey seal); proteins.

Pierce, G.J.; Boyle, P.R.; Hastie, L.C.; Santos, M.B. 1994. Diets of squid *Loligo forbes*i and *Loligo vulgaris* in the northeast Atlantic. Fisheries Research (Amsterdam). 21(1-2): 149-163.

“Diets of the loliginid squid *Loligo forbes*i and *Loligo vulgari*s were investigated by stomach contents sampling during 1990-1993. Monthly samples of *Loligo forbesi* were collected at Aberdeen and additional samples were obtained from the Irish Sea, Faroe, the English Channel, Vigo, Lisbon and the Azores. Samples of *Loligo vulgaris* were obtained from Vigo, Barcelona, Lisbon and Faro. *Loligo forbesi* feeds primarily on fishes, crustaceans and cephalopods. In Scottish waters, Gadidae (mainly *Merlangius merlangus* and *Trisopterus* sp.), Ammodytidae and Clupeidae were the most frequently identified prey. The relative importance of fish was slightly higher, and that of crustaceans lower, in the diet of larger squid. Gadidae and Clupeidae were more prominent in the winter diet, with sandeels being taken more frequently in the summer. The same prey taxa were important in the diet of *Loligo forbesi* across all areas. Fishes occurred in more than 80% of non-empty stomachs except for the Lisbon sample, in which crustaceans were the most frequently identified prey taxon. The species composition of the diet varied between areas. Thus, scad *Trachurus picturatus* was the most important prey in the Azores. The broad composition of the diet in *Loligo vulgaris* was similar, although crustaceans were apparently less important, but there were differences in species eaten between areas, and between the two *Loligo* species. Samples of the ommastrephid squid *Todaropsis eblanae* taken at Aberdeen indicated that this species was also primarily piscivorous, taking Gadidae and Clupeidae.”

Keywords: Ammodytidae; predators (invertebrates, *Loligo forbesi*).

Pierce, G.J.; Diack, J.S.W.; Boyle, P.R. 1989. Digestive tract contents of seals in the Moray Firth area of Scotland. Journal of Fish Biology. 35(Supplement A): 341-343.

Keywords: *Ammodytes*; Scotland; otoliths; predators (mammals, common seal, grey seal).

Pierce, G.J.; Santos, M.B. 1996. Trophic interactions of squid *Loligo forbesi* in Scottish waters. In: Greenstreet, S.P.R.; Tasker, M.L., eds. Aquatic predators and their prey; Royal Society of Edinburgh conference: 1994 Aug.; Edinburgh, Scotland. Oxford, England; Cambridge, MA: Blackwell Scientific Publications: 9: 58-64.

"*Loligo forbesi* is primarily piscivorous, although the diet also includes crustaceans and there is some cannibalism. In 1990/91, depending on assumptions about natural mortality, the Scottish population of *Loligo forbesi* may have eaten between 9000 and 16000 tonnes of food, including 1700-3000 tonnes of sandeels (Ammodytidae), a similar amount of *Trisopterus* spp. and 1000-1700 tonnes of whiting *Merlangius merlangus*."

Keywords: *Ammodytes*; Scotland; predators (invertebrates, veined squid).

Pierce, G.J.; Thompson, P.M.; Miller, A. [and others]. 1991. Seasonal variation in the diet of common seals (*Phoca vitulina*) in the Moray Firth area of Scotland. Journal of Zoology, London. 223(4): 641-652.

"Seasonal variation in the diet of common seals (*Phoca vitulina*) in the Moray Firth, north-east Scotland, was determined from analysis of faecal samples collected at haul-out sites during each month of 1988. Data on diet of common seals in 1987 are also presented. Limitations of the methods available for quantification of diet are discussed. Although some of the observed variation in diet from month to month may reflect changes in the sampling regime, a clear seasonal pattern was apparent, with clupeids predominating in the winter and sandeels in the summer. The trends observed are consistent with opportunistic feeding on the most abundant prey."

Keywords: *Ammodytes*; Scotland; predators (mammals, common seal).

Pierotti, R. 1979. The reproductive behavior and ecology of the herring gull in Newfoundland. Halifax, NS: Dalhousie University. Ph.D. dissertation.

Keywords: *Ammodytes*; Newfoundland; predators (birds, herring gull).

Pierotti, R. 1982. Habitat selection and its consequences to fitness in the herring gull. Ecology. 63: 854-868.

Keywords: *Ammodytes*; predators (birds, herring gull).

Pierotti, R. 1988. Associations between marine birds and mammals in the northwest Atlantic Ocean. In: Burger, J., ed. Seabirds and other marine vertebrates: competition, predation, and other interactions. New York. Columbia University Press: 31-58. Chapter 2.

Keywords: *Ammodytes*; Atlantic Ocean (northwest); abundance; distribution; importance; predators (birds, mammals).

Pietsch, T.W.; Zabetian, C.P. 1990. Osteology and interrelationships of the sand lances teleostei Ammodytidae. Copeia. 1990(1): 78-100.

"*Embolichthys mitsukurii* (Jordan and Evermann), thought to be the least derived member of the teleost family Ammodytidae, is compared anatomically with other ammodytids, and with an assemblage of outgroup taxa (Cheimarrichthyidae, Pinguipedidae, Percophidae, Trichonotidae, Creediidae, Champsodontidae, Chiasmodontidae, Leptoscopidae, Trachinidae, and Uranoscopidae) shown previously by the senior author to represent the core of, but not necessarily to delimit, the perciform suborde-Trachinoidei. Evidence is provided to show that ammodytids are trachinoids and that the family represents the sister group of the Trachinidae plus Uranoscopidae. Although there is considerable homoplasy, a large number of unique (among the groups examined) derived features, including osteological, myological, and soft-tissue characters (as well as perhaps physiological and behavioral adaptations), serve to support a hypothesis of monophyly for these three families."

Keywords: Ammodytidae; *Embolichthys mitsukurii*; taxonomy.

Pihl, L. 1994. Changes in the diet of demersal fish due to eutrophication-induced hypoxia in the Kattegat, Sweden. Canadian Journal of Fisheries and Aquatic Sciences (Ottawa). 51(2): 321-336.

Keywords: *A. lancea*; distribution; environmental impacts; predators (fish, whiting); pollution.

Pilon, C.; Burton, J.; McNeil, R. 1983. Summer food of the great and double-crested cormorants on the Magdalen Islands, Quebec. Canadian Journal of Zoology. 61(12): 2733-2739.

"*Phalacrocorax carbo* and *P. auritus* generally ate flatfishes (especially winter flounder, *Pseudopleuronectes americanus*), American sand lances *Ammodytes americanus* and cunners *Tautogolabrus adspersus*. Relatively more great cormorants than double-crested cormorants ate flatfishes and cunners during both summers, while relatively more double-crested cormorants fed on American sand lances during the summer of 1977. These fishes and other prey taken in lesser extent were mostly bottom-associated species; however, both cormorants, especially double-crested cormorant, take advantage of capelin *Mallotus villosus* and Atlantic herring *Clupea harengus* schools which come spawning close to the seashore. Great and double-crested cormorants appear to be opportunistic feeders since their diet varies with the availability of prey."

Keywords: *A. americanus*; Canada; Quebec; predators (birds, double-crested cormorant, great cormorant).

Pimm, S.L. 1984. The complexity and stability of ecosystems. Nature. 307: 321-326.

Keywords: *Ammodytes*; ecosytem.

Pinto, J.M. 1984. Laboratory spawning of *Ammodytes hexapterus* from the Pacific coast of North America with a description of its eggs and early larvae. Copeia. 1: 242-244.

"When put in an outdoor holding tank with sand the fish immediately buried in the sand and showed no activity until the spring when they emerged to spawn. The mechanism causing the fish to enter the overwintering stage is still unclear but is suggested to be related to the level of fat content in the fish and to local environmental factors such as zooplankton standing, stock, water temperature and day length. Spawning occurred in the holding tank on 14-15 March 1982. The eggs were deposited on the surface of the sand and were spread evenly over the tank's area. They were coated with sand grains and looked like sand pellets. None of these eggs hatched, mainly due to nematode predation. After spawning, the fish remained buried in the sand but were seen moving actively through it."

Keywords: *A. hexapterus*; behavior; eggs; spawning.

Pinto, J.M.; Pearson, W.H.; Anderson, J.W. 1984. Sediment preferences and oil contamination in the Pacific sand lance (*Ammodytes hexapterus*). Marine Biology. 83: 193-204.

"Sand lance *A. hexapterus* Pallas, forage for zooplankton in the water column and are under heavy predation from fish, marine birds and marine mammals. To avoid predation, these fish bury themselves in soft bottom sediments when not foraging and during overwintering. Sand lance were collected in Sequim Bay, Washington State, USA, in 1982. In 3 experiments the fish were presented with: 4 different sediment types (fine sand, coarse sand, gravel, silt) to determine their sediment preferences; clean and oil-contaminated preferred sediment to determine whether the fish would avoid the contamination; and clean unpreferred and oil-contaminated preferred sediment to determine whether the contamination would alter their sediment preferences. In the 1st experiment, sand lance preferred to bury in fine and coarse sands and avoided gravel and silt. In the 2nd experiment, sand lance avoided sand contaminated with Prudhoe Bay crude oil (116 and 1050 ppm). In the 3rd experiment, sand lance avoided the oiled sand (131 and 1041 ppm) and buried in clean gravel, and also avoided both oiled sand (113 and 1004 ppm) and clean silt, and chose to remain in the water column. The sediment particle size and the way it affects water flow through the sediment seemed to be responsible for the preferences. The sediment type, the sediment distribution, the nutritional state of the fish, and the predation pressure probably influence how sand lance use the sediment as a refuge and how they respond to contamination of that refuge."

Keywords: *A. hexapterus*; behavior; burrowing; habitat; oil; sediments.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. U.S. National Marine Fisheries Service, Fishery Bulletin. 78: 544-549.

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; predators (mammals, harbor seal).

Pitcher, K.W. 1981. Prey of the Steller sea lion, *Eumetopias jubatus*, in the Gulf of Alaska. U.S. National Marine Fisheries Service, Fishery Bulletin. 79: 467-472.

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; predators (mammals, Steller sea lion).

Pitcher, K.W. 1990. Major decline in number of harbor seals *Phoca vitulina richardsi*, on Tugidak Island, Gulf of Alaska. Marine Mammal Science. 6: 121-134.

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; predators (mammals, harbor seal).

Pitcher, K.W.; Calkins, D.G. 1979. Biology of the harbor seal (*Phoca vitulina richardsii*) in the Gulf of Alaska. [Place of publication unknown]: Outer Continental Shelf Environmental Assessment Program Research Unit 229; final report; contract number 03-5-002-69: 231-309.

Sand lance was the highest in percentage of occurrence during fall among stomachs examined from harbor seals in the Kodiak Island area.

Keywords: *A. hexapterus*; Alaska; Kodiak Island; predators (mammals, harbor seal).

Pitcher, K.W.; Calkins, D.G. 1983. Biology of the harbor seal *Phoca vitulina richardsoni* in the Gulf of Alaska. In: Environmental assessment of the Alaskan continental shelf. Final reports of the principal investigators 19. Juneau, AK: National Oceanic and Atmospheric Administration, National Ocean Service: 23-310.

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; predators (mammals, harbor seal).

Pitcher, T.J.; Wyche, C.J. 1983. Predator-avoidance behaviours of sand-eel schools: why schools seldom split. In: Noakes, D.L.G. [and others], eds. Predators and prey in fishes. Developments in Environmental Biology of Fishes. The Hague, Netherlands: Dr. W. Junk Publishers; 2: 193-204.

“In a large outdoor tank 250 sand-eels (*Ammodytes* sp.) cruised as a single school performing consistent behaviours when close encounters with faster swimming mackerel occurred. Sand-eels near fishing gear in the wild showed similar behaviours. Cruise and Avoid were the most frequent behaviours, followed by Herd, Mill, Split and Join. Flash Expansion, Hourglass and Vacuole were occasional, whereas Ball was rare. Cruise and Mill were apparently unconnected with predation. School manoeuvres can be generated by combinations of four behavioural mechanisms of individual fish: (1) schooling tendency, (2) startle response, (3) nearest neighbour distance, and (4) minimum approach distance allowed intruders. The minimum approach distance, bringing about behaviours like Herd and Vacuole, may represent an optimization of the relative swimming performance of sand-eels and their predators with the need to monitor predator behaviour. Paradoxically, minimum approach distance may come about simply through sand-eels schooling with intruders. Rapid reformation of the school after Flash Expansion, high polarity, and integrity of the school maintained in the thin ‘neck’ of Hourglass all testify to the high degree of schooling tendency evolved by sand-eels. Schools were difficult to split as a consequence. When two schools join, the new swimming direction is the resultant vector of the two original directions. Leading fish join by swinging smoothly onto the new track, but fish downstream of the initial join are progressively more likely to continue in their original course, producing interdigitation. At the far side of the school, interdigitated peripheral fish take up a new course only after large ill-coordinated turns; this creates a ‘Confusion Zone’. The Confusion Zone, reported here for the first time, may result invevitably from ‘good schooling’. Such a potential danger zone created on joining may explain the evolution of reluctance to split.”

Keywords: *Ammodytes*; behavior; predators; schooling.

Pitt, T.K. 1973. Food of American plaice *Hippoglossoides platessoides* from the Grand Bank, Newfoundland Canada. Journal of the Fisheries Research Board of Canada. 30(9): 1261-1273.

Keywords: *Ammodytes*; Newfoundland; Grand Bank; energetics; predators (fish, American plaice); seasonal variation.

Pitt, T.K. 1976. Food of yellowtail flounder on the Grand Bank and a comparison with American plaice. International Commission for the Northwest Atlantic Fisheries Research Bulletin. 12: 23-27.

Keywords: *Ammodytes*; Newfoundland; Grand Bank; predators (fish, American plaice, yellowtail flounder).

Podrazhanskaya, S.G.; Chumakov, A.K. 1989. Food habits, diets and demand for food in Greenland halibut of the northwest Atlantic: diurnal rhythms and diets of commercial fishes of the world ocean: 123-140.

“The paper describes the results of analysis of Greenland halibut stomach contents made by the Polar Fisheries Research Institute. Fish aged 2 to 10 years were sampled in NWA in 1969-1981. The basic food items of the mature part of halibut population found in the north of the area are beaked redfish, roundnose grenadier. In the south the prey are capelin, sandeel, crustaceans, juvenile cod and halibut. The major feeding season is July to November. The maximum feeding intensity occurs at 600-700 m. The natural daily ration varies between 1.2% and 0.4% of the body weight in males aged 5-16, and from 1.2% to 0.8% in females aged 5-20.”

Keywords: *Ammodytes*; predators (fish, Greenland halibut).

Polianskii, Y.I. 1955. Parasites of the fish of the Barents Sea. Moskva: Akademy of Sciences USSR. 168 p. (Translated as IPST Cat. No; 1655 in 1966).

Keywords: *Ammodytes*; Barents Sea; parasites.

Ponoamrenko, V.P. 1992. Interesting findings of the greater sand eel *Hyperoplus lanceolatus* and cod *Gadus morhua.* Voprosy Ikhtiologii. 32(1): 170-171.

“A specimen of the greater sand eel (*Hyperoplus lanceolatus*) was taken on 28 September 1973 at a point with coordinates of 75° 50’ N, 20° 44’ E at a depth of 30 m and at a water temperature, at the bottom, of 3.6 °C and, at the surface, of 3.5 °C. The back of the sand eel was blue-green; the sides and abdomen–silvery. The captured specimen was a 22-cm-SL male with sex products at maturity stage II. The stomach was empty. On the vomer were present two weak, toothlike processes. The lower jaw is pointed and projected anteriorly. The upper jaw is not protrusile. D 55; A 30; P 12. The length of the pectoral fin was 78 percent of the length of the lower jaw and 34 percent of the head length; its posterior tip did not reach a vertical from the beginning of the dorsal fin. This was the second capture of a greater sand eel north of Bear Island Medvezhiy Island. In 1963, a specimen 21.5 cm long was taken along the coast of West Spitzbergen at a depth of 65 m at a water temperature, at the bottom, of 3 °C. The capture of the sand eel described in this report was interesting in that it occurred in the Zyuydkapskiy Channel, which is located between shoals surrounding Bear Island and Spitzbergen. In the area, warm water of the South Spitzbergen Current converges with cold waters of the Strait of Stur-fjord, the islands of Edzh-Nadezhda, and the Spitzbergen Bank. The southeastern slope of the Zyuydkapskiy Channel, where the greater sand eel was taken, is most intensively influenced by the warm waters.”

Keywords: *Hyperoplus lanceolatus*; maturity; migration; temperature.

Ponton, D.; Fortier, L. 1992. Vertical distribution and foraging of marine fish larvae under the ice cover of southeastern Hudson Bay. Marine Ecology Progress Series. 81(3): 215-227.

“In ice-covered southestern Hudson Bay (northern Quebec, Canada), the production of suitable zooplankton prey for marine fish larvae was similar within and outside the area covered by the Great Whale River plume. Within the plume however, light attenuation by the turbid surface layer reduced the foraging efficiency of first-feeding Arctic cod

Boreogadus saida and sand lance *Ammodytes* sp. larvae. In daytime, first-feeding larvae accumulated at the pycnocline where food availability (i.e. light × prey density) was maximum. Below the pycnocline, the average number of prey ingested by individual larvae (foraging gain) declined with depth. At night, fish larvae and their prey redistributed more uniformly over the water column, suggesting a similar passive response to the turbulence field in the absence of a light gradient. The observed ideal free distributions (IFDs) were better explained by unequal foraging abilities of the larvae than by density-dependent interactions among the assemblage of planktonic predators."

Keywords: *Ammodytes*; Canada; Hudson Bay; distribution; habitat; ice cover; larvae; turbidity.

Ponton, D.; Gagne, J.A.; Fortier, L. 1993. Production and dispersion of freshwater, anadromous, and marine fish larvae in and around a river plume in subarctic Hudson Bay, Canada. Polar Biology. 13(5): 321-331.

"From 1988 to 1990, fish larvae were sampled before, during, and after ice breakup within and outside the plume of the Great Whale River off Kuujjuarapik, southeastern Hudson Bay, Canada. Arctic cod (*Boreogadus saida*) and sand lance (*Ammodytes* spp.) were the most abundant larvae. Half of the larval fish taxa emerged before the ice broke up in the bay. The highest densities of arctic cod, sand lance, slender eelblenny, and gelatinous snailfish larvae were in salinities exceeding 25 practical salinity units (p.s.u.). Arctic shanny, sculpins, and capelin larvae were more abundant at salinities between 1 and 25 p.s.u.. Burbot and coregonid larvae were clearly associated with fresh or brackish waters even when caught in the bay. The timing and extent of the Great Whale River freshet influenced the distribution of marine fish larvae in southeastern Hudson Bay and determined the moment when the larvae of anadromous and freshwater species entered the bay."

Keywords: *Ammodytes*; Canada; Hudson Bay; abundance; distribution; larvae.

Popova, O.A. 1962. Some data on the feeding of cod in the Newfoundland area of the northwest Atlantic. In: Marti, Y.Y., ed. Soviet fisheries investigations in the northwest Atlantic. VINRO—PINRO, Moskow: 228-248.

Keywords: *Ammodytes*; Newfoundland; predators (fish, cod).

Popp Madsen, K. 1957. A Danish fishery for sand-eel (Ammodytidae). Annals Biologiques, Copenhagen. 12: 101.

Keywords: Ammodytidae; Denmark; fisheries.

Porter, J.M.; Sealy, S.G. 1981. Dynamics of seabird multispecies feeding flocks: chronology of flocking in Barkley Sound, British Columbia in 1979. Colonial Waterbirds. 4: 104-113.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds).

Porter, J. M.; Sealy, S.G. 1982. Dynamics of seabird multispecies feeding flocks: age-related feeding behaviour. Behaviour. 81: 91-109.

Keywords: *Ammodytes*; predators (birds).

Potter, D.C.; Lough, R.G. 1987. Vertical distribution and sampling variability of larval and juvenile sand lance *Ammodytes* sp. on Nantucket shoals and Georges Bank Atlantic Ocean. Journal of Northwest Atlantic Fishery Science. 7(2): 107-116.

"Verticle distribution and movement of sand lance larvae and juveniles (<81 mm SL) are summarized from four cruises during winter and spring seasons in 1978, 1981 and 1983. Opening-closing nets (1-m^2 and 10-m^2 MOCNESS) were used to sample discrete strata for day and night vertical profiles and to make serial double-oblique transects for spatial variability. In December-January, recently-hatched larvae (5 mm SL) were found throughout the water column in well-mixed shelf water, with highest density usually in the 10-20 m depth range. In February-March, the larger larvae (>10 mm SL) were found throughout the water column during both day and night, but these appeared to be

in transition to adult behavior, with many of them living near the bottom during the day and moving up in the water column at night. In April, premetamorphic young (20-30 mm SL) were caught mostly at night, and their abundance increased with depth. In May, postmetamorphic juveniles (50-81 mm SL) were caught mostly at night. Presumably, they were near the bottom or burrowed in the substrate during the day. Avoidance of the samplers by large larvae (>10 mm) and juveniles prevent firm conclusions on their verticle distribution and movement."

Keywords: *Ammodytes*; Georges Bank; Nantucket Shoals; diurnal variation; growth; juveniles; larvae; seasonal variation.

Potts, G.W. 1986. Predator-prey interactions between pollock and sand eels. Progress in Underwater Science. 11: 69-79.

Keywords: *A. lanceolatus*; predators (fish, pollock).

Poulsen, E.M. 1931. Biological investigations upon the cod in Danish waters. Meddelelser Komm. fra Danmarks Fiskeri- og Havundersogelser, Ser. Fiskeri. 10(1): 1-148.

Keywords: *Ammodytes*; Denmark; predators (fish, cod).

Powers, K.; Backus, R. 1987. Energy transfer to seabirds. In: Backus, R., ed. Georges Bank. [Place of publication unknown]: MIT Press: 372-374.

"Sand lance (*Ammodytes* sp.) was found in the stomachs of greater, sooty, and Cory's shearwaters and black-legged kittiwakes. We observed gannets and great black-backed and herring gulls (the large gulls) feeding on sand lance. These sand lance were often driven to the surface by feeding humpback and fin whales. Most of the sand lance and most of the occurrences of sand lance in stomachs were in the GBnw region in waters less than 100 m deep to the east of Cape Cod and in the Great South Channel."

Keywords: *Ammodytes*; Georges Bank; predators (birds, black-legged kittiwake, Cory's shearwater, gannet, great black-backed gull, greater shearwater, herring gull, sooty shearwater; mammals, fin whale, humpback whale)

Powles, P.M. 1958. Studies of reproduction and feeding of Atlantic cod (*Gadus callarias* L.) in the southwestern Gulf of St. Lawrence. Journal of the Fisheries Research Board of Canada. 15: 1383-1402.

"The quantity of fish taken in the diet increased in the 21-30 cm. size group. Young capelin *(Mallotus villosus*) and sand launce (*Ammodytes americanus*) were the most common fish ingested at this stage."

Keywords: *A. americanus*; Gulf of Saint Lawrence; predators (fish, Atlantic cod).

Poxton, M.G. 1987. Fishery studies in the estuary and Firth of Forth Scotland UK. In: Symposium on the natural environment of the estuary and Firth of Forth; [dates of meeting unknown]; [location unknown]. In: Proceeding of the Royal Society of Edinburgh, Section B (Biol. Sci.); 93: 495-508.

"A total of fifty species of fish have been recorded of which thirty-six occurred in the estuary and thirty-nine in the firth. Others are however known to occur. Of the twenty-eight species entrained into the intakes of local power stations, the sprat, herring, whiting and sand goby were most numerous, while other common species were sandeels, eelpout and pogge. Sand gobies, whiting, common dabs and sprats were the most numerous species taken by Agassiz trawling with herring, cod, eelpout, butterfish, pogge, flounders and plaice also commonly taken. Only herring, sprat, whiting, cod and fatherlasher were recorded using a midwater trawl and only the clupeoids occurred in all the catches. The catches of the 2 m beam trawl used in sandy bays in the firth were dominated by plaice, common dabs, sand gobies and sandeels. The ichthyoplankton surveys undertaken in 1986 have caught twenty-three species as eggs and twelve species as larvae. The majority of the eggs were those of the common dab, whiting, flounder, rockling and sprat, while the majority of larvae were sandeels and clupeoids."

Keywords: *Ammodytes*; Scotland; abundance; distribution; eggs; larvae.

Prakash, A. 1962. Seasonal changes in feeding of coho and chinook (spring) salmon in southern British Columbia waters. Journal of the Fisheries Research Board of Canada. 19: 851-866.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (fish, chinook salmon, coho salmon).

Prakhova, N.V.; Kulikov, M.Y.; Ul'yanov, M.Y. 1980. Food composition of the south Kuril pink salmon in the southern part of the feeding area and off Iturup Island. Biological Resources of the Kuroshio and Adjacent Waters, Shuntov, V.P. 104: 113-115.

"The main food items found in the stomachs of the South Kuril pink salmon from June to September were euphausiids, amphipods, copepods and larval sand lance and greenling. The food composition is more homogenous in fishes caught in areas rich in plankton (about 500 mg/m^3) than in those from areas poor in plankton (less than 200 mg/m^3). Differences in the food composition of pink salmons from oceanic and coastal feeding areas are accounted for by different distribution patterns and composition of food organisms in these areas."

Keywords: *A. personatus*; Japan; predators (fish, pink salmon).

Preston, W.C. 1968. Breeding ecology and social behavior of the black guillemot, *Cepphus grylle*. Ann Arbor: MI: University of Michigan. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (birds, black guillemot).

Prime, J.H.; Hammond, P.S. 1990. The diet of grey seals from the south-western North Sea assessed from analyses of hard parts found in feces. Journal of Applied Ecology. 27(2): 435-447.

"(1) To assess variation in the diet of grey seals (*Halichoerus grypus* Fab.) in the southwestern North Sea, feces were collected from Donna Nook, Lincolnshire in each month of 1985. (2) Otoliths from the fecal samples were identified and measured to estimate the size of the fish ingested. (3) Reduction in size of otoliths as a result of passing through the seals' gut was accounted for by applying species-specific digestion coefficients calculated from feeding experiments on captive animals. (4) For the whole year, the three species (sandeels (Ammodytidae), cod (*Gadus morhua* L.) and Dover sole (*Solea solea* L.)) accounted for 56.2% of the diet by weight. Other flatfish (dab *Limanda limanda* L.), flounder (*Platichthys flesus* L.) and plaice (*Pleuronectes platessa* (L.)) contributed a further 21.6% by weight. (5) Cod, sandeels and other roundfish dominated the diet at the beginning of the year. Flatfish took over in the spring to be succeeded by sandeels during the summer. Cod returned to the diet in October and the year ended with the diet divided between flatfish and roundfish, excluding sandeels. (6) Sandeel otoliths could not be identified to species but length-frequency distributions showed that more than one species was consumed throughout the year. Dover sole dominated the diet in May; the time of peak spawning in the Humber/Wash area. Cod was most prevalent in October, the time of its southward migration into the area. (7) The results suggested that the seals were regularly feeding offshore; the estimated distance within which prey contributing to the feces could have been taken included the areas where sandeels are most abundant in the south-western North Sea. (8) Shrimp remains were present in the samples only at the beginning of the year, the time when pups are being weaned and starting to feed for themselves. Other crustacean remains, found throughout the year, were probably from the stomachs of larger fish consumed. (9) Fecal analysis cannot account for prey items with no hard parts or whose hard parts are not consumed. However, calculation of digestive efficiency suggested that no major component of the diet had been missed."

Keywords: *Ammodytes*; North Sea; otoliths; predators (mammals, grey seal).

Prince, P.A.; Harris, M.P. 1988. Food and feeding ecology of breeding Atlantic alcids and penguins. Proceedings of the International Ornithology Congress. 19: 1195-1204.

Keywords: *Ammodytes*; predators (birds).

Pritchard, A.L.; Tester, A.L. 1943. Notes on the food of coho salmon in British Columbia. Fisheries Research Board of Canada, Progress Reports of the Pacific Coast Stations. 55: 10-11.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (fish, coho salmon).

Pritchard, A.L.; Tester, A.L. 1944. Food of the spring and coho salmon in British Columbia. Bulletin of the Fisheries Research Board of Canada. 66: 1-23.

Keywords: *A. hexapterus*; British Columbia; predators (fish, chinook salmon, coho salmon).

Pruter, J. 1989. Phanologie und Ernährungsokologie der Dreizehenmowen (*Rissa tridactyla*)–Brutpopulation auf Helgoland. Oekologie der Voegel. 11(2): 189-200.

Keywords: *Ammodytes*; Germany; North Sea; predators (birds, black-legged kittiwake).

Quinn, T.; Schneider, D.E. 1991. Respiration of the teleost fish *Ammodytes hexapterus* in relation to its burrowing behavior. Comparative Biochemistry and Physiology [Part] A. 98(1): 71-76.

“Oxygen consumpton rates of the Pacific Sandlance (*Ammodytes hexapterus*) determined under conditions of declining oxygen tension were oxygen independent to a significantly lower tension in winter (Pc = 16 Torr) than in summer (Pc = 30 Torr). Under normoxic conditions at both 5 and 12 °C, winter acclimatized fish showed a 17% reduction in the rate of oxygen consumption when compared to summer acclimatized fish, indicating an inverse compensatory shift in seasonal metabolic rate.”

Keywords: *A. hexapterus*; behavior; metabolism; respiration.

Rabin, D.; Rogers, D.E. 1978. Seasonal composition and food web relationships of marine organisms in the nearshore zone of Kodiak Island–including ichthyoplankton, meroplankton, forage fishes, marine birds and marine mammals. Part A: A report on the ichthyoplankton component of the study. In: Environmental assessment of the Alaskan Continental Shelf; quarterly reports of principal investigators for April-June 1978. Boulder, CO: U.S. National Oceanic and Atmospheric Administration, Environmental Research Laboratories.

“Fish larvae from late March and early April samples have been identified or typed for future identification. Larvae from families Ammodytidae (sandlance), Cottidae (sculpins), Hexagrammidae (greenlings), and Stichaeidae (prickle-backs) were relatively abundant. Larvae from families Agonidae (poachers), Bathymasteridae (ronquils), Cyclopteridae (snailfishes), Gadidae (codfishes), Osmeridae (smelts), Pholidae (gunnels), and Pleuronectidae (righteye flounders) have also been identified. The laboratory findings indicate: larval stages of forage fishes, such as sand lance and snake prickleback, were present in the early spring period and occurrence of greenling larvae in surface (neuston) samples was relatively high.”

Keywords: *A. hexapterus*; Alaska; abundance; distribution; larvae; seasonal variation.

Rachlin, J.W. 1990. Ecology of nearshore marine fishes. In: Molloy, D.P., ed. The New York natural history conference. N.Y. State Museum Circular. 54: 44.

Keywords: *A. americanus*; Atlantic (northwest); behavior; ecology; models.

Rae, B.B. 1967a. The food of cod in the North Sea and on the west of Scotland grounds. Marine Research. 1967(1). 68 p.

“It is evident that sand eels are the outstanding item in the food in certain localities. Sand eels are eaten at all times of the year in the Scottish area but these fish are predominantly a summer food of the cod, reaching remarkable proportions on the grounds adjacent to the north coast of Scotland.”

Keywords: *Ammodytes*; North Sea; Scotland; predators (fish, cod).

Rae, B.B. 1967b. The food of cod on Faroese Grounds. Marine Research. 1967(6). 23 p.

Sand eels were usually the most common fish eaten by cod.

Keywords: *Ammodytes*; Faroese; predators (fish, cod).

Rae, B.B. 1967c. The food of the dogfish *Squalus acanthias* L. Marine Research. 1967(4): 6-15.

“The food consists primarily of pelagic fish. The herring is the outstanding single species and along with sand eels and mackerel, and semi-pelagic types such as whiting and *Gadus esmarkii*, forms the bulk of the food.”

Keywords: *Ammodytes*; North Sea; Scotland; predators (fish, dogfish).

Rae, B.B. 1968a. The food of cod in Icelandic waters. Marine Research. 1968 (6): 19.

“Of the individual fish types in the food of Icelandic cod, sand eels and capelin were of outstanding importance throughout the period of sampling, March to September.”

Keywords: *Ammodytes*; Iceland; predators (fish, cod).

Rae, B.B. 1968b. The food of seals in Scottish waters. Marine Research. 1968(2): 1-28.

“The food of seals in Scottish waters was studied by the examination of the stomach contents of 368 grey seals and 175 common seals. Sand eels were found in 0.6% of the grey seals sampled on the Scottish mainland and 22% of the ones sampled in Shetland. Sand eels occurred in 4.7% of the common seals sampled.”

Keywords: *Ammodytes*; Scotland; predators (mammals, grey seal, common seal).

Raitt, D.S. 1934. A preliminary account of the sandeels of Scottish waters. Journal du Conseil. 9(3): 365-372.

Keywords: *Ammodytes*; Scotland; distribution.

Raitt, D.S. 1935. The occurrence of four species of sand eels, of economic importance, in Scottish waters, one of which is new to science. Scotland Nature. (211): 61-62.

Keywords: *Ammodytes*; Scotland; distribution.

Ralph, C.J.; Hunt, G.L., Jr.; Raphael, M.G.; Piatt, J.F. 1995. Ecology and conservation of the marbled murrelet in North America: an overview. In: Ralph, C.J.; Hunt, G.L., Jr.; Raphael, M.G.; Piatt, J.F., eds. Ecology and conservation of the marbled murrelet. Gen. Tech. Rep. PSW-GTR-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture: 3-22.

“Murrelets have also been associated with particular marine habitats that are favored by prey, such as sand lance. Murrelets aggregate in shallow bays of fjords, in estuaries, and off beaches because these locations are where prey such as sand lance might be common. Carter (1984) found murrelets in waters over sand and gravel bottom, possibly because of the concentration of sand lance.

“We do not know if the availability of fish species important to murrelets has declined, because the relationship of the abundance and distribution of the several species taken by the bird and the interplay of the behavior and distribution of foraging birds is unknown.”

Keywords: *A. hexapterus*; importance; predators (birds, marbled murrelet).

Randall, J.E.; Ida, H.; Earle, J.L. 1994. *Ammodytoides pylei*, a new species of sand lance (Ammodytidae) from the Hawaiian Islands. Pacific Science. 48(1): 80-89.

“A new sand lance, *Ammodytoides pylei*, is described from 17 specimens collected on sand substratum in the depth range of 7 to 120 m from Molokai to the Ladd Seamount in the Northwestern Hawaiian Islands. It is characterized by 48-52 dorsal rays, 22-25 anal rays, 15-17 pectoral rays, 109-116 lateral-line scales, 29-33 gill rakers, 59-60 vertebrae, an elongate body (depth 8.5-10 in standard length (SL)), and a series of small blackish spots at the margin of the dorsal fin. The spawning behavior is described.”

Keywords: *Ammodytoides pylei*; Hawaii; meristics; spawning; taxonomy.

Rankine, P.W.; Morrison, J.A. 1988. Predation on herring larvae and eggs by sand-eels *Ammodytes marinus* (Rait) and *Hyperoplus lanceolatus* (Lesauvage). Journal of the Marine Biology Association. 69(2): 493-498.

“This note describes sand-eel predation on herring eggs and larvae made during a survey of a spawning ground 85,000 m^2 in area, on Ballantrae Bank in the Firth of Clyde, Scotland, [UK] in April 1987. Sand-eels were observed living in the coarse gravel sediments used by the spawning herring. Individual sand-eels were dissected and found to contain up to 400 eggs and larvae in their stomachs. Large populations of sand-eels occur around the coast of Scotland in contiguous distribution with known herring spawning areas. These observations suggest that sand-eels may be important egg and larval predators.”

Keywords: *A. lanceolatus; A. marinus*; Scotland; food and feeding habits.

Rasmussen, E.V. 1985. The occurrence of the sooty shearwater *Puffinus griseus* in Denmark. Dansk Ornithologisk Forenings Tidsskrift. 79(1-2): 1-9.

“It is here suggested that the observations reflect a real increase of Sooties in the North Sea, and that recent changes in the stocks of various fish species in the area are responsible for this increase, at least in part. From what is known of the food choice of the Sooty Shearwater it appears likely that the increased stocks of sand-eels in particular have benefitted the Sooties in the area. The sand-eel itself is believed to have gained by the decrease, due to over-fishing, of herring and mackerel.”

Keywords: *Ammodytes*; North Sea; predators (birds, sooty shearwater).

Rass, T.S. 1949. Composition of the ichthyofauna of the Barents Sea and the systematic indicators of the eggs and larval fish of its reserves. Trudy Vsesoyuznogo Nauchno–Issledovatel’Skogo Instituta Morskogo Rybnogo Khozyaistva i Okeanografii. 17: 7-65.

Keywords: *A. hexapterus; A. marinus*; Barents Sea; distribution; eggs; larvae.

Ray, G.C. 1988. Ecological diversity in coastal zones and oceans. In: Wilson, E.O.; Peter, F.M., eds. Biodiversity. Washington, DC: National Academy Press: 36-49.

Keywords: *Ammodytes*; ecology.

Reay, P.J. 1970. Synopsis of biological data on North Atlantic sandeels of the genus *Ammodites* (*A. tobianus, A. dubius, A. americanus* and *A. marinus*). FAO Fisheries Synopsis. 82: 48 p.

Keywords: *A. americanus, A. dubius, A. marinus, A. tobianus*; fisheries; general; growth; maturation.

Reay, P.J. 1972. The seasonal pattern of otolith growth and its application to back-calculation studies in *Ammodytes tobianus* L. Journal du Conseil, Conseil International pour l’Exploration de la Mer. 34: 485-504.

Keywords: *A. tobianus*; growth; otoliths.

Reay, P.J. 1973. Some aspects of the biology of the sand eel, *Ammodytes tobianus* L., in Langstone Harbour, Hampshire. Journal of the Marine Biological Association of the United Kingdom. 53: 325-346.

“Samples of *Ammodytes tobianus* from Langstone Harbour were obtained by beach-seine between 1968 and 1971. Separate spring- and autumn-spawning groups were distinguished on the basis of otolith structure, vertebral number, gonad development, and the arrival time and size of the juvenile fish. The spring-spawners were about four times as abundant as the autumn-spawners.

“The maximum observed length of the spring-spawners was 173 mm, and the maximum age VII-group. An average annual instantaneous mortality coefficient of 1.29 was calculated from the age-composition data. The sex-ratio was 1:1. Maturity was usually reached at two years but occurred in some fish at one year of age.

“Growth parameters calculated for the spring-spawning groups were as follows: L = 160 mm, KL = 0.77, W = 13.0 g, KW = 0.86. Calculated annual growth-rates as instantaneous annual coeficients were always lower than the annual mortality-rates, and showed that, at least from the age of one year, the total biomass of a year-class decreased. Variation in the growth increments of the same age-groups in different years occurred.

“An examination of the seasonal pattern of growth in the young fish revealed a growth extending from March to August (to October in 0-group spring-spawners). In I-group spring-spawners, for which most data were available, May was the month of peak growth with a monthly growth-rate (as average daily instantaneous rate) up to 0.77% for length, and 2.59% for weight. There was a chacteristic period of no or slow growth in June, and some evidence for a slight secondary peak after this, but the rates from June to August were lower than those in both April and May. The period of rapid growth in May coincided with rapid increase in water temperature, and mean monthly values of 11-13 °C, but there was no evidence to suggest a direct influence of temperature on the seasonal growth pattern.

“Ponderal index values for I-group spring-spawners showed a rapid increase in early spring and peak values were reached in May, after which they fluctuated in an irregular way. It was concluded that some of the decreases in ponderal index arose from growth in length proceeding at a faster rate than growth in weight, and others from weight loss. The latter 5, presumably reflecting unfavourable environmental conditions, were associated with weight loss in the mesenteric fat deposits. In 1971 this fat was dissected out and weighed. It was found to be the main constituent of the body cavity, and formed up to 13.5% of the total dried weight of the fish. The mean dry weight of the mesenteric fat deposits increased from 0.003 g in February to 0.225 g in late May.

“Comparison of the results of the Langstone Harbour study with data from other areas revealed differences in spawning-group composition, spawning season, and size and growth.”

Keywords: *A. tobianus*; Hampshire; age and growth; biology; maturity; spawning.

Reay, P.J. 1986. Ammodytidae. In: Whitehead, P.J.P.; Bauchot, M.L.; Hureau, J.C. [and others], eds. Fishes of the north-eastern Atlantic and the Mediterranean. Paris: Unesco; 517-1007. Vol. 2.

Keywords: Ammodytidae; distribution; general; taxonomy.

Reid, G. 1961. Stomach content analysis of troll-caught king and coho salmon, southeastern Alaska, 1957-1958. U.S. Fish and Wildlife Service Special Scientific Report—Fisheries. 376: 1-8.

Keywords: *A. hexapterus*; Alaska; predators (fish, chinook salmon, coho salmon).

Reimchen, T.E.; Douglas, S. 1984. Feeding schedule and daily food consumption in red-throated loons (*Gavia stellata*) over the prefledgling period. Auk. 101: 593-599.

Keywords: *Ammodytes*; predators (birds, red-throated loon).

Repecka, R.; Ziliukas, V.; Stankus, S. 1996. The abundance of the fish larvae and fry in the coastal zone of the Baltic Sea and Kursiu Lagoon. Fishery and Aquaculture in Lithuania. Zuvininkyste Lietuvoje: 95-108.

“The fish larvae and fry investigations were made using ichthyoplankton net and beach-seine in coastal zone of the Baltic Sea and Kursiu Lagoon. Fourteen fish species were registered in catches by beach-seine in coastal zone in 1995. The fry of marine (sprat, herring, turbot, flounder, lesser sandeel) and migratory (smelt, vimba, whitefish) fish species were the most abundant, however but the number of some freshwater fish species as pike-perch, bleak was comparatively high in coastal zone.”

Keywords: *A. marinus*; Lithuania; Baltic Sea; abundance; larvae.

Reynolds, W.W.; Casterlin, M.E. 1985. Vagile macrofauna and the hydrographic environment of the Saco River estuary and adjacent waters of the Gulf of Maine. Hydrobiologia. 128(3): 207-216.

“We also examined the stomach contents of specimens of two common fish species to determine their local feeding habits. Yearling *Pollachius virens* fed primarily on *Ammodytes americanus*.”

Keywords: *A. americanus*; Gulf of Maine; anthropogenic impacts; habitat; predators (fish, pollock).

Rice, J.A.; Crowder, L.B.; Binkowski, F.P. 1987. Evaluating potential sources of mortality for larval bloater (*Coregonus hoyi*)–starvation and vulnerability to predation. Canadian Journal of Fisheries and Aquatic Sciences. 44(2): 467-472.

Keywords: *Ammodytes*; fisheries; predators (fish).

Rice, S.D.; Karinen, J.F. 1976. Acute and chronic toxicity, uptake and depuration, and sublethal metabolic response of Alaskan marine organisms to petroleum hydrocarbons. Environmental assessment of the Alaskan Continental Shelf: Principal investigators reports for the year ending March 1976. 8: 25-47.

“This study was designed to determine the acute and chronic toxicity of crude oil and its component fractions on physiological and behavioral mechanisms of selected arctic and subarctic organisms and to determine recovery rates of selected organisms in laboratory and field studies. It involved physiological bioassay tests of applied research on species indigenous to the Gulf of Alaska, Bering Sea, and Beaufort Sea. Specific Objectives and Studies: (1) Determine acute toxicity of previously untested species such as amphipods, mysids, sandlances, and others. (2) Determine acute toxicity at different temperatures with several species such as scallops, pink salmon, and shrimp. (3) Determine the chronic toxicity to shrimp and herring eggs and the effects of oil on newly extruded eggs of crabs. (4) Determine the uptake and depuration of oil components for previously untested species. (5) Determine the effect of temperature on oil component uptake and depuration. (6) Determine the effect of oil on metabolic rate of fish and invertebrates. (7) Determine the effect of oil on scallop growth and behavior. (8) Determine the effect of oil on crab autotomy response. (9) Determine histopathology effects of oil using routine histology, enzyme histochemistry, and electron microscopy.”

Keywords: *A. hexapterus*; Alaska; anthropogenic impacts; disease; growth; oil; pollution; temperature; toxicity.

Richards, S.W. 1959. Pelagic fish eggs and larvae of Long Island Sound. In: Oceanography of Long Island Sound. Bulletin Bingham Oceangraphic College. 17(1): 95-124.

Keywords: *Ammodytes*; Long Island Sound; abundance; distribution; eggs; larvae.

Richards, S.W. 1963. The demersal fish population of Long Island Sound. Bulletin Bingham Oceanographic College. 18(2). 101 p.

Keywords: *Ammodytes*; Long Island Sound; abundance; distribution.

Richards, S.W. 1965. Description of the postlarvae of the sand lance (*Ammodytes*) from the east coast of North America. Journal of the Fisheries Research Board of Canada. 22(5): 1313-1317.

Apparently, among North American sand lance larvae, environmental factors have induced differences that previously were used as criteria for species separation. Two such factors, temperature and salinity, are discussed in Richards et al. 1963 (see entry below). Evidently the cold water of higher salinity offshore and to the north slows development and produces thin larvae with high counts compared with larvae that develop in the slightly warmer and perhaps less saline waters near bays and estuaries.

Basically, North American sand lances are winter and spring spawners; larvae occur from December to April south of Cape Cod, from February to May north of Cape Cod, and during spring and early summer in the far north. Fry from each area occur correspondingly later. No larvae have ever been recorded from September to November along this coast.

Keywords: *Ammodytes*; Atlantic; description; postlarvae.

Richards, S.W. 1976. Mixed species schools of postlarvae of *Ammodytes hexapterus* and *Clupea harengus harengus.* Journal of the Fisheries Research Board of Canada. 33: 843-844.

“Small schools of post-larval *Ammodytes hexapterus* and *Clupea harengus harengus* were observed and captured at Margaree Harbor entrance in the Gulf of St. Lawrence on July 20, 1974 and captured at Goldsmith Inlet beach in Long Island Sound on April 18, 1975. These species appeared similar, yet *A. hexapterus* averaged 14 mm longer than *C. harengus harengus* at Margaree, but 9 mm shorter than herring at Goldsmith Inlet beach. In both areas sand lances were narrower than herring.

“Post-larval *A. hexapterus* do not bury in the sand, and they will school together with post-larval *C. harengus harengus* regardless of the differences in sizes between the two species.”

When the schools of sand lance and herring were chased, they swam away or hid behind the tentacles of a red jellyfish. The sand lance made no attempt to escape by burying in the sand.

Keywords: *A. hexapterus*; Atlantic; behavior; length; postlarvae.

Richards, S.W. 1982. Aspects of the biology of *Ammodytes americanus* from the St. Lawrence River to Chesapeake Bay, 1972-75, including a comparison of the Long Island Sound postlarvae with *Ammodytes dubius*. Journal of Northwest Atlantic Fishery Science. 3(2): 93-104.

“During the autumn, sand lance from Georges Bank and Long Island Sound concentrated on copepods and mysids. Small snails were common + lots of bottom organisms. Winslade (1994) reported that *A. marinus* in European waters fed only during daylight, however *A. americanus* in this study apparently feeds during day and night. Eggs [sic] counts for eight females from Long Island Sound (89-141 mm) varied from 1,855 to 5196, with a mean of 3,475. *A. americanus,* which is primarily a pelagic plankton feeder, was found to feed on benthic invertebrates, presumably during times of low zooplankton abundance. Recently-consumed food was found in the stomachs of many specimens throughout the 24-hr day. Fecundity of age-groups 2 and 3 of the closely related *A. marinus* = 10,000-15,000 eggs, Macer, 1966.”

Keywords: *A. americanus; A. dubius; A. marinus*; Atlantic; Georges Bank; Long Island Sound; fecundity; food and feeding habits.

Richards, S.W.; Kendall, A.W., Jr. 1973. Distribution of sand lance *Ammodytes* sp., larvae on the continental shelf from Cape Cod to Cape Hatteras from RV Dolphin surveys in 1966. Fishery Bulletin. 71(2): 371-386.

“Postlarvae of one species of sand lance, which resembled *Ammodytes marinus* exactly, were collected along the east coast of the United States between Martha’s Vineyard, Mass., and Cape Hatteras, N.C. (lat 41 to 35 N) in January-February, April, May, and December 1966. They were more abundant in tows taken at night than in tows

taken during the day. Recently hatched specimens (4-8 mm) were more abundant in shallow water. Diurnal migrations are probably related to feeding in all larger size groups."

Evidence indicated that complicated movements occurred during development of larval sand lances. After hatching from demersal eggs, larvae eventually were dispersed throughout the water column, where they drifted generally offshore and slightly south. Within this general drift, they tended to move toward the surface during the day for feeding purposes and back into deeper water at night. Their availability to the Gulf V sampler apparently decreased after they reached 25 millimeters. During May, larvae and juveniles disappeared from the water column. General migration back to the coast or to the bottom on offshore banks was indicated.

The long spawning season, causing hatching to take place from late November through mid-April, was evidenced by the patchy distribution of small specimens and the multimodal character of length frequencies. Interspersion of groups prevented accurate analysis of growth during the hatching season.

Keywords: *Ammodytes*; abundance; distribution; larvae; postlarvae.

Richards, S.W.; Perlmutter, A.; McAneny, D.C. 1963. A taxonomic study of the genus *Ammodytes* from the east coast of North America (Teleostei: *Ammodytes*). Copeia. (2): 358-377.

"Two species, *Ammodytes hexapterus* Pallas, 1931 and *Ammodytes dubius* Reinhardt, 1838, are recognized from collections from Hudson Bay—western Greenland to Virginia along the east coast of North America. *A. hexapterus*, which ranges inshore from 41-60 degrees N, is a deep-bodied fish with meristic-character counts of V = 61-73; D = 51-62; A = 23-33. It may be partially divided into a group of fish of small size with low meristic counts from semi-enclosed bays and a group of fish of larger size with a wide range of meristic counts from along exposed coastal areas. *A. dubius*, a northern and offshore form, ranges from 37-69 degrees N, usually in waters of salinities higher than 30 0/00. It is a slender sand lance with meristic-character counts of V = 64-75 (78); D = 55-67; A = 26-35, which show a marked latitudinal cline. A discussion of the nomenclatural confusion concerning this genus is included."

Keywords: *A. hexapterus; A. dubius*; taxonomy.

Richards, S.W.; Schew, W.A. 1989. Species composition of food brought to roseate tern chicks on Falkner Island, Connecticut in summer 1984. Connecticut Warbler. 9(1): 1-5.

Keywords: *A. americanus*; Connecticut; predators (birds, roseate tern).

Richardson, F. 1961. Breeding biology of the rhinoceros auklet on Protection Island, Washington. Condor. 63: 456-473.

Keywords: *A. hexapterus*; Washington; predators (birds, rhinoceros auklet).

Ricklefs, R.E. 1984. Some considerations on the reproductive energetics of pelagic seabirds. Studies in Avian Biology. 8: 84-94.

Keywords: *Ammodytes*; predators (birds).

Riddiford, N. 1993. Recent changes in Fair Isle seabird populations. Seabird. 15: 60-67.

Keywords: *Ammodytes*; Shetland; predators (birds).

Riehl, R. 1978. The fish fauna of Ibiza (Baleares): Pisces. Senckenbergiana Biologica 59(3-4): 173-182.

"A number of marine fish were caught on the north coast of Ibiza Island (Baleares). The collection includes 34 species. *Ammodytes tobianus* and *Pleuronectes platessa* were found in the Mediterranean Sea for the first time."

Keywords: *A. tobianus*; Mediterranean; distribution; taxonomy

Rigaut, J.P.; Chalumeau, M.T. 1984. Pyruvate kinase ec–2.7.1.40 isozyme patterns of fish. Comparative Biochemistry and Physiology [Part] B. 77(3): 451-458.

“A complex system of pyruvate kinase (PK) isozymes was demonstrated by electrophoresis in the tissues of 22 different species of fish [*Scyliorhinus caniculus, Raja radiata, Raja clavata, Clupea harengus, Salmo gairdneri, Puntius–Barbus tetrazona, Cyprinus carpio, Rutilus rutilus, Silurus glanis, Anguilla anguilla, Gadus merlangus, Spinachia spinachia, Entelurus* species, *Lebistes reticulatus, Mugil auratus, Pterophyllum scalare, Ammodytes tobianus, Scomber scombrus, Trichogaster leeri, Gobius paganellus, Trigla cuculus* and *Limanda limanda*]. The most slowly anodal isozyme could correspond to the K4 homotetramer observed in all the other vertebrates studied so far. In at least 18 out of 19 different of teleosts exists a major fast anodal isozyme, which was named ‘PK–E’. A slightly less anodal additional band exists in 14 of these species (‘PK–E’). In 9 teleosts another isozyme (‘PK–L’) is present, in liver and red blood cells only. Several K–E, E–E (and possibly K–L) sets of tetramer hybrids are often noted. K2 E2 is the predominant PK in the heart muscles of 9 teleosts. The major isozyme of skeletal muscle is K4 in 15 teleosts, E4 in 3 others and K2 E2 in a last one. This may explain some of the differences, noted by others, between kinetic parameters of muscle PK in various species of fish. In all the organs of 3 chondrichthyans studied, PK–K is the only isozyme present (with the exception of 2 miner [sic] bands in the heart muscle of *Scyliorhinus*).”

Keywords: *A. tobianus*; physiology; proteins.

Ritchie, A. 1932. The food and feeding habits of the haddock. Rapports et Procès-Verbaux des Reunions Conseil International pour l’Exploration de la Mer. 80(3): 16.

“Fish do not form a regular diet of the haddock although at certain places and times they may contribute a most important part of the food supply. The sand-eels (*Ammodytes*)—both postlarval and adolescent—are the most important in this respect, and, on the grounds to the north and west of Scotland the abundance and distribution of these play a most important role in the movements of the haddock shoals during the feeding period.”

Keywords: *Ammodytes*; predators (fish, haddock).

Ritchie, W. 1993. Environmental impacts of the Braer oil spill and development of a strategy for the monitoring of change and recovery. Marine Policy. Shetland, Scotland (UK); 17(5): 434-440.

“The environmental impact of the Braer oil spill (85000 tonnes) in south Shetland was unique. Severe wind and wave conditions produced extremely turbulent sea conditions for the entire period. An oil slick did not form. The adjacent coastline consisted of cliffs with strong dissipative and reflective properties. The oil (Gulfaks) was very light. Winter conditions prevailed with rain and sleet. Some oil was carried on to the land by spray. Visible coastal and intertidal impact was negligible. A large fraction of oil was dispersed into the water and taken by currents to basins of fine sedimentation in deep water, considerable distances from the spill. The monitoring programme has laid emphasis on the marine environment, notably the seabed, both chemically and biologically. Sea birds, otters, seals and the important sand eel populations will be monitored. Terrestrial and coastal habitats will receive less attention. Fish and salmon farms will also bestudied over time. The Ecological Steering Group for the Oil Spill in Shetland (ESGOSS) and its four task groups on terrestrial and ornithological impacts, intertidal and sublittoral ecosystems, physical and chemical processes, and wider applications are described.”

Keywords: *Ammodytes*; Shetland; anthropogenic impacts; environmental impact; oil; pollution.

Robards, M.D.; Anthony, J.; Piatt, J.F. [and others]. [In press]. Changes in proximate composition and somatic energy content for Pacific sand lance (*Ammodytes hexapterus*) from Kachemak Bay, Alaska, relative to maturity and season. Journal of Experimental Marine Biology and Ecology.

Mean dry-weight energy values of adult Pacific sand lance (*Ammodytes hexapterus*) peaked in spring and early summer and then declined by about 25 percent during late summer and fall. Late summer declines in energy density paralleled gonadal development. Gender differences were apparent only from August to October.

Keywords: *A. hexapterus*; Alaska; Cook Inlet; condition index; energetics; proximate composition; seasonal variation; spatial variation.

Robards, M.D.; Piatt, J.F.; Kettle, A.B.; Abookir, A.A. 2000. Temporal and geographic variation in fish communities of Lower Cook Inlet, Alaska. Fishery Bulletin. 98: [page nos. unknown].

“The nearshore and shelf fish communities of Lower Cook Inlet, Alaska were studied at 3 locations (Kachemak Bay, Chisik Island, and the Barren Islands). The Barren Island waters are largely oceanic, Kachemak Bay receives largely oceanic water but has a significant freshwater runoff component, and Chisik Island waters are predominantly estuarine in nature. Beach seines and mid-water trawls were the primary capture methods at all sites. Kachemak Bay was sampled over the course of two years (1995 & 1996), whereas Chisik Island and the Barren Islands were only sampled in the summer of 1996.

“The study areas support a diverse nearshore fish community of at least 52 species. Of these species, 50 were caught in Kachemak Bay, 24 at Chisik Island, and 12 at the Barren Islands. Pacific sand lance was clearly the dominant nearshore species at the Barren Islands and Kachemak Bay comprising 99% and 71% of the total individuals respectively.”

Keywords: *A. hexapterus*; Alaska; Cook Inlet; abundance, distribution; seasonal variations.

Robards, M.D.; Piatt, J.F.; Rose, G.A. 1999. Maturation, fecundity, and intertidal spawning of Pacific sand lance (*Ammodytes hexapterus*) in the northern Gulf of Alaska. Journal of Fish Biology 54: 1050-1068.

We investigated seasonal maturation and spawning of Pacific sand lance (*Ammodytes hexapterus*) in Kachemak Bay, Alaska, between May 1996 and October 1997. Most sand lance reached maturity in their second year. Sand lance spawned intertidally in late Sptember and October on fine gravel or sandy beaches soon after the seasonal peak in water temperatures.

Robb, A.P. 1990. Gastric evacuation in the whiting (*Meriangus merlangus* L.). In: Council Meeting of the International Council for the Exploration of the Sea; Copenhagen (Denmark): 9.

“This paper describes the effect of fish size, meal size, temperature and prey type on gastric evacuation in whiting (*Merlangus merlangus*). A linear evacuation model gave a good description of the data. Larger fish eliminated meals of a given size at a faster rate than smaller fish. When fish of similar size were given meals of different sizes, the larger meals were eliminated at a faster rate when expressed as g/h, but actually took longer to disappear by virtue of their size. Increase in temperature was accompanied by an increase in evacuation rates. No difference was found between the rates at which sandeel and clupeoid prey were evacuated.”

Keywords: *Ammodytes*; predators (fish, whiting).

Robertson, G. 1989. Scotland’s over-exploited waters. ECOS: a Review of Conservation. 10(3): 25-28.

“A review of exploitation which portrays an ironic picture of economic success and environmental problems, notably in the areas of: oil production; fish farming; offshore mineral prospecting; and fishing for sandeels. One of the problems is the wide range of responsibilities placed upon the Department of the Environment, and so it is suggested that the environmental protection duties of the Department are split off from its other functions.”

Keywords: *Ammodytes*; Scotland; anthropogenic impacts.

Robertson, I. 1974. The food of nesting double-crested and pelagic cormorants at Mandarte Island, British Columbia, with notes on feeding ecology. Condor. 76: 346-348.

Keywords: *A. hexapterus*; British Columbia; predators (birds).

Robinette, R.L.; Ha, J.C. 1997. The significance of fishing by northwestern crows. Wilson Bulletin. 109: 748-749.

“On two occasions large groups of Northwestern Crows were observed fishing systematically for Pacific sand lances buried in sandy areas at very low tides. They found the sand lance by flipping sand to each side with their beaks while digging a 5-8 cm hole in the sand. The crows swallowed the fish whole. Crows could find and handle a fish in

less than five minutes. The authors concluded that the average crow needs only 3.4 sand lances/day to satisy their daily energy requirements, whereas they needed 961.2 average sized worms."

Keywords: *A. hexapterus*; Washington; predators (birds, northwestern crow).

Robins, C.R.; Bohlke, J.E. 1970. The 1st Atlantic species of the Ammodytid fish genus *Embolichthys.* Notulae Natural of the Academy of Natural Sciences of Philadelphia. 430: 1-11.

Keywords: *Embolichthys*; taxonomy.

Robins, C.R. [and others] 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. Spec. Publ. 20. [Place of publication unknown]: American Fisheries Society.

Lists species and names for three members of the family Ammodytidae—sand lances: *Ammodytes americanus* DeKay, 1842, American sand lance, found in the Atlantic; *A. dubius* Reinhardt, 1837, northern sand lance, found in the Atlantic; and *A. hexapterus* Pallas, 1814, Pacific sand lance, found in the Pacific.

Populations of *A. hexapterus* from the eastern Arctic, previously identified with *hexapterus*, were assigned to *americanus* by Richards (see Richards 1982 item, above).

Keywords: *A. americanus; A. dubius; A. hexapterus*; distribution; taxonomy.

Robinson, C.K.; Lapi, L.A.; Carter, E.W. 1982. Stomach contents of spiny dogfish (*Squalus acanthias*) caught near the Qualicum and Fraser Rivers, April-May, 1980-1981. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 1656: 21 p.

Keywords: *A. hexapterus*; British Columbia; predators (fish, spiny dogfish).

Robinson, D.G. 1969a. Number, size composition, weight and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia April 24-25, 1968. Fisheries Research Board of Canada, Manuscript Report. 1067: 63 p.

Keywords: *A. hexapterus*; British Columbia; Strait of Georgia; abundance; distribution; food and feeding habits; juveniles; larvae.

Robinson, D.G. 1969b. Number, size composition, weight and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia July 4-6, 1967. Fisheries Research Board of Canada, Manuscript Report. 1012: 71 p.

Keywords: *A. hexapterus*; British Columbia; Strait of Georgia; abundance; distribution; food and feeding habits; juveniles; larvae.

Robinson, D.G.; Barraclough, W.E.; Fulton, J.D. 1968a. Data record: number, size composition, weight and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia May 1-4, 1967. Fisheries Research Board of Canada, Manuscript Report Series. 964: 105 p.

"*A. hexapterus* stomach contents larvae + postlarvae =1 percent copepods."

Keywords: *A. hexapterus*; British Columbia; Strait of Georgia; food and feeding habits; larvae; postlarvae.

Robinson, D.G.; Barraclough, W.E.; Fulton, J.D. 1968b. Number, size composition, weight and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia June 5-9, 1967. Fisheries Research Board of Canada, Manuscript Report. 972: 109 p.

Keywords: *A. hexapterus*; British Columbia; Strait of Georgia; abundance; distribution; food and feeding habits; juveniles; larvae.

Rodway, M.S.; Carter, H.R.; Sealy, S.G.; Campbell, R.W. 1992. Status of the marbled murrelet in British Columbia. Proceedings of the Western Foundation of Vertebrate Zoology. 5(1): 17-41.

“The marbled murrelet (*Brachyramphus marmoratus*) is widespread in nearshore habitats throughout coastal British Columbia. Populations have been censused reliably only in Barkley and Clayoquot sounds on the west coast of Vancouver Island. The provincial population may approach 45,000 breeding birds. Local studies and casual observations suggest a movement from exposed inshore waters into sheltered nearshore Georgia by a portion of the population. No nests have been found in British Columbia, but evidence indicates that nesting occurs in old-growth forests within 101 km of the ocean. Adult diet during the breeding season is mostly fish, primarily Pacific sandlance (*Ammodytes hexapterus*) and Pacific herring (*Clupea harengus*). Euphausiids are important in the spring at Langara Island in the Queen Charlotte Islands. Sandlance are the prey most frequently fed to nestlings. Data on winter diet are scant. The most serious threat to marbled murrelets in British Columbia is the rapid removal of old-growth forest nesting habitat. Only a small portion of this habitat is currently protected within established parks and government reserves. Information on the amount of suitable old-growth habitat remaining in British Columbia is urgently needed to identify critical areas and focus conservation efforts. Marbled murrelets also suffer substantial mortality at sea in gill nets and from oil pollution.”

Keywords: *A. hexapterus*; British Columbia; predators (birds, marbled murrelet).

Rodway, M.S.; Montevecchi, W.A. 1996. Sampling methods for assessing the diets of Atlantic puffin chicks. Marine Ecology Progress Series. 144(1-3): 41-55.

“Three methods for sampling the diets of Atlantic puffin *Fratercula arctica* chicks were compared and evaluated. Prey-carrying puffins were captured in mist-nets, or observed with a telescope or with unaided eyes. Prey samples collected in mist-nets yielded higher proportions of gravid capelin *Mallotus villosus* than did samples obtained visually. Telescopic samples produced higher estimates of the numbers of larval fish landed by puffins (larval fishes are often lost when food-laden birds are caught in mist-nets), and yielded underestimates of the lengths of male capelin. Slight correction factors made the 3 prey sampling methods comparable. Visual sampling procedures had the advantages of creating less disturbance and allowing puffins to deliver food to chicks. Use of telescopic sampling is, however, dependent on colony topography. Forage fishes, heavily dominated by 2-yr-old capelin, made up 88% and 98% of the frequency and mass, respectively, of the prey delivered to puffin chicks. Small prey (larval capelin and sandlance *Ammodytes* spp., hake *Urophycis tenuis*, crustaceans) were most commonly fed to young chicks. Gravid and male capelin tended to be more commonly fed to chicks midway through the nestling period, a time of rapid growth. Spent female and immature capelin were fed more commonly to older chicks. The lengths of gravid capelin tended to increase through the nestling period. Gravid and spent female and male capelin and sandlance fed to puffin chicks were shorter in 1992 than in 1993 or 1994. Successful puffin chicks on Great Island, Newfoundland, Canada, were fed an average of 1105 (SD = 435) prey items weighing 2812 g (SD = 579) equivalent to 12506 kJ (SD = 2391). Extrapolation of these findings suggests that the population of Atlantic puffins in Newfoundland consumes about 8000+ t of forage fishes, mostly 2-yr-old female capelin during a breeding season. Data on age-class and gender status of prey harvests by marine birds will provide needed input in energetics and trophic models.”

Keywords: *Ammodytes*; Atlantic (northwest); predators (birds, Atlantic puffin).

Roessingh, M. 1957. Problems arising from the expansion of the industrial fishery for the sandeel, *Ammodytes marinus* Raitt, towards the Dutch coastal area. ICES C.M. 1957, Near Northern Seas Comm. 3 p. [Mimeo].

Keywords: *A. marinus*; fishery.

Rogers, B.J.; Wangerin, M.E.; Garrison, K.J.; Rogers, D.E. 1981. Epipelagic meroplankton, juvenile fish, and forage fish: distribution and relative abundance in coastal waters near Yakutat. In: Environmental assessment of the Alaskan Continental Shelf. Final Reports of Principal Investigators. 12: 603-708.

“The shelf off Yakutat represents only a small portion of Alaska’s Continental Shelf; however, it supports several fish and shellfish taxa of commercial and ecological importance. While adult distributions and abundances for many taxa are known from commercial trawl catches, relatively little is known about epipelgic larval and egg stages of these

taxa or about forage fish which also frequent the epipelagic zone. Pacific sand lance, sablefish, halibut, Pacific cod, and arrowtooth flounder spawn in the winter whereas herring, capelin, walleye pollock, Pacific ocean perch, butter sole, starry flounder, razor clams, weathervane scallops, tanner crab, and Dungeness crab reproduce in the spring or summer. Juvenile salmon and adult forage fish will probably be most abundant in the spring and summer. Herring and capelin spawn in bays or on beaches and initially, their larvae will be inshore. Halibut, arrowtooth flounder, and sablefish spawn in deep water offshore. The other species of fish spawn at a variety of depths, hence their larvae will be widely dispersed. Salmon spawn in nearly every stream in the Yakutat area, but the most important spawning areas are the southeast shore of Yakutat Bay (pink salmon) and coastal rivers to the southeast of the bay."

Keywords: *A. hexapterus*; Alaska; abundance; distribution; spawning.

Rogers, D.E.; Rabin, B.J.; Garrison, K.; Wangerin, M. 1983. Seasonal composition and food web relations of marine organisms in the nearshore zone of Kodiak Island—including ichthyoplankton, zooplankton, and fish. In: Environmental assessment of the Alaska Continental Shelf. Final reports of the principal investigators. 17: 541-658.

Keywords: *A. hexapterus*; Alaska; Kodiak Island; abundance; distribution; ecology; food web.

Rogers, D.E.; Rabin, D.J.; Rogers, B.J. [and others]. 1979. Seasonal composition and food web relationships of marine organisms in the nearshore zone of Kodiak Island including icthyoplankton, meroplankton (shellfish), zooplankton, and fish. [Seattle, WA]: University of Washington, Fisheries Research Institute, final report FRI-UW-7925: 291 p.

Keywords: *A. hexapterus*; Alaska; Kodiak Island; abundance; distribution; ecology; food web.

Romano, M.D.; Roby, D.D.; Piatt, J.F. 1998. Effect of prey type on the growth of piscivorous seabirds: captive feeding trials. Exxon Valdez Oil Spill Restoration Project Annual Rep. (Project 96163N). Corvallis, OR: Oregon Cooperative Fish and Wildlife Research Unit, Dept. of Fisheries and Wildlife, Oregon State University.

Keywords: *A. hexapterus*; Alaska; calorific value; energy density; predators (birds, black-legged kittiwake, tufted puffin).

Roseneau, D.G.; Byrd, G.V. 1997. Using Pacific halibut to sample the availability of forage fishes to seabirds. In: Forage fishes in marine ecosystems: Proceedings of the international symposium on the role of forage fishes in marine ecosystems; [dates of meeting unknown]; [location unknown]. Report 97-01. Fairbanks, AK: University of Alaska Fairbanks, Alaska Sea Grant College Program: 231-241.

Authors examined 586 stomachs from sport-caught halibut and recorded prey delivered to chicks of black-legged kittiwakes, common murres, and tufted puffins. Sand lance were more common than capelin in June, but thereafter, few sand lance were recorded and capelin were the dominant prey.

Keywords: *A. hexapterus*; Alaska; predators (birds, black-legged kittiwake, common murre, tufted puffin; fish, Pacific halibut).

Roseneau, D.G.; Springer, M.I.; Murphy, E.C.; Springer, A.M. 1985. Population and trophic studies of seabirds in the northern Bering and eastern Chukchi seas, 1981. [Place of publication unknown]: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program; final report 30: 1-58.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (birds).

Rosenthal, R.J. 1978. Preliminary observations on the distribution, abundance and food habits of some nearshore fishes in the northeastern Gulf of Alaska. [Place of publication unknown]: [publisher unknown]; Prepared for National Oceanic and Atrmospheric Administration, Outer Continental Shelf Environmental Assessment Program. 71 p. Available from: [unknown].

Keywords: A. hexapterus; Alaska; predators (fish).

Rosenthal, R.J. 1983. Shallow water fish assemblages in the northeastern Gulf of Alaska: habitat evaluation, species composition, abundance, spatial distribution and trophic interaction. In: Environmental assessment of the Alaskan Continental Shelf. Final Reports of Principal Investigators, [Place of publication unknown]: Biological Studies. National Oceanic and Atmospheric Administration 17 p.

The stomach contents of 486 specimens from 26 species were examined for food items. Pacific sand lance were found in the stomachs of kelp greenling *(Hexagrammos decagrammus*), lingcod (*Ophiodon elongatus*), Pacific halibut (*Hippoglossus stenolepis*), black rockfish (*Sebastes melanops*), whitespotted greenling (*Hexagrammos stelleri*), Pacific tomcod (*Microgadus proximus*), and rock sole (*Lepidopsetta bilineata*). For the black rockfish, the Pacific sand lance was the most frequent prey and ranked first in the prey index. For Pacific halibut, sand lance was high and ranked second in identifiable contents. For all other species listed, the sand lance appeared to be a minor part of their diet. The major forage species, in frequency of occurrence, was the Pacific sand lance. Hundreds to even thousands of sand lance have been observed in individual schools along the shores of Prince William Sound. Some of the aggregations were located just under the sea surface, and others were near the bottom at depths of 25 to 30 m. This species exhibited more versatility in terms of habitat utilization than any other fish in the region. Besides forming large pelagic schools, sand lance use the benthos by burying themselves in the sand and gravel. They also occupy the littoral zone by digging into the softer beach sediments.

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; Prince William Sound; abundance; importance; predators (fish, kelp greenling, lingcod, Pacific halibut, black rockfish, whitespotted greenling, Pacific tomcod, rock sole).

Rosenthal, R.J.; Field, L.J.; Myer, D. 1981. Survey of nearshore bottomfish in the outside waters of southeastern Alaska. Juneau, AK: Alaska Department of Fish and Game; final report. 85 p.

Keywords: *A. hexapterus*; Alaska; southeastern Alaska; abundance; distribution.

Rosenthal, R.J.; Haldorson, L.; Field, L.J. [and others]. 1982. Inshore and shallow bottomfish resources in the southeastern Gulf of Alaska (1981-1982). Juneau, AK: Alaska Department of Fish and Game; final report. RVO542. 166 p.

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; abundance; distribution.

Rosenthal, R.J.; Lees, D.C. 1979. A preliminary assessment of compostion and food webs for demersal fish assemblages in several shallow subtidal habitats in lower Cook Inlet, Alaska. [Place of publication unknown]: [publisher unknown]; report for the Alaska Department of Fish and Game, Commercial Fisheries Division. 58 p. Available from: [unknown].

Keywords: *A. hexapterus*; Alaska; Cook Inlet; abundance; distribution; food web.

Rosenthal, R.J.; Moran–O'connell, V.; Murphy, M.C. 1988. Feeding ecology of ten species of rockfishes scorpaenidae from the Gulf of Alaska USA. California Fish and Game. 74(1): 16-37.

"Summer diets of ten species of rockfish [*Sebastes melanops, S. flavidus, S. ciliatus, S. entomelas, S. emphaeus, S. nebulosus, S. ruberrimus, S. maliger, S. caurinus* and *S. nigrocinctus*] collected in the inshore waters of southeastern Alaska during 1980-82 are presented and compared with studies of rockfish food habits from other regions of the Pacific coast. All species utilized a variety of food and usually capitalized on the most accessible prey types. The bottom-dwelling species were most dependent on detrital based food sources, whereas schooling or pelagic rockfish consumed substantial quantites of zooplankton and fish. A number of common food items (e.g., crabs,

shrimps, brittle stars, and fish) were shared by the bottom-dwellers. Pacific sand lance, a key component in the inshore forage base, was the dominant food of the more pelagic black, yellowtail and widow rockfishes. Two other pelagic schoolers, the Puget Sound and dusky rockfishes ate significant amounts of pelagic crustacea and gelatinous [sic] zooplankton. Dietary overlaps for these common pelagic and demersal rockfish species were strong during the three summers of observation. Geographic variations in diet suggested that rockfish were capable of substituting prey as long as these foods are of the same general size and type."

Keywords: *A. hexapterus*; Alaska; southeastern Alaska; importance; predators (fish, black rockfish, china rockfish, copper rockfish, dusky rockfish, yelloweye rockfish, yellowtail rockfish, quillback rockfish, widow rockfish).

Rothschild, B.J.; Osborn, T.R. 1988. Small-scale turbulence and plankton contact rates. Journal of Plankton Research. 10(3): 465-474.

Keywords: *Ammodytes*; distribution; larvae.

Rounet, J. 1987. Feeding of the ray *Raja microocellata* (Montagu, 1818) in Bertheaume Bight (Brittany). Cahiers de Biologie Marine. 28(2): 199-206.

"Examination of the stomach contents of the ray *Raja microocellata* (Montagu, 1818) revealed that this species fed upon fast exclusively Teleosts. The most frequent prey is *Ammodytes tobianus* (L. 1758). Among the three other species of fished rays, *Raja brachyura* (Lafont, 1873) showed the nearest feeding habits of *Raja microocellata*."

Keywords: *A. tobianus*; predators (ray *Raja microocellata*).

Rountree, R.A. 1994. Broad-scale distribution patterns of summer flounder and their prey based on bottom trawl surveys collected from 1973-92 between Cape Hatteras and the Scotian shelf. American Fisheries Society Annual Meeting Abstract. 124: 18.

Keywords: *Ammodytes*; Atlantic (northwest); predators (fish, summer flounder).

Rowe, D.M.; Denton, E.J. 1994. Reflections of light and fast pulses of sound as methods of signalling between fish. In: Williamson, R., ed. Orientation and migration in the sea symposium; University of Plymouth (England). Journal of Marine Biological Association U.K. 74: 719.

Keywords: *Ammodytes*; pigmentation; schooling behavior.

Runge, J.A.; Therriault, J.C.; Legendre, L. [and others]. 1991. Coupling between ice microalgal productivity and the pelagic metazoan food web in southeastern Hudson Bay a synthesis of results. Polar Research. 10(2): 325-338.

"A multidisciplinary study of the ice algal production cycle in southweastern Hudson Bay in spring, 1986, provided an exceptional opportunity to observe trophic interaction between the ice algae and metazoan zooplankton. Larvae of Arctic cod and sand lance, the yolk-sac stages of which were found in samples immediately after the onset of ice melt, were in a good position to feed on the resulting high concentrations of copepod nauplii in mid-June. These results therefore suggest a strong coupling between the ice algal production cycle and production cycles in the pelagic food web in this region."

Keywords: *Ammodytes*; Canada; Hudson Bay; food; larvae.

Russell, F.S. 1973. A summary of the observations on the occurrence of planktonic stages of fish off Plymouth 1924-1972. Journal of the Marine Biological Association of the United Kingdom. 53(2): 347-355.

Keywords: *Ammodytes*; Atlantic (northeast); distribution; larvae.

Russell, F.S. 1980. Distribution of post larval fish in the Bristol Channel UK. Bulletin of Marine Ecology. 8(4): 283-290.

“To give a preliminary list of the species in the Bristol Channel with some indication of their relative abundance and distribution, results were extracted from the data for research vessel cruises in 1974 when there was good coverage from April-Aug. and from July, 1973, when there was also good coverage. The samples were taken with a Lowestoft 20-inch plankton sampler, using a nylon mesh of 280 µm, towed obliquely on a grid of stations in the area between 3° and 5° W. The seasonal distribution of each species and their relative abundance in the seven cruises in 1974 are given. The pattern of seasonal distribution is that which would be normally expected for the area. Only a few species occurred in sufficient numbers in the catches to enable their spatial distribution to be studied. The most numerous species was *Sprattus sprattus*. Next in abundance were S*ardina pilchardus, Merlangius merlangus, Trisopterus minutus*, gobies, rockling, *Pollachius pollachiu*s, sand-eels, *Limanda limanda* and *Callionymus* spp.”

Keywords: *Ammodytes*; Atlantic (northeast); abundance; distribution; larvae; seasonal variation.

Russell, F.S.; Demir, N. 1971. On the seasonal abundance of young fish. XII: The years 1967, 1968, 1969 and 1970. Journal of the Marine Biological Association of the Unitied Kingdom. 51: 127-131.

Keywords: *Ammodytes*; Atlantic (northeast); abundance; annual variation; larvae.

Ryder, R.A. 1957. Avian-pinniped feeding associations. Condor. 59: 68-69.

Keywords: *Ammodytes*; predators (birds, mammals).

Ryland, J.S. 1964. The feeding of plaice and sand-eel larvae in the southern North Sea. Journal of the Marine Biological Association of the Unitied Kingdom. 44: 343-364.

“Larvae of the sand-eel, *Ammodytes marinus*, appear in large numbers in the Southern Bight during March. The principal food in sand-eel guts were copepod nauplii and appendicularians.”

Keywords: *A. marinus*; North Sea; abundance; food and feeding habits; larvae.

Sabates, A.; Demestre, M.; Sanchez, P. 1990. Revision of the family Ammodytidae Perciformes in the Mediterranean with the first record of *Gymnammodytes semisquamatus*. Journal of the Marine Biological Association of the United Kingdom. 70(3): 493-504.

“The study of the morphological and meristic characters of larval and adult sandeels (*Gymnammodytes* spp.) collected off the Catalan coast (NW Mediterranean) has revealed the co-occurrence of *G. cicerelus* and *G. semisquamatus* in the Mediterranean. The geographical distribution of *G. semisquamatus* had hitherto been thought to be limited to the European Atlantic coasts. The comparative analysis of specimens of *G. semisquamatus* from the Mediterranean and from the North Atlantic has demonstrated a marked latitudinal cline in the meristic counts. An exhaustive overview is presented of the bibliography referring to the Ammodytidae family in the Mediterranean, and the validity of the numerous references is discussed. Finally, it has been shown that the accepted description of *G. cicerelus* included the two species: *G. cicerelus* and *G. semisquamatus*. In the present paper an up-to-date diagnosis of both species is presented.”

Keywords: *Gymnammodytes cicerelus; Gymnammodytes semisquamatus*; Mediterranean; taxonomy.

Safina, C. 1988. Ecological interactions among prey fish, bluefish, and common terns in a coastal Atlantic system. Dissertation Abstracts International [Section] B: The Sciences and Engineering. 49(1): 1-232.

“These studies were designed to investigate factors which affect prey availability to common terns (*Sterna hirundo*), the community dynamics prey and predatory fishes, and the ways in which terns respond to changing food availability during their late spring and summer breeding season. One predatory fish, the bluefish (*Pomatomus saltatrix*), appeared to cause sharp declines in prey numbers and cause prey to remain near to the surface. Despite the shift

toward the surface, prey availability to terns declined during summer. Sandeels (Ammodytes) and anchovies (Anchoa) were the major prey of terns and bluefish in the study area. The author suggests that the temporal and spatial partitioning of habitat by these fishes more likely results from predation pressure acting on different predator avoidance strategies in the two species, rather than from competition."

Keywords: *Ammodytes*; Atlantic Ocean; predators (birds, common tern; fish, bluefish).

Safina, C.; Burger, J. 1985. Common tern foraging: seasonal trends in prey fish densities and competition with bluefish. Ecology. 66(5): 1457-1463.

"Terns feeding in the study area caught sandeels (*Ammodytes americanus*) and bay anchovies (*Anchoa mitchilli*) almost exclusively, with *Ammodytes* by far the more important."

Keywords: *A. americanus*; New York; importance; predators (birds, common tern).

Safina, C.; Burger, J. 1988. Prey dynamics and the breeding phenology of common terns (*Sterna hirundo*). Auk. 105(4): 720-726.

Keywords: *A. americanus*; New York; importance; predators (birds, common tern).

Safina, C.; Burger, J. 1989. Population interactions among free-living bluefish and prey fish in an ocean environment. Oecologia (Berlin). 79(1): 91-95.

"We used sonar to measure relative abundance, location, and depth of prey fish schools (primarily *Anchoa* and *Ammodytes*) in the ocean near Fire Island Inlet, New York [USA] from May to August for 4 years to examine predator-prey interactions. Prey fish numbers built through May, peaked in June, and thereafter declined coincident with the arrival of predatory bluefish. Bluefish abundance and feeding behavior correlated inversely with prey fish abundance and depth. Bluefish may drive seasonal patterns of prey abundance and distribution in this area through direct predation and by causing prey to flee."

Keywords: *Ammodytes*; Atlantic (northwest); abundance; predators (fish, bluefish); sonar.

Safina, C.; Burger, J.; Gochfield, M.; Wagner, R.H. 1988. Evidence for prey limitation of common and roseate tern reproduction. Condor. 90: 852-859.

Keywords: *A. americanus*; New York; importance; predators (birds, common tern, roseate tern).

Safina, C.; Wagner, R.H.; Witting, D.A.; Smith, K.J. 1990. Prey delivered to roseate and common tern chicks; composition and temporal variability. Journal of Field Ornithology. 61(3): 331-338.

Studies done at Cedar Beach, New York, showed that roseate terns were highly specialized and fed their chicks mostly sand eels (*Ammodytes americanus*). For both roseate and common terns, the American sand eel was the most common prey delivered to chicks. Common tern had 780 deliveries of sand eels or 35.5 percent of all deliveries. Roseate tern had 751 deliveries of sandeels or 72 percent of all deliveries. Roseates appeared better able to exploit sand eels than are common terns because roseates seem able to dive more deeply and sand eels tend to remain near the bottom unless pursued by predatory fish.

Keywords: *A. americanus*; Atlantic; New York; importance; predators (birds, roseate tern, common tern).

Saint-Pierre, R.; Brêthes, J.C.; Desroslers, G. [and others]. 1984. Premières observations biologiques sur le lançon d'Amérique (*Ammodytes americanus*) habitant les elots de rejet de dragage dans la lagune de Grande-Entrée (lles-de-la-Madeleine), Province de Québec. 37 p. Available from: Dir. Rech. Pêches, Min. Pêches et Océans, Ste-Flavie, PQ.

Keywords: *A. americanus*.

Sakaguchi, M.; Hishikawa, K. 1963. On the fishery of sand-eel, *Ammodytes personatus* Girard. Bulletin of the Isewan Regional Fisheries Research Laboratory, Supplement. 1: 1-12.

Keywords: *A. personatus*; fisheries.

Sakamoto, W.; Tanaka, Y. 1986. Relations between environmental structure of front and the change of concentration of fish larvae and eggs. 1: Water temperature patterns and distributions of fish eggs and larvae in the vicinity of shallow sea front. Bulletin of the Japanese Society of Scientific Fisheries. 52(5): 767-776.

Keywords: *A. personatus*; Japan; eggs; environmental effects; larvae; temperature.

Salomonsen, F. 1955. The food production in the sea and the annual cycle of Faeroese marine birds. Oikos. 6: 92-100.

Keywords: *Ammodytes*; predators (birds).

Sameoto, D.D. 1971. The distribution of herring (*Clupea harengus* L.) larvae along the southern coast of Nova Scotia with some observations on the ecology of herring larvae and the biomass of macrozooplankton on the Scotian Shelf. Fisheries Research Board of Canada Technical Report. 252: 1-72.

Keywords: *Ammodytes*; Nova Scotia; distribution; ecology.

Sameoto, D.D.; Lewis, M.K. 1980. Zooplankton and micronekton associated with acoustic scattering layers on the Nova Scotia shelf and slope during June 1978. Canadian Technical Report Fisheries and Aquatic Sciences. 936: 1-32.

“Zooplankton, macrozooplankton, and micronekton communities were sampled during the night on the slope of the Nova Scotia shelf during June 1978. The numbers of copepods and biomass of zooplankton were highest off the shelf in an area about 12 nautical miles south of the edge of the shelf (the 180 m contour). The fish and fish larvae collected were dominated by *Ammodytes tobianus* on the inner stations and by myctophids, primarily *Benthosema graciale,* on the stations farther offshore. Intense acoustic scattering layers were found on the stations off the shelf. The biological samples provided evidence as to the animals responsible for the acoustic scattering. Over 100 species of zooplankton and nekton species were identified and enumerated.”

Keywords: *A. tobianus*; Nova Scotia; abundance; distribution; larvae.

Sandine, P.H. 1984. Zooplankton (Barnegat Bay). In: Ecology of Barnegat Bay, [City unknown], NJ: [Publisher unknown]: 95-134.

“Microplankton reach peak abundances during March/April following the spring phytoplankton bloom, and again in summer. During January-April, larval winter flounder *Pseudopleuronectes americanus* and sand lance *Ammodytes* predominate. In June-September, eggs and larvae of bay anchovy *Anchoa mitchilli* and larvae of gobies Gobiidae are characteristic.”

Keywords: *A. americanus*; New Jersey; abundance; distribution.

Sanger, G.; Hironaka, V.F.; Fukuyama, A.K. 1978. The feeding ecology and trophic relationships of key species of marine birds in the Kodiak Island area: May-September 1977. In: Environmental assessment of the Alaskan Continental Shelf, annual reports of principal investigators. Boulder, CO: National Oceanic and Atmospheric Administration, Environmental Research Laboratories: 3: 773-848.

“Sandlance and pollock were far less important in terms of biomass, but sandlance were fairly persistent (20%-40% of the cruises in all species except the sooty shearwater), and pollock showed up in all three of the Alaskan breeders on 60% to 80% of the cruises. Moreover, since Baird and Moe (1978) report a higher frequency and volume of sandlance and pollock in food samples from black-legged kittiwakes and tufted puffins in Sitkalidak Strait than we

report here, the overall importance of these two prey species to birds is probably greater than this preliminary assessment suggests."

Keywords: *A. hexapterus*; Alaska; Kodiak Island; predators (birds, black-legged kittiwake, common murre, tufted puffin).

Sanger, G.A. 1972. Fishery potentials and estimated biological productivity of the subarctic Pacific region. In: Takenouti, A.Y., ed. Biological oceanography of the northern north Pacific Ocean dedicated to Sigeru Motoda. Tokyo, Japan: Idemitsu Shoten: 561-574.

Keywords: *Ammodytes*; north Pacific Ocean; abundance; distribution.

Sanger, G.A. 1986. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. In: Outer Continental Shelf environmental assessment program. final reports of principal investigators. [Place of publication unknown]: U.S. Department of Commerce; U.S. Department of the Interior. 45: 631-771.

"Pacific sand lance, capelin, the euphausiid *Thysanoessa inermis*, and unidentified squids were generally the most important prey to pelagic birds in the Gulf of Alaska. In general, seabirds appear to utilize commercially-important species of prey in the Gulf of Alaska to only a small degree, but possible future fisheries for capelin and Pacific sand lance could have serious consequences to breeding seabirds if other suitable prey were not available.

"Future studies of seabird feeding ecology in the gulf of Alaska should focus on the relationship between reproductive success and the distribution and availability of prey, and on defining annual, seasonal and geographic variations in diets and the trophic relationships between primary producers, seabirds, fishes, and other apex predators."

Keywords: *A. hexapterus*; Alaska; Bering Sea; Gulf of Alaska; importance; predators (birds, sooty shearwater, short-tailed shearwater, pelagic cormorant, red-faced cormorant, oldsquaw, white-winged scoter, glaucous-winged gull, mew gull, black-legged kittiwake, arctic tern, Aleutian tern, common murre, thick-billed murre, marbled murrelet, Kittlitz's murrelet, rhinoceros auklet, horned puffin, tufted puffin).

Sanger, G.A. 1987a. Trophic interactions between forage fish and seabirds in the southeastern Bering Sea. In: Forage fishes of the southeastern Bering Sea: conference proceedings; [dates of meeting unknown]; [location unknown]. OCS Study, MMS 87-0017. [Place of publication unknown]: [publisher unknown]: 19-28.

"Studies conducted during the Alaska Outer Continental Shelf Environmental Assessment Program (OCSEAP) in the late 1970s documented that seabirds in the southern Bering Sea feed heavily on juvenile walleye pollock, while in the northern Gulf of Alaska Pacific sand lance and capelin are the main prey.

"Alaskan waters are the only major geographic region within the world ranges of sand lance and capelin with no major fishery for these species at present. Recent interest by Japan and Iceland in a capelin fishery in Alaskan waters could be a harbinger of greater fishing efforts and greater fishing efforts are likely to affect seabird populations.

"The importance of Pacific sand lance in seabird diets in the Gulf of Alaska from southeast Alaska to Buldir Island in the Aleutian Islands suggest that this species is abundant in most coastal waters, although they appear to have a highly clumped distribution. Pacific sand lance are also apparently abundant in Bristol Bay, Norton Sound, and the eastern Chukchi Sea. The distribution of sand lance in seabird food samples from OCSEAF studies corroborate this general distribution pattern."

Keywords: *A. hexapterus*; Alaska; distribution; importance; predators (birds, tufted puffin).

Sanger, G.A. 1987b. Trophic levels and trophic relationships of seabirds in the Gulf of Alaska. In: Croxall, J.P., ed. Seabirds: feeding ecology and role in marine ecosystems. Cambridge, United Kingdom: Cambridge University Press: 229-257.

Keywords: *A. hexapterus*; Alaska; Gulf of Alaska; food and feeding habits; importance; predators (birds, sooty shearwater, pelagic cormorant; glaucous-winged gull; black-legged kittiwake, common murre, marbled murrelet; Kittlitz's murrelet, rhinoceros auklet, horned puffin, tufted puffin).

Sanger, G.A. 1987c. Winter diets of common murres and marbled murrelets in Kachemak Bay, Alaska. Condor. 89: 426-430.

Keywords: *A. hexapterus*; Alaska; Kachemak Bay; predators (birds, common murre, marbled murrelet).

Sanger, G.A. Baird, P.A. 1977. Population dynamics and trophic relationships of marine birds in the Gulf of Alaska and southern Bering Sea. Part 14: The trophic relationships of marine birds in the Gulf of Alaska and the southern Bering Sea. In: Environmental assessment of the Alaskan Continental Shelf: receptors—birds. Boulder, CO: U.S. National Oceanic and Atmospheric Administration, Environmental Research Laboratories. 4: 694-757.

"An evaluation of the impact of petroleum development on the ecosystem requires an understanding of the structure (food web pathway) and dynamics (energy flow through the food web) of that ecosystem. About 740 bird specimens for feeding studies, or other marine bird food samples were collected in 1976 at colony study sites, or at sea. The frequency of ocurrence of fish, squid, and nektonic Crustacea in the stomachs of 14 species of birds was determined on samples pooled from all areas and seasons. Fish predominated in sooty shearwaters, common murres, horned puffins and black-legged kittiwakes. Squid predominated in thick-billed murres, and crustaceans predominated in crested and Cassin's auklets and ancient murrelets. All three prey categories were well represented in a few species, including northern fulmars, short-tailed shearwater, thick-billed murres and tufted puffins. Preliminary data from prey samples identified to species suggest that capelin, sand lance, juvenile walleye pollock, *Thysanoessa* spp. euphausiids and the large hyperiid amphipod *Parathemisto libellula* are important in the diets of several species of marine birds."

Keywords: *A. hexapterus*; Alaska; Bering Sea; Gulf of Alaska; predators (birds); trophic levels.

Sanger, G.A.; Hatch, S.A. 1987. Diets of nestling tufted puffins (*Fratercula cirrhata*) in the Gulf of Alaska and eastern Aleutian Islands in 1986, with special reference to "forage fish." Anchorage, AK: U.S. Fish and Wildlife Service.

Keywords: *A. hexapterus*; Alaska; Aleutian Islands; Gulf of Alaska; predators (birds, tufted puffin).

Sanger, G.A.; Jones, R.D., Jr. 1982. The winter feeding ecology and trophic relationships of marine birds in Kachemak Bay, Alaska. OCSEAP Final Report. Anchorage, AK: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 16: 161-294.

"Despite the plethora of prey species in the overall diet of the oldsquaw, the Pacific sand lance was considerably more important than any other, based on overall IRI values." Sand lance were important in the diet of marbled murrelets with a IRI of about 400.

Keywords: *A. hexapterus*; Alaska; Kachemak Bay; importance; predators (birds, oldsquaw, marbled murrelet).

Sanger, G.A.; Jones, R.D., Jr. 1984. Winter feeding ecology and trophic relationships of oldsquaws and white-winged scoters on Kachemak Bay, Alaska. In: Nettleship, D.N.; Sanger, G.A.; Springer, P.F., eds. Marine birds: their feeding ecology and commercial fisheries relationships: Proceedings of the Pacific seabird group symposium; 1982 Jan. 6-8; Seattle, WA. [Place of publication unknown]: [publisher unknown]: 20-28.

"The feeding ecology of oldsquaws (*Clangula hyemalis*) and white-winged scoters (*Melanitta deglandi*) was studied on Kachemak Bay from November 1977 through April 1978. These species form the bulk of a large wintering waterfowl population. Oldsquaws were extreme generalists, eating at least 61 prey species. The most important were the

Pacific sandlance (*Ammodytes hexapterus*). On the basis of birds observed and collected and the known habitats of their prey species, both sea ducks presumably foraged in water less than 20 m deep. Oldsquaws mostly over substrates of sand and mud, and scoters mostly over bottoms of shell debris and cobbles." They assumed that oldsquaws captured sandlance when the latter were buried in the sand.

Keywords: *A. hexapterus*; Alaska; Kachemak Bay; importance; predators (birds, oldsquaw).

Sanger, G.A.; Jones, R.D., Jr; Wiswar, D.W. 1979. The winter feeding habits of selected species of marine birds in Kachemak Bay, Alaska. In: Environmental assessment of the Alaskan Continental Shelf, annual reports of principal investigators. Boulder, CO: National Oceanic and Atmospheric Administration, Environmental Research Laboratory: 309-347.

Pacific sand lance occurred in the diet of oldsquaws during February. Sand lance occurred in the diet of common murres during winter.

Keywords: *A. hexapterus*; Alaska; Kachemak Bay; predators (birds, oldsquaw, common murre).

Sanmartin, D.M.L.; Quinteiro, A.P.; Rodriguez, A.; Fernandez, J.A. 1989. Some Spanish cestode fish parasites. Journal of Fish Biology. 34(6): 977-978.

Keywords: *A. lanceolatus*; parasites.

Sasaki, R. 1978. The results of recovery of tagged fish and several biological informations of masu salmon, *Oncorhynchus masou* (Brevoort), migrating to the Shakotan waters. In: Materials of the research council for masu salmon in the Sea of Japan. [Place of publication unknown]: [publisher unknown]. In Japanese.

Stomach contents of 395 masu caught near Shakotan Peninsula from late December through February consisted predominantly of sand lance, the most important food item in this region. As in spring, two or three sand lance were found in the stomachs of individual masu, indicating that masu were actively feeding in winter in this area. Sand lance migrate for spawning from mid and late January along the coastal areas near the Shakotan Peninsula.

Keywords: *A. personatus*; Japan; importance; predators (fish, masu salmon).

Satina, C.J.; Burger, M.; Gochfield, M.; Wagner, R.H. 1988. Evidence for prey limitation of common and roseate tern reproduction. Condor. 90: 852-859.

Keywords: *Ammodytes*; predators (birds, common tern, roseate tern).

Sato, H. 1990. Study and research of ecology of resource of regional bottom fishies. 2: Sand lance, *Ammodytes personatus.* Hokkaido–Ritsu Wakkanai Suisan Shikenjo Jigyo Hokokusho. 1989: 23-28.

Keywords: *A. personatus*; Japan; catch; ecology; fisheries; habitat.

Sato, H.; Imai, Y. 1993. Survey and research on fish resources. 1: Resources ecological research of regional bottom fishes; 2: Sandeel. Hokkaido–Ritsu Wakkanai Suisan Shikenjo Jigyo Hokokusho. 1991: 18-24.

Keywords: *A. personatus*; Japan; ecology; fisheries.

Sato, H.; Maruyama, H. 1991. Study and research on the ecology of the regionality bottom fish resources. 2: Sandeels. Hokkaido–Ritsu Wakkanai Suisan Shikenjo Jigyo Hokokusho. 1990: 20-26.

Keywords: *A. personatus*; Japan; catch; ecology; fisheries.

Schaefer, M.B. 1970. Men, birds and anchovies in the Peru current-dynamic interactions. Transactions of the American Fisheries Society. 99: 461-467.

Keywords: *Ammodytes*; importance; predators (birds).

Scherer, M.D. 1984. The ichthyoplankton of Cape Cod Bay Massachusetts. In: Davis, J.D., ed. Lecture notes on coastal and estuarine studies: observations on the ecology and biology of western Cape Cod Bay, Massachusetts. Berlin, West Germany; New York: Springer-Verlag: 11: 151-190.

Keywords: *A. americanus*; Massachusetts; ecology; estuary .

Schneider, D.C.; Hunt, G.L., Jr. 1984. A comparison of seabird diets and foraging distribution around the Pribilof Islands, Alaska. In: Nettleship, D.N.; Sanger, G.A.; Springer, P.F., eds. Marine birds: their feeding ecology and commercial fisheries relationships: Proceedings of the Pacific seabird group symposium; 1982 Jan. 6-8; Seattle, WA. Special Publication. Ottawa, ON: Canadian Wildlife Service, Ministry Supply Service: 86-95.

Keywords: *A. hexapterus*; Alaska; Pribilof Islands; importance; predators (birds, red-faced cormorant, black-legged kittiwake).

Schorger, A.W. 1947. The deep diving of the loon and old-squaw and its mechanism. Wilson Bulletin. 59: 151-59.

Keywords: *Ammodyte*s; predators (birds).

Scofield, N.B. 1899. The fur seals and fur-seal islands of the north Pacific Ocean. Part 3: Special papers relating to the fur seal and to the natural history of the Pribilof Islands—list of fishes obtained in the waters of arctic Alaska: *Ammodytes personatus*. U.S. Treasury Department of Commerce Fur-seal Industry (1896-1897). 16: 498-499.

Keywords: *A. personatus*; Alaska; distribution.

Scott, J.M. 1973. Resource allocation in four syntopic species of marine diving birds. Corvallis, OR: Oregon State University. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (birds).

Scott, J.M. 1990. Offshore distributional patterns, feeding habits, and adult-chick interactions of the common murre in Oregon. Studies in Avian Biology. 14: 103-108.

Sand lance were fed to murre chicks at sea but were considered to be of low importance.

Keywords: *A. hexapterus*; Oregon; predators (birds, common murre).

Scott, J.S. 1968. Morphometrics, distribution, growth, and maturity of offshore sand launce (*Ammodytes dubius*) on the Nova Scotia banks. Journal of the Fisheries Research Board of Canada. 25(9): 1775-1785.

“A population of *Ammodytes dubius* occurs on the Nova Scotia banks, the fish being much larger than those reported previously for the species. The ranges of vertebral and anal fin ray numbers for *A. dubius* are extended. Research records of the launce, from catches and from stomach contents of predators, indicate that it is widely distributed over the banks throughout the year, but is concentrated in depths of 20-50 fath. Maturity data show that it is a winter spawner. A tentative growth curve, based on age-length determinations using otoliths, indicates that the growth pattern is similar to that of *A. lanceolatus*. The launce is shown to be an important item in the diet of cod and a constituent, in the egg or the adult stage, in the diets of many other commercially exploited fishes of the Nova Scotia banks.”

Large numbers of sand lance eggs, in late stages of development, were found in the stomach contents of yellowtail flounders (*Limanda ferruginea*) on Western Bank on January 23, 1967, and February 12, 1968. A table shows 16 species of fish as feeding on sand lance (Atlantic cod, haddock, white hake, pollock, redfish, Atlantic halibut, American plaice, witch flounder, yellowtail flounder, Atlantic wolfish, Atlantic herring, throny skate, smooth skate, winter skate, spiny dogfish, and longhorn sculpin). Of interest is year-round feeding by some. The percentage by volume of sand lance in the diet of Atlantic cod ranges up to 50 percent in large cod. These figures do not reflect the importance of the larvae and eggs of the sand lance in the diet of many of the fishes of the area. The eggs and larvae are vital factors in sustaining the stocks of many of the Nova Scotia fishes at their present levels.

Keywords: *A. dubius*; Nova Scotia; distribution; growth; importance; spawning; morphometrics; predators (fish, Atlantic cod, haddock, white hake, pollock, redfish, Atlantic halibut, American plaice, witch flounder, yellowtail flounder, Atlantic wolfish, Atlantic herring, thorny skate, smooth skate, winter skate, spiny dogfish, longhorn sculpin).

Scott, J.S. 1972a. Eggs and larvae of northern sand lance (*Ammodytes dubius*) from the Scotian Shelf. Journal of the Fisheries Research Board of Canada. 29: 1667-1671.

“Eggs from stomachs of yellowtail flounder (*Limanda ferruginea*) from Emerald Bank, south of Nova Scotia, were identified as those of northern sand lance, *Ammodytes dubius*. They were larger than those of other *Ammodytes* species, with a mean diameter of 1.05 mm. Ovarian eggs from ripe *A. dubius* were smaller (mean diameter 0.7 mm) with a unimodal distribution of egg diameters, indicating a single spawning each season.

“Larvae were widespread and abundant on the Scotian Shelf from February to April. They hatched at about 4-mm length and grew to about 25-mm length between February and May on Emerald Bank. Growth rates decreased to the north. Numbers and distribution of melanophores changed with larval length, but showed no differences in number at given length between geographical areas. Change in numbers of anal, caudal, and dorsal fin rays followed a pattern similar to that of corresponding melanophores.”

Keywords: *A. dubius*; Nova Scotia; eggs; larvae; predators (fish, yellowtail flounder).

Scott, J.S. 1972b. Morphological and meristic variation in northwest Atlantic sand lances (*Ammodytes*). Journal of the Fisheries Research Board of Canada. 29: 1673-1678.

“Although morphometrics and meristics have provided an indication of taxonomic status of different *Ammodytes* groups, these criteria are not sufficient in themselves. Genetic (electrophoretic) and cultural (interbreeding, larval rearing) techniques might be more rewarding in a fish showing such variability of characters.”

Keywords: *Ammodytes*; Atlantic; meristics; morphometrics; taxonomy.

Scott, J.S. 1973a. Food and inferred feeding behavior of northern sand lance (*Ammodytes dubius*). Journal of the Fisheries Research Board of Canada. 30: 451-454.

Keywords: *A. dubius*; food and feeding habits.

Scott, J.S. 1973b. Intestinal helminth parasites of northern sand lance *Ammodytes dubius*. Journal of the Fisheries Research Board of Canada. 30(2): 291-292.

Keywords: *A. americanus; A. dubius; A. marinus*; parasites.

Scott, J.S. 1973c. Otolith structure and growth in northern sand lance, *Ammodytes dubius*, from the Scotian Shelf. International Commission for the Northwest Atlantic Fistheries Research Bulletin. 10: 107-115.

Keywords: A*. dubius*; Scotland; growth; otolith.

Scott, J.S. 1980. Occurrence of pollock, *Pollachius virens*, and sand lance, *Ammodytes* sp., larvae in the Bay of Fundy. Journal of Northwest Atlantic Fishery Science. 1: 45-48.

“A plankton survey of the bay of Fundy in March 1979 revealed for the first time the occurrence of pollock and sand lance larvae. Distributions of numbers per tow and length composition of catches indicated that the pollock larvae originated outside the Bay and dispersed from the south toward the inner part of the Bay. Similar data for sand lance indicated two spawning areas, one near Cape Chignecto from which the larvae dispersed toward the mouth of the Bay, and the other near Long Island, western Nova Scotia, with apparent mixing at the mouth of the Bay of larvae from both spawning sites.”

Keywords: *Ammodytes*; Nova Scotia; abundance; distribution; larvae; spawning.

Scott, J.S. 1982. Selection of bottom type by groundfishes of the Scotian shelf. Canadian Journal of Fisheries and Aquatic Science. 39: 943-947.

Keywords: *Ammodytes*; Nova Scotia; habitat.

Scott, T. 1903. Some further observations on the food of fishes, with a note on the food observed in the stomach of a common porpoise. In: Twenty-first annual report (1902) Fisheries Board of Scotland. Part III: Scientific investigations. [Place of publication unknown]: [Publisher unknown]: 218-227.

Keywords: *Ammodytes*; Scotland; otoliths; predators (mammals).

Scott, W.B.; Scott, M.G. 1988. Atlantic fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences. 219. 731 p.

Keywords: *Ammodytes*; Canada.

Sealy, S.G. 1972. Adaptive differences in breeding biology in the marine bird family Alcidae. Ann Arbor, MI: University of Michigan. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (birds).

Sealy, S.G. 1973. Interspecific feeding assemblages of marine birds off British Columbia. Auk. 90: 796-802.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds).

Sealy, S.G. 1975a. Aspects of the breeding biology of the marbled murrelet in British Columbia. Bird-Banding. 46: 141-154.

Keywords: *A. hexapterus*; British Columbia; predators (birds, marbled murrelet).

Sealy, S.G. 1975b. Feeding ecology of the ancient and marbled murrelets near Langara Island, British Columbia. Canadian Journal of Zoology. 53: 418-433.

Sand lance made up 67 percent of the food items in the diet of adult and subadult marbled murrelets (sample of 75 individuals). Author thought the breeding season was possibly controlled by the cycles of abundance of fishes near shore, especially the sand lance, which were taken by the murrelet in great quantities in the study area.

Also, fishes such as *Cymatogaster* and *Ammodytes* tend to spend the winter and early spring in midwater offshore but migrate to the surface and move inshore in late spring, thus possibly becoming available to murrelets only at this time.

The Pacific sand lance ranks third in importance in the diet of adult ancient murrelets during the terrestrial phase of its life cycle but ranks first in the marbled murrelet's diet. Subadult ancient murrelets take *Thysanoessa* and *Ammodytes* equally by volume during their short period of attendance at the colonies. The juveniles of both species took mainly Pacific sand lance.

Keywords: *A. hexapterus*; British Columbia; importance; predators (birds, marbled murrelet, ancient murrelet).

Sealy, S.G. 1990. Auks at sea: prospects for future research. In: Sealy, S.G., ed. Auks at sea. Studies in Avian Biology. 14: 1-6.

Keywords: *Ammodytes*; predators (birds).

Sekiguchi, H. 1977a. Further observation on the feeding habits of planktivorous fish sand-eel in Ise Bay. Bulletin of the Japanese Society of Scientific Fisheries. 43: 417-422.

"The feeding habits of sand-eels (*Ammodytes personatus*), was [sic] studied by examining the digestive tract of the specimens obtained in March-June 1974 in Ise Bay, Japan. The planktonic organisms eaten were mainly crustaceans, the most dominant in number and in bulk being *Acartia clausi* and *Paracalanus parvus* (Copepoda), which were abundantly found in the environment during the period of sand-eel fisheries. The discrepancy of population density of the 2 spp. was not marked in the environment, although *Acartia* occurred dominantly in March to May and *Paracalanus* in June. Sand-eels fed exclusively on Acartia in March to May, while *Paracalanus* was preyed on in June. Sand-eels would prey exclusively on the more dominant of the 2 spp."

Keywords: *Ammodytes*; Japan; Ise Bay; food and feeding habits.

Sekiguchi, H. 1977b. On fat deposit of the spawners of sand-eels in Ise Bay, central Japan. Bulletin of the Japanese Society of Scientific Fisheries. 43(2): 123-127.

"Fat deposit of the spawners of sand-eels [*Ammodytes personatus*] was examined in relation to their maturity and population breeding on the basis of samples collected at Toshi Island from Dec. 5, 1974 to Feb. 17, 1975. Maximal gonad weight was about 21% of body weight in mean during spawning season in Dec. 1974. Then, abrupt decreases of gonad index and population maturity was found in late Dec. 1974-Jan. 1975. Decreases of weight and fat deposit without viscera were observed in Dec.-Jan. Rapid deposition of fat and growth increment began in accordance with vigorous feeding in Feb. Fluctuation of the fat deposit and body weight in relation to their maturity and reproduction was more marked in the fish of the 2 yr class than in those of the 1 yr class."

Keywords: *A. personatus*; Japan; Ise Bay; gonad index; fat; growth; maturity; spawning.

Sekiguchi, H. 1978. *Acartia clausi* (Copepoda: Calanoida) in the guts of plaktivorous sandeels. Bulletin of the Japanese Society of Scientific Fisheries. 44(6): 695.

"A source of mortality such as predation by planktivorous fishes is relatively concentrated in the older states of *Acartia* species. However, in the copepod populations such as *Diaptomus,* most of the mortality occurs during egg to naupliar 4 stages and seconarily in naupliar 6 stage, mortality in adults being of little consequence since minimal predation occurs at that stage. This consideration suggests that *Acartia* adults evolve to survive and to lay eggs for only a very brief period. Any shortening of the posterior stages relative to the earlier ones will be promoted in *Acartia* species which have been known to complete isochronal development. There are several ways in which isochronal development could be selectively advantageous."

Keywords: *A. personatus*; food and feeding habits.

Sekiguchi, H. 1982. Food habits of the sandeel spawners from Ise Bay, central Japan. Bulletin of the Faculty of Fisheries Mie University. 7: 1-7.

Keywords: *A. personatus*; Japan; Ise Bay; food and feeding habits.

Sekiguchi, H.; Nagoshi, M.; Horiuchi, K.; Nakanishi, N. 1976. Feeding fat deposits and growth of sand-eels in Ise Bay central Japan. Bulletin of the Japanese Society of Scientific Fisheries. 42(8): 831-835.

“Feeding, fat deposits and growth of sand-eels (*Ammodytes personatu*s) were examined by taking samples from the Tsu fish market from Feb. 25-May 29, 1974. Rapid growth and accumulation of fat was observed shortly before the sand-eels entered the dormant state they pass through in summer. Sand-eels in this state depend on the nutritional accumulation gained beforehand. The nutritional condition in May, shortly before the sand-eels pass into a dormant state, probably has a great influence on their survival and on the resource potential of Ise Bay.”

Keywords: *A. personatus*; Japan; Ise Bay; aestivation; food and feeding habits; growth; fat.

Sekiguchi, H.; Nagoshi, M.; Mori, Y.; Kato, Y. 1974. The feeding habits of larvae and juveniles of sand-eel, *Ammodytes personatus* (Girard), and anchovy, *Engraulis japonica* Houttuyn, in Ise Bay. Bulletin of the Faculty of Fisheries Mie University. 1(1): 33-41.

Keywords: *A. personatus*; Japan; Ise Bay; food and feeding habits; juveniles; larvae.

Senta, T. 1965a. Nocturnal behavior of sand-eels, *Ammodytes personatus* Girard. Bulletin of the Japanese Society of Scientific Fisheries. 31: 506-510.

“Though many works have been made on the habit of sand-eels, there are few studies on the nocturnal behavior of the fish. The present author found following facts in regard to the subject through the survey with the fish larval net (71.5 cm. in diameter) in the Seto Inland Sea.

“During the period from January to May, sand-eels rise to the sea surface by night, and especially abundantly in January and February (Table 1). These fishes caught in the period up to early in April were all 1-age fish, and those caught thereafter were all 0-age fish.... These fishes, especially in January, were thin after spawning, and the indicator of body length-body weight relation continued to increase in its value during the period....

“From the stomach condition, it was affirmed that they keep on feeding even by night. Adult sand-eels seemed to feed seldom on larvae of the same family, at least by night, on account of the fact that they are swimming in the separate layers of the sea....”

Keywords: *A. personatus*; Japan; behavior; food and feeding habits.

Senta, T. 1965b. The buoyancy of sand-eel eggs and their distribution in the Seto Inland Sea. Bulletin of the Japanese Society of Scientific Fisheries. 31: 511-516.

Keywords: *A. personatus*; Japan; Seto Inland Sea; distribution; eggs.

Serebryakov, V.P. 1965. Some results of Soviet research work on ichthyoplankton in the northwest Atlantic: eggs and larvae of cod. International Commission for the Northwest Atlantic Fisheries Environmental Symposium Special Publication. 6: 425-433.

Keywords: *Ammodytes*; Atlantic (northwest); abundance; distribution; eggs; larvae.

Sharpe, F. 1995. Return of the killer bubbles: interactions between alcids and fish schools. Proceedings of the 22d meeting of Pacific Seabird Group: 59 (Abstract).

Keywords: *Ammodytes*; predators (birds).

Shealer, D.A.; Kress, S.W. 1994. Post-breeding movements and prey selection of roseate terns at Stratton Island, Maine. Journal of Field Ornithology. 65(3): 349-362.

“Roseate terns (*Sterna dougallii*) from at least eight breeding colonies in the northeastern United States disperse to southern Maine each August before migrating to their wintering quarters. Peak numbers of terns are recorded in mid-August, and during this time daily counts may exceed 200 adults and 100 juveniles on Stratton Island. Roseate terns use the island as a loafing and roosting site and feed in the surrounding waters of Saco Bay during the day. From 1989 to 1992, 193 individual adults and 31 fledglings were identified by observing color-band combinations and reading numbers on leg bands. Length of stay varied among individual terns and years and ranged from 1 to 26 d. Using appropriate Jolly-Seber sighting-resighting models it was estimated that 5-10% of all breeding adult Roseate Terns in the northeastern U.S. disperse to Stratton Island each August. During this post-breeding period, juvenile terns practice fishing for themselves but are still dependent on their parents for food. In 2 yr of study, adults fed fledglings sand lance (*Ammodytes* sp.) exclusively. It is suggested that roseate terns disperse to Stratton Island each August because of the availability of sand lance in Saco Bay.”

Keywords: *Ammodytes*; Atlantic (northwest); predators (birds, roseate tern).

Shelton, P.A. 1992. Detecting and incorporating multispecies effects into fisheries management in the north-west and south-east Atlantic. In: Payne, A.I.L.; Brink, K.H.; Mann, K.H.; Hilborn, R., eds. Conference on Benguela trophic functioning; [dates of meeting unknown]; Cape Town, South Africa. In: South African Journal of Marine Science (Rogge Bay); 12: 723-737.

Keywords: *A. dubius*; ecology; fisheries; trophic interactions.

Shepherd, B.G.; Hartman, G.F.; Wilson, W.J. 1986. Relationships between stream and intragravel temperatures in coastal drainages, and some implications for fisheries workers. Canadian Journal of Fisheries and Aquatic Sciences. 43(9): 1818-1822.

Keywords: *Ammodytes*; temperature; substrate.

Shepherd, D.A. 1988. Foraging interactions among black-billed magpies, northwestern crows, and red foxes on Kodiak Island, Alaska. Murrelet. 69: 68-69.

“Crows sought sand lance by picking into the substrate while walking over the interidal zone; however, the birds were frequently displaced by foxes before successfully securing prey. Foxes would then excavate each site and remove one or more fish. Foxes also captured sand lance independently of crows. Crows and magpies were seen to frequently obtain food from holes dug by foxes.”

Keywords: *A. hexapterus*; Alaska; Kodiak Island; predation (birds, black-billed magpie, northwestern crow; mammals, red fox).

Sherman, K.; Jones, C.; Sullivan, L. [and others]. 1981. Congruent shifts in sand eel abundance in western and eastern North Atlantic ecosystems. Nature. 291(5815): 486-489.

“It has been suggested, on the basis of model simulations and slowly accumulating empirical data, that changes in the structure of marine ecosystems may be caused as much by changes in the trophic levels as by environmental factors. Support for this is found in recently observed shifts in species abundance of North Sea fish stocks, where large catches in the 1970s of small, fast-growing, opportunistic plankton-feeding fishes–sprat, sand eel and Norway pout–have been accounted for as the result of the replacement by these species of depleted herring and mackerel stocks. In support of replacement, the authors describe evidence from the north-west Atlantic which indicates that population explosions of small, fast-growing sand eel (*Ammodytes*) can coincide with depletions of larger tertiary predators, including herring and mackerel in a continental shelf ecosystem.”

Keywords: *Ammodytes*; North Sea; competition; larvae; trophic interactions.

Sherman, K.; Lasker, R.; Richards, W.; Kendall, A.W., Jr. 1983. Ichthyoplankton and fish recruitment studies in large marine ecosystems. Marine Fisheries Review. 45: 1-25.

Keywords: *Ammodytes*; recruitment.

Sherman, K.; Smith, W.G.; Green, J.R. [and others]. 1987. Zooplankton production and the fisheries of the northeastern shelf. In: Backus, R.H.; Bourne, D.W., eds. Georges Bank. Cambridge, MA: M.I.T. Press: 268-282.

Keywords: *Ammodytes*; Georges Bank; fisheries.

Sherman, K.; Smith, W.; Morse, W. [and others]. 1984. Spawning strategies of fishes in relation to circulation, phytoplankton production, and pulses in zooplankton off the northeastern United States. Marine Ecology Progress Series. 18: 1-19.

Keywords: *Ammodytes*; spawning.

Shirota, A. 1970. Studies on the mouth size of fish larvae. Bulletin of the Japanese Society of Scientific Fisheries. 36(4): 353-368.

Keywords: *A. personatus*; larvae; morphology.

Sibert, J.; Kask, B. 1978. Do fish have diets? In: Shepherd, B.G.; Ginetz, R.M., eds. Proceedings of the 1977 northeast Pacific chinook and coho salmon workshop; [dates of meeting unknown]; [location unknown]. Canadian Fisheries Marine Service Technical Report; 759: 48-57.

Keywords: *A. hexapterus*; predators (fish, chinook salmon, coho salmon).

Sibly, R.M.; McCleery, R.H. 1983. The distribution between feeding sites of herring gulls breeding at Walney Island, U.K. Journal of Animal Ecology. 52: 51-68.

“We occasionally found the remains of the sand eel (*Ammodytes* sp.) in the colony, and saw a few gulls paddling for these at the bottom of sandy beaches. The technique used was similar to that used for *Macoma*.”

Keywords: *Ammodytes*; British Isles; predators (birds, herring gull).

Sim, G. 1884. The food of fishes. International Fisheries Exhibition, London. 11: 500-548.

Keywords: *Ammodytes*; food; predators (fish).

Simenstad, C.A.; Isakson, J.S.; Nakatani, R.E. 1977. Marine fish communities of Amchitka Island, Alaska TID-26712. In: Merritt, M.L.; Fuller, R.G., eds. The environment of Amchitka Island, Alaska. U.S. Devel. Admin. Info. Cntr. [Place of publication unknown]; [publisher unknown]: 451-492.

The Pacific sand lance appears to be a significant importer of offshore-derived zooplankton biomass into the inshore fish communities. An intermediate-depth (110 to 146 m) group of Pacific sand lance and tadpole snailfish is also designated. The stomach contents of top carnivores, such as the Pacific halibut, indicated that pelagic schools of Pacific sand lance also were common members of this demersal community. Juvenile Pacific halibut and Pacific sand lance were observed regularly in nearshore waters year round. Food web figures show sand lance important in intertidal, inshore sand-gravel and epipelagic communities. In the inshore sand-gravel community is a two-compartment food web, one oriented to the neritic fishes, the salmonids, Atka mackerel, and Pacific sand lance. The prey organisms in the neritic compartment are adult and larval Pacific sand lance, among others. The Pacific halibut is a higher order consumer that feeds principally on rock sole and Pacific sand lance. Rock sole in the southeastern Bering Sea depend on polychaetes and mollusks as their major food items, with crustaceans, Pacific sand lance, and echinoderms of secondary importance. The diet compostion of offshore halibut was similar to that in the western, northwestern, and central Bering Sea, where fishes fish, etc., such as Pacific sand lance are the primary prey.

If one considers the Pacific sand lance to be the western Aleutian ecological equivalent of smelt and herring, the diets of halibut throughout the Bering Sea are very similar. Sand lance were found in *Gadus macrocephalus, Oncorynchus gorbuscha, Salvelinus malma, Gadus macrocephalus, Trichodon trichodon, Pleurogrammus monoptergius, Gymnocanthus galeatus, Hippoglossus stenolepsis, Sebastes ciliatus, Hemilepidotus hemilepidotus, Myoxocephalus polyacanthacephalus,* and *Liparis callyodon*. Sand lance contained only Gammarid, caprellid, and hyperiid amphipods and calanoid and harpacticoid copepods. Pacific cod offshore feed exclusively on red Irish lord and Pacific sand lance. The maturing migrating sockeye and chum salmon of the epipelagic community are primarily piscivorous, preying on the two forage fish resident in that community: Pacific sand lance and planktivorous northern lampfish.

The pelagic trophic equivalent of the amphipod is the Pacific sand lance, and although this fish constitues an unpredictable rapid-swimming resource, it contributes to the diets of 8 of the 10 species studied from the inshore sand-gravel community. Its larval and prejuvenile forms are also in the diets of three fishes of the inshore rock-algae community. This forage fish is the system's main means of energy transfer between zooplankton and the piscivorous fishes of the community. No predator can afford to prey selectivelly on sand lance because its occurrence is apparently not certain enough to guarantee a reliable food resource. When it occurs, however, it appears to be the selected preferred prey. Stomachs of predators were unusually distended with sand lance whenever their schools were in the inshore waters. Even the rock greenling was observed to capture sand lance to distension during a large inshore influx of schools of sand lance in August 1973. Studies of the avian predators of Amchitka inshore fish also have shown the occurrence of sand lance in the diets of many species. Offshore the sand lance appears to suffer little predation pressure from epipelagic piscivores.

As a major prey organism of nearshore fishes, the Pacific sand lance was second only to amphipods in the number of identified food-web links to inshore predators. Although we were unable to evaluate fully the abundance of the Pacific sand lance, we consider that the role of this planktivorous fish in importing biomass from offshore waters into the inshore ecosytem is an important feature of the inshore portion of the marine food web.

Keywords: *A. hexapterus*; Alaska; Amchitka Island; distribution; habitat; importance; predators (birds, fish).

Simenstad, C.A.; Mayer, R.M.; Nakatani, R.E. 1978. Nearshore fish and macroinvertebrate communtities of Attu Island, Alaska. FRI-UW-7807. [Seattle, WA]: University of Washington, Fisheries Research Institute.

Keywords: A*. hexapterus*; Alaska; Attu Island; abundance; distribution.

Simenstad, C.A.; Miller, B.S.; Nyblade, C.F. [and others]. 1979. Food web relationships of northern Puget Sound and the Strait of Juan de Fuca: a sysnthesis of available knowledge. FRI-UW-7914. [Seattle, WA]: University of Washington, Fisheries Research Institute.

Keywords: *A. hexapterus*; Washington; food web.

Simenstad, C.A.; Salo, E.O. 1982. Foraging success as a determinant of estuarine and nearshore carrying capacity of juvenile chum salmon (*Oncorhynchus keta*) in Hood Canal, Washington. In: Melteff, B.R.; Neve, R.A., eds. Proceedings of the north Pacific aquaculture symposium; [dates of meeting unknown]; [location unknown]. In: Alaska Sea Grant Report; 82-2: 21-37.

Keywords: *A. hexapterus*; Washington; predators (fish, chum salmon).

Simpson, A.C. 1949a. Notes on the occurrence of fish eggs and larvae in the southern bight of the North Sea during the winter of 1946-47. Annals of Biology, Copenhagen. 4: 90-94.

Keywords: *Ammodytes*; North Sea; distribution; eggs; larvae.

Simpson, A.C. 1949b. Notes on the occurrence of fish eggs and larvae in the southern bight of the North Sea during the winter of 1947-48. Annals of Biology, Copenhagen. 5: 90-97.

Keywords: *Ammodytes*; North Sea; distribution; eggs; larvae.

Singh-Renton, S.; Bromley, P.J. 1996. Effects of temperature, prey type and prey size on gastric evacuation in small cod and whiting. Journal of Fish Biology. 49(4): 702-713.

“Gastric lavage was used to investigate the effects of temperature, prey type and prey size on gastric evacuation in small cod *Gadus morhua* and whiting *Merlangius merlangus*, The fish were fed to satiation and subsequently the stomach contents were sampled to determine the rate at which food was evacuated. Satiation meal size was positively related to temperature and differed between prey types. The gastric evacuation rate (GER) also tended to increase with temperature and varied with prey type. GER at temperatures of 11.3-12.7 °C averaged 1.5-1.7 times higher than at 6-9.5 °C. There was no significant difference ($P > 0.05$) in the evacuation of lugworm *Arenicola marina*, sandeel *Ammodytes* spp., and herring *Clupea harengus*, but the GER of brown shrimp *Crangon vulgaris* was much slower ($P < 0.05$). No significant changes in GER were observed when fish were fed on three different size groups of either herring or brown shrimp. In whiting, there was no significant difference in the GER of individual herring or brown shrimp when they were fed as single species meals or incorporated in meals containing a mixture of prey species.”

Keywords: *Ammodytes*; predators (fish).

Sissenwine, M.P.; Cohen, E.B.; Grosslein, M.D. 1984. Structure of the Georges Bank ecosystem. Rapports et Procès-Verbaux des Reunions Conseil International pour l’Exploration de la Mer. 183: 243-254.

Keywords: *Ammodytes*; Georges Bank; ecology.

Slater, P.J.B. 1980. Factors affecting the numbers of guillemots *Uria aalge* present on cliffs. Ornis Scandinavica. 11: 155-163.

Keywords: *Ammodytes*; predators (birds, guillemot).

Smeenk, C.; Gaemers, P.A. 1987. Fish otoliths in the stomachs of white-beaked dolphins *Lagenorhynchus albirostris.* European Cetacean Society Newsletter. 1: 12-13.

Keywords: *Ammodytes*; otoliths; predators (mammals, white-beaked dolphin).

Smidt, E. 1971. Summary report of the ICNAF norwestlant [sic] surveys, 1963. International Commission for the Northwest Atlantic Fisheries Redbook Part III. [Vol. unknown]: 275-295.

Keywords: *Ammodyte*s; distribution.

Smigielski, A.S.; Halavik, T.A.; Buckley, L.J. [and others]. 1984. Spawning, embryo development and growth of the American sand lance *Ammodytes americanus* in the laboratory. Marine Ecology—Progress Series. 14: 287-292.

“*Ammodytes americanus* adults were captured and transported to the laboratory and spawned. Eggs and larvae were successfully incubated at 2, 4, 7 and 10 C. Specific growth rates in dry wt per day were 2.4% at 2 C, 3.23% at 4 C, 4.75% at 7 C and 5.62 at 10 C. This was the first successful attempt to spawn sand lance in the laboratory and to rear the larvae through metamorphosis. The early life history of this fish can be completed under controlled laboratory conditions.”

Keywords: *A. americanus*; eggs; larvae; spawning.

Smith, H.M.; Pope, T.E.B. 1906. List of fishes collected in Japan in 1903, with descriptions of new genera and species. Proceedings of the United States National Museum. 31(1489): 459-499.

Synonymy: Satsuma = Malakichthys; Lysodermus = Minous; Insidiator = Sugyrundus Lambdopsetta = Laeops. Apogonids are listed with size and locality; some with a brief color description.

Keywords: Japan; distribution; taxonomy.

Smith, J.E., ed. 1968. 'Torrey Canyon' pollution and marine life. Cambridge, England: Cambridge University Press. 196 p.

Keywords: *Ammodytes*.

Smith, R.L.; Paul, A.J.; Paul, J.M. 1991. Timing and abundance of herring and other fish larvae in an Alaskan glaciated fjord. University of Alaska Sea Grant Program Sea Grant Report. 91-01: 25-35.

Keywords: *A. hexapterus*; Alaska; Resurrection Bay; abundance; distribution; larvae.

Smith, R.L.; Paulson, A.C.; Rose, J.R. 1978. Food and feeding relationships in the benthic and demersal fishes of the Gulf of Alaska and Bering Sea. [Place of publication unknown]: [publisher unknown]; report prepared for the National Oceanographic and Atmospheric Administration; [contract no. 03-5-022-56]. 70 p.

Keywords: A. *hexapterus*; Alaska; Bering Sea; Gulf of Alaska; predators (fish).

Smith, W.G. 1980. What studies of young fish tell about fish populations. Underwater Naturalist. 12(4): 9-16.

"A brief account is given of methods of studying fish populations with synopses of the spawning habits of the following fish: *Gadus morhua, Melanogrammus aeglefinus, Brevoortia tyrannus, Pomatomus saltatrix, Ammodytes, Scomber scombrus* and *Paralichthys dentatus.*"

Keywords: *Ammodytes*; spawning.

Smith, W.G.; McMillan, D.G.; Obenchain, C. [and others]. 1980. Spawning cycles of marine fishes off Northeastern United States, based on broad scale surveys of eggs and larvae, 1977-79. International Council for the Exploration of the Sea Council Meeting 1980. 22 p.

Keywords: *Ammodytes*; Atlantic (northwest); eggs; larvae; spawning.

Smith, W.G.; Sullivan, L.; Berrien, P. 1978. Fluctuations in production of sand lance larvae in coastal waters off the Northeastern United States, 1974 to 1977. In: Council Meeting 1978. International Council for the Exploration of the Sea collected papers. Charlottenlund (Denmark).

Keywords: *Ammodytes*; abundance; distribution; larvae; temperature.

Smitt, F.A. 1895. A history of Scandinavian fishes. Stockholm, Sweden; London, England: [Publisher unknown].

Keywords: *Ammodytes*; historical.

Snarski, D. 1970. Kittiwake ecology, Tuxedni National Wildlife Refuge. Alaska Cooperative Wildlife Research Unit, Quarterly Report. July-September; 22(1): 10-13.

Keywords: *A. hexapterus*; Alaska; predators (birds, black-legged kittiwake).

Snarski, D. 1971. Kittiwake ecology, Tuxedni National Wildlife Refuge. Alaska Cooperative Wildlife Research Unit, Quarterly Report. July-September; 23(1): 6-8.

Keywords: *A. hexapterus*; Alaska; predators (birds, black-legged kittiwake).

Snow, B. 1960. The breeding biology of the shag, *Phalacrocorax aristotelis* on the island of Lundy, Bristol Channel. Ibis. 102: 554-575.

“It seems probable that the breeding season of the species is timed to coincide with the availability of the sand-eel (*Ammodytes* spp.) which analysis of stomach contents has shown to [be] the Shag’s chief food.”

Keywords: *Ammodytes*; British Isles; importance; predators (birds, shag).

Snyder, J.O. 1912. Japanese shore fishes collected by the United States Bureau of Fisheries steamer “Albatross” expedition of 1906. Proceedings of the United States National Museum. 42(1909): 399-450.

Keywords: *Ammodytes*; Japan; distribution; taxonomy.

Sobolevskij, E.I. 1996. Distribution and seasonal feeding dynamics of the harbour seal *Phoca largha* in the Bering Sea. Biologiya Morya/Marine Biology. 22(4): 221-226.

“Analysis of original and literature data shows variations in the distribution of the seal (*P. largha*) in different seasons. Concentrations are mainly observed during the spring period, while in summer and autumn the animals scatter along the coast. The seals feed on a wide variety of organisms. In most sea areas they prefer mass fish species (walleye pollock, sand lance, capelin) and invertebrates (small crabs, octopus).”

Keywords: *A. hexapterus*; Bering Sea; predators (mammals, harbor seal).

Soleim, P.A. 1945. A contribution to the knowledge of the lesser sandeel *Ammodytes lancea* in north European waters. Report on Norwegian Fishery and Marine Investigations. 8(1): 1-28.

Keywords: *A. lancea*.

Soljan, T. 1948. Fishes of the Adriatic: fauna and flora of the Adriatic. Zagreb, [Yugoslavia]: Nakladni Zavod Hrvatske. 1.

Under Familia Ammodytidae, lists *Ammodytes cicerellus* RAF and *Ammodytes tobianus* L.

Keywords: *A. cicerellus; A. tobianus*; Adriatic; distribution.

Somerton, D.; Murray, C. 1976. Field guide to the fish of Puget Sound and the Northwest coast. Seattle, WA: University of Washington Press. 70 p.

“The fish most commonly encountered in Puget Sound and the Strait of Juan de Fuca at depths J150 ft, and several species common along the open coast from Oregon through British Columbia, are listed and described. These include salmon, trout, char, rockfish, sculpins, greenlings, seaperch, snailfish, lumpfish, clingfish, herring, smelt, sand lance, tube-snouts, sticklebacks, pipefish, gobies, cod, poachers, pricklebacks, gunnels, wolffishes, flounders, sanddabs, cartilagenous fish, and miscellaneous fish with long continuous dorsal fins. Commonly seen families are situated near the front or the back of the book to facilitate searching. Species within a family are arranged according to their morphological similarity. Most of the species descriptions are accompanied by an illustration which is labeled with features that are the most helpful for distinguishing between fish of similar appearance and are most easily recognized under a variety of viewing conditions. The guide is printed on water-resistant material so it can be handled with wet hands or taken under water.”

Keywords: *A. hexapterus*; Washington; Puget Sound; distribution.

Sorita, J.; Okamoto, S. 1992. Fluctuations in the stock of sand eel in the eastern Seto Inland Sea an ecological study. Bulletin of the Japanese Society of Fisheries and Oceanography. 56(2): 201-205.

Keywords: *A. personatus*; Japan; aestivation; catch; life history; spawning; substrate; temperature; maturity.

Spaans, A.L. 1971. On the feeding ecology of the herring gull *Larus argentatus* Pont. in the northern part of the Netherlands. Ardea. 2: 75-186.

Keywords: *Ammodytes*; Netherlands; predators (birds, herring gull).

Spalding, D.J. 1964. Comparative feeding habits of the fur seal, sea lion, and harbour seal on the British Columbia coast. Fisheries Research Board of Canada Bulletin. 146: 18-21.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (mammals, fur seal, sea lion).

Sparholt, H. 1990a. An estimate of the total biomass of fish in the North Sea. Journal du Conseil, Conseil International pour l'Exploration de la Mer. 46(2): 200-210.

Keywords: *Ammodytes*; North Sea; abundance; fisheries; stock assessment.

Sparholt, H. 1990b. Improved estimates of the natural mortality rates of nine commercially important fish species included in the North Sea: multispecies VPA model. Journal du Conseil, Conseil International Pour l'Exploration de la Mer. 46(2): 211-223.

Keywords: *Ammodytes*; North Sea; fisheries; mortality.

Speckman, S.G.; Springer, A.M.; Piatt, J.F. 1993. Marbled murrelet abundance patterns at sea in relation to the marine environment (abstract). Pacific Seabird Group Bulletin. 20(1): 42.

Keywords: *A. hexapterus*; predators (birds, marbled murrelet).

Springer, A.M. 1991. Seabird relationships to food webs and the environment: examples from the north Pacific. In: Montevecchi, W.A.; Gaston, A.J., eds. Studies of high-latiitude seabirds. 1: Behavioral, energetic and oceanographic aspects of seabird feeding ecology. Occas. Pap. 68. [Place of publication unknown]: Canadian Wildlife Service: 39-48.

"Most piscivorous seabirds in Alaska feed on only a few taxa of common forage fishes, particularly cods, sand lance, and capelin. The distribution of prey corresponds to the distribution of several species of seabirds: for example, common murres greatly outnumber thick-billed murres at all colonies in Alaska where the major prey is capelin or sand lance."

Keywords: *A. hexapterus*; Alaska; north Pacific Ocean; importance; predators (birds, common murre, pigeon guillemot, black-legged kittiwake).

Springer, A.M. 1992. A review: walleye pollock in the north Pacific—How much difference do they really make? Fisheries Oceanography. 1: 80-96.

Keywords: *A. hexapterus*; predators (fish, walleye pollock).

Springer, A.M. 1993. Report of the seabird working group. In: Is it food?: Addressing marine mammal and seabird declines: Workshop summary; [dates of workshop unknown]; [location unknown]. Alaska Sea Grant Rep. 93-01. [Fairbanks, AK]: University of Alaska, Fairbanks: 14-29.

"Murres and kittiwakes on St. Lawrence I. feed on a variety of fishes, including primarily arctic cod and sand lance. Murres and kittiwakes at Bluff depend on saffron cod and sand lance for the bulk of their diets, and the abundance of these fishes is greater in warm years than in cold years. Auklets compete for zooplankton with fishes, including particularly juvenile pollock, as well as arctic cod, sand lance, and capelin. See Figure 2 on page 15 showing principal prey of murres and kittiwakes in Alaska. Kittiwakes apparently feed primarily on sand lance at Cape Peirce, while

common murres feed on sand lance, saffron cod, and pollock. On Buldir, thick-billed murres and both species kittiwake feed some on sand sand lance, while on Agattu, common murres and black-legged kittiwakes feed almost entirely on sand lance. Sand lance also is important to seabirds at other islands in the central Aleutians.

“Sand lance is an essential prey species of piscivorous seabirds throughout most of the Bering Sea. The rather infrequent occurrence of sand lance at Buldir Island has been attributed to the lack of shallow water surrounding it compared to other islands in the Aleutian chain, such as the neighboring Near Islands, which have relatively expansive shallows and where sand lance is by far the most important prey of seabirds. Judging from the small number of sand lance in seabird diets on the Pribilofs and St. Matthew Island, they are uncommon in both places in spite of an extent of shallow water around them similar to that around many of the Aleutian Islands where sand lance are common. One important difference between the Aleutian Islands and the Pribilofs and St. Matthew Island, though, is the abundance of pollock, which is insignificant in the Aleutians compared to the shelf around the Pribilofs and St. Matthew Island. The paucity of sand lance might be related to the surfeit of pollock.

“Overall, sand lance appears to be the most important summer prey of murres, kittiwakes, and other piscivorous seabirds in the Gulf of Alaska.”

Keywords: *A. hexapterus*; Alaska; Aleutian Islands; Bering Sea; importance; predators (birds, black-legged kittiwake, common murre, thick-billed murre).

Springer, A.M.; Byrd, G.V. 1989. Seabird dependence on walleye pollock in the southwestern Bering Sea. In: Proceedings of the international symposium on the biology and management of walleye pollock; 1988 [dates unknown]; Anchorage, AK. Alaska Sea Grant Rep. 89-1. [Fairbank, AK]: University of Alaska, Fairbanks: 667-677.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (birds).

Springer, A.M.; Dondratiev, A.Y.; Ogi, H. [and others]. 1993. Status ecology, and conservation of *Synthilboramphus* murrelets and auklets. In: Vermeer, K.; Briggs, K.T.; Morgan, K.H.; Siegel-Causey, D., eds. Proceedings of a symposium on the status of seabirds in the north Pacific; 1990 Feb; [location unknown]. Ottawa, ON: Canadian Wildlife Service: 187-201.

Keywords: A*. hexapterus*; north Pacific; predators (birds).

Springer, A.M.; McRoy, C.P.; Turco, K.R. 1989. The paradox of pelagic food webs in the northern Bering Sea. II: Zooplankton communities. Continental Shelf Research. 9: 359-386.

Keywords: *A. hexapterus*; Alaska; Bering Sea; food web.

Springer, A.M.; Murphy, E.C.; Roseneau, D.G. [and others]. 1987. The paradox of pelagic food webs in the northern Bering Sea: I: Seabird food habits. Continental Shelf Research. 17(8): 895-911.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (birds).

Springer, A.M.; Piatt, J.F.; Van, V.G. 1996. Sea birds as proxies of marine habitats and food webs in the western Aleutian Arc. Fisheries Oceanography. 5(1): 45-55.

“We propose that ocean conditions of the Near Islands in the western Aleutian Arc mimic those of the shallow continental shelf of the eastern Bering Sea to the extent that the marine community, including assemblages of forage fishes and their avian predators, has distinctly coastal characteristics. In contrast, marine avifauna and their prey at neighbouring Buldir Island are distinctly oceanic. For example, at the Near Islands, the ratio of thick-billed to common murres, *Uria lomvia* and *U. aalge*, is low and black-legged kittiwakes, *Rissa tridactyla*, but not red-legged kittiwakes, *R. brevirostris*, nest there. Diets of murres and kittiwakes are dominated by sand lance, *Ammodytes hexapterus*, an abundant coastal species. At Buldir Island, thick-billed murres greatly outnumbered common murres, red-legged kittiwakes and black-legged kittiwakes are both abundant, and diets of the birds consist primarily of oceanic squid and

lantern fish (Myctophidae). This mesoscale difference in food webs is apparently a consequence of the local physiography. A broad escarpment on the Near physiographic block creates a comparatively expansive, shallow, shelf-like habitat around the Near Islands, where a pelagic community typical of coastal regions flourishes. Buldir Island is the only emergent feature of the Buldir physiographic block, with little shallow water surrounding it and, apparently, little opportunity for other than oceanic species to exist. Patterns in the distribution of fishes, and thus of sea birds, throughout the Aleutian Islands might be largely explained by the presence or absence of shelf-like habitat and the relationship between physical environments and food webs. In the larger context of fisheries oceanography, this model for the Aleutian Islands improves our ability to interpret physical and biological heterogeneity in the ocean and its relationship to regional community dynamics and trends in the abundance and productivity of individual species at higher trophic levels."

Keywords: *A. hexapterus*; Alaska; Bering Sea; Near Islands; importance; predators (birds, black-legged kittiwake, common murre, horned puffin, thick-billed murre, tufted puffin).

Springer, A.M.; Roseneau, D.G.; Cooper, B.A. [and others]. 1984. Population and trophic studies in the northern Bering and eastern Chukchi seas, 1983. In: Environmental assessment Alaska Continental Shelf. Boulder, CO: [publisher unknown]; final report principal investigators BLM/National Oceanic and Atmospheric Administration, OCSEAP.

Keywords: *A. hexapterus*; Alaska; Bering Sea; Chukchi Sea; predators (birds).

Springer, A.M.; Roseneau, D.G.; Johnson, M. 1979. Ecological studies of colonial seabirds at Cape Thompson and Cape Lisburne, Alaska. Ann. Rep. 2. [Place of publication unknown]: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, OCSEAP: 517-574.

Keywords: *A. hexapterus*; Alaska; predators (birds).

Springer, A.M.; Roseneau, D.G.; Lloyd, D.S. [and others]. 1986. Seabird responses to fluctuating prey availability in the eastern Bering Sea. Marine Ecology Progress Series. 32: 1-12.

Keywords: *A. hexapterus*; Alaska; Bering Sea; predators (birds).

Springer, A.M.; Roseneau, D.G.; Murphy, E.C.; Springer, M.I. 1984. Environmental controls of marine food webs: food habits of seabirds in the eastern Chukchi Sea. Canadian Journal of Fisheries and Aquatic Sciences. 41(8): 1202-1215.

"Food habits of thick-billed murres (*Uria lomvia*), common murres (*U. aalge*), and black-legged kittiwakes (*Rissa tridactyla*) were examined at two breeding colonies in the eastern Chukchi Sea between 1976 and 1980. Cods (Gadidae), sculpins (Cottidae), sand lance (*Ammodytes hexapterus*), and capelin (*Mallotus villosus*) were the dominant (biomass) prey of thick-billed murres. Cods, sand lance, and capelin were the dominant prey of common murres and kittiwakes. Annual changes in the consumption of fishes by murres and kittiwakes suggest that available fish biomass in the eastern Chukchi Sea was low in 1976 and 1977, but increased each year through 1979 and 1980. The average size of several taxa of fishes eaten by the birds increased also between most years. Invertebrates were less important than fishes in all years, were eaten most frequently by thick-billed murres, and were eaten more frequently in 1976-77 than in 1978-79. A pattern of climatic cooling in the early 1970's followed by warming in the second half of the decade caused annual differences in the extent and duration of sea ice, and apparently in the spacial and temporal development of Alaskan Coastal Water, a major oceanographic feature of the Bering-Chukchi shelf. Fluctuations in the physical environment could have led to changes in fish populations through direct physiological and behavioral effects, or indirectly by altering the abundance of important zooplankton prey populations. Variability in the reproductive success of murres and kittiwakes in the northern Bering Sea and eastern Chukchi Sea corresponded with the apparent changes in fish stocks: reproductive success was very low in 1976 but improved in successive years. Short-term responses of seabirds to environmental fluctuation and its proposed effect on supporting food webs suggest that the stability of regional seabed populations could also be affected by long-term changes in weather and climate."

Keywords: *A. hexapterus*; Bering Sea; Chukchi Sea; predators (birds, black-legged kittiwake, common murre, thick-billed murre).

Springer, A.M.; Speckman, S.G. 1997. A forage fish is what? Summary of the symposium. In: Baxter, B.R., ed. Proceedings of the symposium on the role of forage fishes in marine ecosystems; [dates of meeting unknown]; [location unknown]. Alaska Sea Grant Program AK-SG-97-01. [Fairbanks, AK]: University of Alaska, Fairbanks: 773-805.

"Sand lance is a quintessential forage fish. As a group of very closely related species, it is possibly the single-most important taxon of forage fish in the Northern Hemisphere."

Keywords: *A. hexapterus*; importance.

Staby, A.; Borch-Jensen, C.; Mollerup, J.; Jensen, B. 1993. Flame ionization detector responses to ethyl esters of sand eel (*Ammodytes lancea*) fish oil compared for different gas and supercritical fluid chromatographic systems. Journal of Chromatography. 648(1): 221-232.

Keywords: *A. lancea*; chromatography; composition; ethyl esters.

Stagg, R.M.; Mcintosh, A. 1996. Hydrocarbon concentrations in the northern North Sea and effects on fish larvae. Science Total Environment. 186(3): 189-201.

"Ethoxyresorufin O-deethylase (EROD) activity was measured in pooled samples of both sandeel and gadoid larvae. For both species the range of EROD activities was large and variable and this is probably due to damage to larvae associated with capture and subsequent denaturation of the enzyme. Despite this the results show elevated EROD activity in samples taken on the southern end of the transect where hydrocarbon fluorescence in the water was highest and there is a significant regression of EROD activity on hydrocarbon concentration. The results therefore suggest a significant elevation of hydrocarbons in a large area of the northern North Sea (5-10 times the true background) and that these concentrations are capable of inducing biological responses associated with deleterious effects in fish larvae."

Keywords: *Ammodytes*; environmental pollution; larvae; oil.

Steven, E.A. 1933. The food consumed by shags and cormorants around the shores of Cornwall (England). Journal of Marine Biological Association of the United Kingdom. 19: 277-292.

"The shags were found to have been feeding principally upon Sand Eels (*Ammodytes* spp.), and other non-marketable fishes."

Keywords: *Ammodytes*; England; predators (birds, cormorant, shag).

Stevens, E.G.; Matarese, A.C.; Watson, W. 1984. Ammodytoidei: development and relationships. American Society of Ichthyologists and Herpetologists Special Publication Number 1: 574-575.

Keywords: *A. americanus; A. dubius; A. hexapterus; A. tobianus; Gymnammodytes semisquamatus; G. cicerellus; Hyperoplus immaculatus; H. lanceolatus*; description; development; eggs; larvae; pigment; taxonomy.

Stillwell, C.E.; Kohler, N.E. 1985. Food and feeding ecology of the swordfish *Xiphias gladius* in the western North Atlantic Ocean with estimates of daily ration. Marine Ecology Progress Series. 22(3): 239-248.

"Analysis of stomach contents and predator-prey relations of 168 swordfish from the western North Atlantic Ocean is presented. The predominant food of swordfish is squid (82% by frequency of occurrence) followed by fish (53%) consisting primarily of gadids, scombrids, butterfish, bluefish, and sand lance. Average food volume in stomachs is 1% of average body weight. Estimates of daily ration range from 0.94%-1.6% of average body weight, with yearly consumption ranging from 3.4-5.8 times average body weight per year. The prey biomass consumed by the swordfish population in the Georges Bank area is estimated to range from 2100-11,000 metric tons over a residency time of 5 mo."

Keywords: *Ammodytes*; Atlantic (northwest); predators (fish, swordfish).

Strachan, G.; McAllister, M.; Ralph, C.J. 1995. Marbled murrelet at-sea and foraging behavior. In: Ralph, C.J.; Hunt, G.L., Jr.; Raphael, M.G.; Piatt, J.F., eds. Ecology and conservation of the marbled murrelet. Gen. Tech. Rep. PSW-GTR-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

The murrelet forages by pursuit-diving in relatively shallow waters, usually between 20 and 80 meters deep. Some foraging occurs at night. Adults holding fish are probably about to fly inland to feed a young. Murrelet prey species include small inshore fish such as sand lance. Murrelets forage mostly in pairs throughout the year. In Alaska, pairs made up 45 percent of the population. In British Columbia, 11 of 13 pairs collected in late April were composed of an adult male and adult female. The reason for pairs is explained on the basis of pair bond maintenance and that an advantage to feeding need not be involved.

Keywords: *A. hexapterus*; predators (birds, marbled murrelet).

Straty, R.R. 1974. Ecology and behavior of juvenile sockeye salmon, *Oncorhynchus nerka*, in Bristol Bay and the eastern Bering Sea. In: Hood, D.W.; Kelley, E.J., eds. Oceanography of the Bering Sea, with emphasis on renewable resources. Occas. Publ. 2. [Fairbank, AK]: University of Alaska, Fairbanks, Institute of Marine Science: 285-320.

The stomachs from more than 1,200 juvenile sockeye salmon from the purse seine catches in Bristol Bay, southwest Alaska, in 1969 and 1970 were analyzed to determine their contents and degree of fullness. The larvae and young of Pacific sand lance were the first item in order of relative importance.

Keywords: *A. hexapterus*; Alaska; Bering Sea; Bristol Bay; importance; predators (fish, sockeye salmon).

Straty, R.R.; Haight, R.E. 1979. Interactions among marine birds and commercial fish in the eastern Bering Sea. In: Bartonek, J.C.; Nettleship, D.N., eds. Conservation of marine birds of northern North America. U.S. Fish and Wildlife Service Wildlife Research Report. 11: 201-219.

Keywords: *A. hexapterus*; Bering Sea; predators (birds).

Strong, C.S. 1995. Distribution of marbled murrelets along the Oregon coast in 1992. Northwest Naturalist. 76(1): 99-105.

“Strip transects from boat and light aircraft were used to quantify the distribution and abundance of marbled murrelets (*Brachyramphus marmoratus*) along the length of the Oregon coast. Murrelets were abundant in central Oregon between Newport and Coos Bay, with observed densities averaging 78 birds/10-km by 100-m strip (N = 90, SE = 5.9). Murrelets were relatively scarce north of Lincoln City ($\bar{x}$ = 6.8 birds/10-km by 100-m strip, N = 32, SE = 1.2), with small concentrations near coastal State Parks that contained old-growth forest stands. Murrelet abundance was variable from Coos Bay to the California border ($\bar{x}$ = 28.4, N = 22, SE = 5.9). Highest densities occurred in a narrow band and decreased sharply at > 1 km from shore. There was evidence of a northward and offshore shift of the population late in July, which may have been related to a prey shift from surf smelt (*Hypomesus* sp.) to Pacific sandlance (*Ammodytes hexapterus*) or to post-breeding dispersal. The abundance of marbled murrelets seen during this study suggests that the population in Oregon is higher than previously estimated.”

Keywords: *A. hexapterus*; Oregon; predators (birds, marbled murrelet).

Sturdevant, M.V. 1995. 1994 forage fish diet study: progress and preliminary data report of stomach analysis by Auke Bay Laboratory. [City unknown], AK: Auke Bay Laboratory, National Marine Fishery Service. Unpublished document. On file with: National Marine Fishery Service, [address unknown].

Keywords: *A. hexapterus*; Alaska; food and feeding habits.

Suddaby, D.; Ratcliffe, N. 1997. The effects of fluctuating food availability on breeding arctic terns (*Sterna paradisaea*). Auk. 114: 524-530.

Keywords: A. marinus; Shetland; predators (birds, arctic tern).

Summers, K.R.; Drent, R.H. 1979. Breeding biology and twinning experiments of rhinoceros auklets on Cleland Island, British Columbia. Murrelet. 60: 16-22.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds, rhinoceros auklet).

Sutcliffe, S. 1983. Intensive feeding activity by gulls near Skomer Island, Dyfed. Bulletin of the Gull Study Group. 5: 12.

Keywords: *Ammodytes*; Atlantic (northeast); predators (birds).

Swartz, L.G. 1966. Sea-cliff birds. In: Wilimovsky, N.J.; Wolfe, J.N., eds. Environment of the Cape Thompson region, Alaska. [Place of publication unknown]: U.S. Atomic Energy Commission.

"Kaftanovski (1938) specifically suggested a preference for sand launce (*Ammodytes*) by common murres. Data from Cape Thompson tend to support his contention. Among the stomachs containing fish remains, sand launce occurred in 26.7% of the stomachs of common murres and in 15.3% of the stomachs of thick-billed murres. *Ammodytes hexapterus* was not recovered from murre stomachs until June 10, after which time it occurred occasionally in the diet with relatively large numbers being found during August. Pacific sand lance was abundant in the diet of black-legged kittiwakes from July 24 until the end of the breeding season. None was found in stomachs taken before July 11. For glaucous gulls sand lance was found in 20% of the stomachs with food. Horned puffins fed on sand lance (25% of stomachs with food). Two pelagic cormorants were examined, one contained a sand lance."

Keywords: *A. hexapterus*; Alaska; Chukchi Sea; importance; predators (birds, common murre, thick-billed murre; black-legged kittiwake; glaucous gull; horned puffin; pelagic cormorant).

Swennen, C.; Duiven, P. 1977. Size of food objects of three fish-eating seabird species: *Uria aalge, Alca torda* and *Fratercula arctica* (Aves, Alcidae). Netherlands Journal of Sea Research. 11: 92-98.

Keywords: *Ammodytes*; predators (birds, guillemot, puffin, razorbill).

Synkova, A.N. 1951. [On the food of Pacific salmon in Kamchatka waters]. Izvestiya TINRO. 39: 105-121, (Fisheries Research Board Translation No. 415).

Keywords: *Ammodytes*; predators (fish, Pacific salmon).

Tabeta, O.; Tsukahara, H. 1969. Ecological studies on fishes stranded upon the beach along the Tsushima Current. II: Observations during the winter months of 1966 in northern Kyushu Japan. Bulletin of the Japanese Society of Scientific Fisheries. 35(1): 43-54.

Keywords: *A. personatus*; mortality; winter.

Taggart, C.T.; Leggett, W.C. 1987. Short-term mortality in post-emergent larval capelin *Mallotus villosus*. 2: Importance of food and predator density, and density-dependence. Marine Ecology-Progress Series. 41(3): 219-229.

Keywords: *Ammodytes*; density; food and feeding habits; larvae.

Takagi, K.; Aro, K.V.; Hartt, A.C.; Dell, M.B. 1981. Distribution and origin of pink salmon (*Oncorhynchus gorbuscha*) in offshore waters of the north Pacific Ocean. International North Pacific Fisheries Commission Bulletin. 40. 195 p.

Keywords: *Ammodytes*; north Pacific; predators (fish, pink salmon).

Tambs-Lyche, H. 1975. Report on the international O group fish survey in Iceland and Greenland waters in July-August 1975. Annales Biologiques. 32: 191-199.

Keywords: *Ammodytes*; Greenland; Iceland; abundance; distribution; larvae.

Tamura, W.; Koganesaki, E.; Fujita, N. 1991. Study of sandeel resources and their ecology. Aomori–Ken Suisan Shikenjo Jigyo Hokoku. 1989: 155-169.

Keywords: *A. personatus*; Japan; catch; distribution; habitat; larvae; length; weight.

Tanasichuk, R.W.; Ware, D.M. 1987. Influence of interannual variations in winter sea temperature on fecundity and egg size in Pacific herring (*Clupea harengus pallasi*). Canadian Journal of Fisheries and Aquatic Sciences. 44(8): 1485-1495.

Keywords: *Ammodytes*; eggs; fecundity; fisheries; temperature.

Tandler, A. 1985. Food for the larval stages of marine fish–live or inert–overview. Israel Journal of Zoology. 33(4): 161-166.

Keywords: *Ammodytes*; food and feeding habits; larvae.

Tarnani, I.K. 1891. The Solovetskiy monastery fishery. Vestnik rybopromyshl. No. 12.

Keywords: *Ammodytes*; fisheries; historical.

Tasker, M. 1989. Priorities for future research into Shetland sandeels. In: Heubeck, M., ed. Seabirds and sandeels: Proceedings of a seminar; 1988 Oct. 15-15 [sic]; Lerwick, Shetland. Lerwick, Shetland: Shetland Bird Club: 1-76.

Keywords: *A. marinus*; Shetland; population dynamics.

Tasker, M.L.; Jones, H.P.; Blake, B.F.; Dixon, T.J. 1985. Distribution and feeding habits of the great skua *Catharacta skua* in the North Sea. Seabird. 8: 34-44.

“The distribution and occurrence of the great skua in the North Sea is described using records made from ships and oil production platforms. Observations made on feeding behaviour agree with previous studies of great skua diet during the breeding season, and indicate that birds may be feeding mainly on sandeels in June and July, but discarded whitefish at other times.”

Keywords: *Ammodytes*; North Sea; predators (birds, great skua).

Tasker, M.L.; Webb, A.; Hall, A.J. [and others]. 1987. Seabirds in the North Sea. Peterborough, [Country unknown]: Nature Conservancy Council.

Keywords: *Ammodytes*; North Sea; predators (birds).

Tate, R.C. 1905. On a collection of fishes from the Inland Sea of Japan made by Mr. R. Gordon Smith. Annals and Magazine of Natural History. 15(7): 1-9.

Synonymy: Chaetopterus = Pristipomoides.

Keywords: *A. personatus*; Japan; taxonomy.

Tatterson, I.N.; Windsor, M.L. 1974. Fish silage. Journal of the Science of Food and Agriculture. 25(4): 369-379.

Keywords: *Ammodytes*; composition; oil; protein.

Tatum, J.B. 1981. Peregrine fishing at sea. British Birds. 74(2): 97.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds, peregrine falcon).

Tawara, S. 1986. Studies on the characteristics of oceanographic condition in relation to fishing conditions in shallow coastal waters. Journal of the Shimonoseki University of Fisheries. 34(1): 1-104.

Keywords: *A. personatus*; Japan; catch; fisheries; hydroacoustics; salinity; seasonal variation; temperature.

Taylor, F.H.C.; Fujinaga, M.; Wilke, F. 1955. Distribution and food habits of the fur seals of the north Pacific Ocean. Washington, DC: Government Printing Office; report of cooperative investigations by the governments of Canada, Japan, and the United States of America; February-July, 1952. 86 p.

Keywords: *A. hexapterus*; north Pacific Ocean; predators (mammals, fur seal).

Taylor, I.R. 1979. Prey selection during courtship feeding in the common tern. Ornis Scandinavica. 10: 142-144.

Keywords: *Ammodytes*; Scotland; predators (birds, common tern).

Templeman, W. 1945. Observations on some Newfoundland sea-birds. Canadian Field Naturalist. 59: 136-147.

Keywords: *Ammodytes*; Newfoundland; predators (birds).

Templeman, W. 1966. Marine resources of Newfoundland. Bulletin of the Fisheries Research Board of Canada. 154: 170 p.

Keywords: *Ammodytes*; Newfoundland.

Templeman, W. 1967. Atlantic salmon from the Labrador Sea and off west Greenland, taken during “A.T. Cameron” cruise, July-August 1965. International Commission for the NorthWest Atlantic Fisheries Research Bulletin. (4): 5-40.

Keywords: *Ammodytes*; Greenland; Labrador; predators (fish, Atlantic salmon).

Templeman, W. 1982. Stomach contents of the thorny skate *Raja radiata* from the northwest Atlantic. Journal of Northwest Atlantic Fishery Science. 3(2): 123-126.

“Stomach contents of thorny skates, *R. radiata*, collected in the Northwest Atlantic from West Greenland to Georges Bank during 1947-1967, were examined and measured by volume. The stomach contents consisted mostly of fish, followed by decapods (especially spider crabs and hermit crabs), cephalopods and polychaetes. The most numerous food items, in descending order of occurrence, were crabs, polychaetes, shrimp, sand lance, amphipods and capelin.”

Keywords: *Ammodytes*; Atlantic (northwest); predators (fish, thorny skate).

Templeman, W.; Fleming, A.M. 1953. Long term changes in hydrographic conditions and corresponding changes in the abundance of marine animals. International Commission for the NorthWest Atlantic Fisheries Annual Proceedings. 3(5): 3-10.

Keywords: *Ammodytes*; abundance.

Thatcher, T.O. 1978. The relative sensitivity of Pacific Northwest fishes and invertebrates to chlorinated sea water. In: Jolley, R.L., ed. Water chlorination: environmental impact and health effects: Proceedings of the 2d conference; [dates unknown]; Gatlinburg, TN. Ann Arbor, MI: Ann Arbor Science Publishers, Inc.: 2: 341-350.

Keywords: *A. hexapterus*; anthropogenic impacts; chlorine; environmental pollution.

Theilacker, G.H. 1987. Feeding ecology and growth energetics of larval northern anchovy, *Engraulis mordax*. Fishery Bulletin. 85(2): 213-228.

Keywords: *Ammodytes*; larvae; predators (fish).

Thomopoulos, A. 1954. Sur l'oeuf d'equille *Ammodytes tobianus* L. Bulletin de la Société Zoologique de France. 79: 112-120.

Keywords: *A. tobianus*.

Thompson, H. 1943. A biological and economic study of cod (*Gadus callarias* L.) in the Newfoundland area including Labrador. Newfoundland Department of Natural Resources Research Bulletin. 14: 1-150.

Sand lance is an important food of cod on Grand Bank and St. Pierre Bank, Canada.

Keywords: *Ammodyte*s; Newfoundland; Labrador; importance; predators (fish, cod).

Thompson, P.M.; Mcconnell, B.J.; Tollit, D.J. [and others]. 1996. Comparative distribution, movements and diet of harbour and grey seals from the Moray Firth, NE Scotland. Journal of Applied Ecology. 33(6): 1572-1584.

"The distribution, movements and foraging activity of harbour and grey seals from the inner moray firth, n.e. Scotland, were compared using a combination of observations at haul-out sites, vhf and satellite-link telemetry, and analyses of diet composition. Sandeels, gadoids, flatfish and cephalopods formed over 95% of the diet of both species. However, dietary data, particularly for grey seals, may be biased toward those individuals which fed in more inshore areas."

Keywords: *Ammodytes*; Scotland; predators (mammals, grey seal, harbour seal).

Thompson, P.M.; Tollit, D.J.; Greenstreet, S.P.R. [and others]. 1996. Between-year variations in the diet and behaviour of harbour seals *Phoca vitulina* in the Moray Firth; causes and consequences. In: Greenstreet, S.P.R.; Tasker, M.L., eds. Aquatic predators and their prey; Proceedings, Royal Society of Edinburgh conference; 1994 Aug.; Edinburgh, Scotland. Oxford, England; Cambridge, MA: Blackwell Scientific Publications. 7: 44-52.

Keywords: *Ammodytes*; Scotland; predators (mammals, harbor seal).

Thompson, P.M.; Wood, D.G.; Tollit, D.; Miller, D. 1992. Seasonal and between-year differences in harbour seal *Phoca vitulina* foraging activity. Rostock-Warnemuende (FRG): 11.

Keywords: *Ammodytes*; Atlantic (northeast); predators (mammals, harbor seal).

Thomson, R.E. 1981. Oceanography of the British Columbia coast. Canadian Special Publication of Fisheries and Aquatic Sciences. 56.

Keywords: *A. hexapterus*; British Columbia.

Thorensen, A.C. 1989. Diving times and behavior of pigeon guillemots and marbled murrelets off Rosario Head, Washington. Western Birds. 20: 33-37.

Keywords: *A. hexapterus*; Washington; predators (birds, marbled murrelet, pigeon guillemot).

Thorsteinson, F.V.; Lensink, C.J. 1962. Biological observations of Steller sea lions taken during an experimental harvest. The Journal of Wildlife Management. 26(4): 353-359.

Keywords: *A. hexapterus*; predators (mammals, Steller sea lion).

Of 56 Steller sea lion stomachs with food, 25 percent contained sand lance. It was the most frequently eaten fish.

Thorsteinson, F.V.; Nelson, R.W.; Lall, D.F. 1961. Experimental harvest of the Steller sea lion in Alaskan waters. U.S. Fish and Wildlife Service Special Scientific Report Fisheries. 371: 1-15.

Keywords: *A. hexapterus*; Alaska; predators (mammals, Steller sea lion).

Thresher R.E. 1988. Latitudinal variation in egg sizes of tropical and sub-tropical north-Atlantic shore fishes. Environmental Biology of Fishes. 21(1): 17-25.

Keywords: *Ammodytes*; Atlantic (northwest); eggs.

Thurow, F. 1966. Beitraege zur Biologie und Bestandkunde des Atlantischen Lachses (*Salmon salar* L.) in der Ostsee. Berichte der Deutschen Wissenschlaftlichen Kommission für Meeresforschung. 18(3/4): 223-379. (Translated from German by Fisheries Research Board of Canada Translation Series 1211. 1969).

Keywords: *Ammodytes*; predation (fish, Atlantic salmon).

Tiews K. 1968. The German sandeel fishery in 1967. Annals of Biology. 24: 196.

Keywords: *A. lancea; A. marinus*; North Sea; catch; fisheries.

Tiews, K. 1978a. Non-commercial fish species in the German bight: records of by-catches of the brown shrimp fishery. In: Symposium on North Sea fish stocks—recent changes and their causes; [dates unknown]; Århus, Denmark. [Place of publicaton unknown]: [publisher unknown]: 172: 259-265.

“A report is given on the fluctuations in the composition of the by-catch of thirteen non-commercial fish species and of two crab species in the German shrimp fishery during the years from 1954 to 1973. These species are: *Pomatoschistus* sp, *Osmerus eperlaus, Agonus cataphractus, Syngnathus* sp, *Liparis* sp, *Ammodytes* sp, *Zoarces viviparus, Myoxocephalus scorpius, Gasterosteus aculeatus, Callionymus lyra, Pholis gunellus, Ciliata mustela, Trigla* sp, *Portunus holsatus*, and *Carcinus maenas*. It is not possible to explain the mechanisms behind these changes.”

Keywords: *Ammodytes*; North Sea; fisheries.

Tiews, K. 1978b. The German industrial fisheries in the North Sea and their by-catches. In: Symposium on North Sea fish stock–recent changes and their causes; [dates unknowwn]; Århus, Denmark. [Place of publication unknown]: [publisher unknown]: 172: 230-238.

This paper deals with the by-catches of the German industrial fisheries for juvenile herring, sprat, and sand-eel as well as of the industrial catches of the German shrimp (*Crangon crangon*) fishery.

Keywords: *Ammodytes*; Germany; catch; fisheries; larvae.

Timakova, M.N. 1957. The feeding and food interrelationships of the navaga and smelt of Onega Bay of the White Sea. In: Materialy po kompleksnomu izucheniyu Belogo morya: Materials for a combined study of the White Sea. Moscow; Leningrad, USSR: Academic Science Press.

Keywords: *Ammodytes*; White Sea; food and feeding habits; predators (fish, navaga).

Tocher, D.R.; Sargent, J.R. 1984. Analyses of lipids and fatty-acids in ripe roes of some northwest European marine fish. Lipids. 19(7): 492-499.

“Lipid class analyses and fatty acid analyses of neutral and polar lipids were carried out on ripe roes of herring [*Clupea harengus*], cod [*Gadus morhua*], haddock [*Melanogrammus aeglefinus*], whiting [*Merlangus merlangus*], saithe [*Pollachius virens*], sand eel [*Ammodytes lancea*] and capelin [*Mallotus villosus*]. Total lipid 10-26% of roe dry wt. The species with the highest total lipid, sand eel and capelin, also had the highest percentage of neutral lipid in total lipid, 77 and 49%, respectively. In the other species, phospholipids accounted for 62-77% of roe total lipid. Both the neutral lipids and especially the phospholipids, of all species were very unsaturated because of high concentrations of (n-3) polyunsaturated fatty acids (PUFA), frequently amounting to 50% of the total egglipid. Phosphatidylcholine

(PC) and phosphatidylethanolamine (PE) had similar fatty acid compositions in all species, with an average ratio (n-3)/(n-6) of @ 20:1. Phosphatidylinositol (PI) consistently had high concentrations of 18:0 and 20:4 (n-6) with an average ratio of (n-3)/(n-6) of 1.8:1. Requirements for high levels of (n-3) PUFA in the embryonic and early larval development stages of marine fish are suggested as is a special role for the 20:4 (n-6) in PI."

Keywords: *A. lancea*; eggs; fatty acids; lipid.

Todd, R.A. 1907. Second report on the food of fishes. Marine Biological Association U.K. Internal Fish Investigation. 1904-05: 53-160.

Keywords: *A. tobianus*; North Sea; predators (fish, whiting).

Todd, R.A. 1915. Report on the food of the plaice. Fishery Investigations. Series II. Sea Fisheries. 2(3): 1-33.

Keywords: *Ammodytes*; North Sea; predators (fish, plaice).

Toft, G.O. 1982. Sandeel Ammodytidae a rare prey taken by the oystercatcher *Haematopus ostralegus*. Fauna Norvegica Series. C 5(2): 95-96.

Keywords: *Ammodytes*; predators (birds, oystercatcher).

Tokranov, A.M.; Maksimenkov, V.V. 1995a. Features of the nutrition of ichthyophagous fishes in the estuary of the Bolshaya River (western Kamchatka). Voprosy Ikhtiologii. 35(5): 651-658.

"Features of the feeding of the Arctic smelt *Osmerus mordax dentex*, Sakhalin char *Salvelinus leucomaenis*, belligerent sculpin *Megalocottus platycephalus*, malma *S. malma*, and starry flounder *Platichthys stellatus* were studied in the Bolshaya River estuary. It was shown that capelin, threespine stickleback, bivalve mollusks, and fish waste predominated (97%) in the diet of *M. platycephalus*; fish (mostly capelin and sand lance), mysids, bivalve mollusks, and fish waste were found in the food spectrum of *P. stellatus*. For *S. leucomaenis* and *S. malma*, more than 99% of their diet consisted of capelin, sand lance, pink salmon fry, and mysids; capelin comprised more than 99% of the diet of *O. mordax dentex*. Age-related changes of the food composition of these ichthyophagous fishes were considered as were their trophic relationships. The role of these species in the trophic system of the Bolshaya River estuary was established (*O. mordax dentex* was found to be an obligate fish-eating predator, *S. leucomaenis*, *S. malma* and *M. platycephalus*–facultative fish-eating predators, and *P. stellatus*–a benthos-and fish-eating species). Trophic links building up the biomass of the fishes studied were identified."

Keywords: *Ammodytes*; Russia; predators (fish, belligerent sculpin, Dolly Varden, Sakhalin char, starry flounder).

Tokranov, A.M.; Maksimenkov, V.V. 1995b. Feeding habits of predatory fishes in the Bol'shaya River Estuary (West Kamchatka). Voprosy Ikhtiologii. 35(9): 102-112.

Keywords: *A. hexapterus*; USSR; predators (fish, Dolly Varden, starry flounder).

Tollit, D.J.; Steward, M.J.; Thompson, P.M. [and others]. 1997. Species and size differences in the digestion of otoliths and beaks: implications for estimates of pinniped diet composition. Canadian Journal of Fisheries and Aquatic Sciences. 54(1): 105-119.

"We examined the digestion of hard remains of between one and four different size ranges of nine key North Sea prey taxa fed to seven captive harbour seals (*Phoca vitulina*). Percentage length reduction (mean 27.5%) and recovery rates (mean 42%) of experimental otoliths varied between species and were positively correlated to fish size and otolith robustness (mass/length). Mean length reduction of egested otoliths increased systematically with increasing size of ingested whiting and sandeel otoliths ($p < 0.00\ 1$), indicating that the size of larger fish may be underestimated. Intraspecific variation in otolith digestion was high (CV = 0.48-1.30), and to control for the artificial conditions of a captive study, external morphological features of otoliths were used to grade the degree of digestion and provide

grade-specific correction factors. Bootstrap simulations were used to estimate 95% confidence intervals around correction factors and when partitioned indicated that calculation errors were in general less important than resampling errors. The application of species-, size-, and grade-specific correction factors progressively improved reconstructed estimates of prey biomass fed. As a consequence, estimates of prey size and diet composition require otoliths from faeces to be graded and more complex correction factors applied."

Keywords: *Ammodytes*; North Sea; otoliths; predators (mammals, harbor seal).

Tollit, D.J.; Thompson, P.M. 1996. Seasonal and between-year variations in the diet of harbour seals in the Moray Firth, Scotland. Canadian Journal of Zoology. 74(6): 1110-1121.

"Predictions concerning the effect of seals upon prey stocks require an understanding of temporal variations in diet composition. This study examined the extent of between-year and seasonal variations in the diet of harbour seals (*Phoca vitulina*) from the Moray Firth, Scotland, between 1989 and 1992. Analyses of fish otoliths and cephalopod beaks collected from 1129 faecal samples were used to derive estimates of the contribution made by each of 35 prey species, based on the number and mass consumed. The key prey, by mass, were sand eels (Ammodytidae) (47%), lesser octopus (*Eledone cirrhosa*) (27%), whiting (*Merlangius merlangus*) (6%), flounder (*Platichthys flesus*) (5%), and cod (*Gadus morhua*) (4%). Between-year and seasonal fluctuations in the contributions of these species were observed. Sand eels contributed 86-20% in summer and 91-49% in winter. Lesser octopus contributed 0-62% in summer and lt 5% in winter, whilst whiting and cod contributed 2-34% in winter and 1-4% in summer. In contrast to 1988, clupeids were unimportant in winter. Differences in diet composition appeared to reflect local changes in the availability of food, especially over-wintering clupeids. Results indicate that dietary information obtained from short-term studies can be a poor indicator of subsequent diet composition and should be treated with caution when used to predict the effect of seals on prey populations."

Keywords: Ammodytidae; Scotland; importance; predators (mammals, harbor seal).

Tomiyama, M.; Funakoshi, S.; Yamada, H. 1996. Resources management of sandlance in Ise Bay. Bulletin of the Japanese Society of Fisheries Oceanography. 60(2): 166-170.

Keywords: *A. personatus*; Japan; fisheries.

Townsend, L.D. 1942. The occurrence of flounder post larvae in fish stomachs. Copeia. 1942(2): 126-127.

Dolly Varden captured near Shumagin Islands in Alaska contained large numbers of flounder juveniles and larvae of sand lance.

Keywords: *A. hexapterus*; Alaska; Aleutian Islands; predators (fish, Dolly Varden).

Trapp, J.L. 1979. Variation in summer diet of glaucous-winged gulls in western Aleutian islands: an ecological interpretation. Wilson Bulletin. 91: 412-419.

Keywords: *A. hexapterus*; Alaska; Aleutian Islands; predators (birds, glaucous-winged gull).

Trasky, L.L.; Flagg, L.B.; Burbank, D.C. 1977. Impact of oil on the Kachemak Bay environment. In: Trasky, L.L.; Flagg, L.B.; Burbank, D.C., eds. Environmental studies of Kachemak Bay and lower Cook Inlet. Alaska Department of Fish and Game, Marine/Coastal Habitat Management, Anchorage. 1.

Keywords: *A. hexapterus*; Alaska; Kachemak Bay; spawning.

Trumble, R.J. 1973. Distribution, relative abundance, and general biology of selected underutilized fishery resources of the eastern north Pacific Ocean. Seattle, WA: University of Washington. 178 p. M.S. thesis.

Keywords: *A. hexapterus*; north Pacific; abundance; biology; distribution.

Tsukamoto, Y.; Zeniya, H.; Yamada, H. 1996. Ring crest structure of sand lance otolith in the initial life stage. Nippon Suisan Gakkai Taikai Koen Yoshishu. 1996: 29.

Keywords: *Ammodytes*; growth; larvae; otoliths.

Tsuruta, Y. 1995. A problem of spawning on undernourished sand lance. Suisan Kaiyo Kenkyu. 59(3): 317-320.

Keywords: *A. personatus*; Japan; aestivation; biological rhythm; dormancy; eggs; food and feeding habits.

Tsvetkov, V.I.; Kalyakina, N.M. 1987. On the relations between white sea fishes and floating macrophytes. Ekologiya (Sverdlovsk). 6: 40-43.

“A study was made of the use of 252 floating algae (*Fucus* and *Ascophyllum* spp.) by various fishes in the White Sea. *Cyclopterus lumpus* was most frequently found in the vicinity of the algae (90%). Other fishes (10%) were identified as herring, ninespine stickleback, gunnel (*Pholis gunnelus*), shorthorn sculpin (*Myoxocephalus scorpius*), armed bullhead (*Agonus cataphractus*), *Liparis liparis*, sand lance (*Ammodytes*), and cod. The food composition of the lumpfish was studied, and was found to contain Amphipoda, Isopoda, Calanoida, Harpacticoida, Decapoda, Cladocera, Mysidacea, Hydroidea, Polychaeta, Bivalvia, Diptera, and Cottidae. The relationship of the cod and floating macrophytes may be of practical importance in the development of floating reefs.”

Keywords: *Ammodytes*; White Sea; distribution; ecology; habitat.

Tuck, L.M. 1960. The murres: their distribution, populations, and biology—a study of the genus *Uria*. Canadian Wildlife Service Monograph Series. 1: 260 p.

“The launce or sand eel (*Ammodytes* sp.) is an important food of murres in shallow-water regions. Adult launce rarely grow longer than seven inches and therefore all age classes are taken. *Ammodytes americanus* is the principal food in summer of both species of murres at the Gannet Island, Labrador. Its European counterpart, *Ammodytes tobianus,* comprised from 80.3 to 86.1 per cent of the food of both species on the Murman coast (Kaftanovski, 1938).”

Keywords: *A. americanus; A. tobianus*; importance; predators (birds, common murre, thick-billed murre).

Tuck, L.M.; Squires, H.J. 1955. Food and feeding habits of Brunnich’s murre (*Uria lomvia lomvia*) on Akpatok Island. Journal of the Fisheries Research Board of Canada. 12: 781-792.

A study of the food and feeding habits of Brunnich’s murre (*Uria lomvia lomvia*) on Akpatok Island, Ungava Bay, was made during the period August 9-28, 1954. Sand lance ranged up 3 percent of the daily occurrences of food brought to chicks.

Keywords: *A. americanus*; Canada; Akpatok Island; predators (birds, thick-billed murre).

Tully, O.; Oceidigh, P. 1989. The ichthyoneuston of Galway Bay (Ireland). I: The seasonal, diel and spatial distribution of larval, post-larval and juvenile fish. Marine Biology (Berlin). 101(1): 27-41.

Keywords: *A. marinus*; Ireland; circadian rhythms; distribution; larvae; seasonal variation.

Turner, J.T.; Bruno, S.F.; Larson, R.J. [and others]. 1983. Seasonality of plankton assemblages in a temperate estuary. Pubblicazioni della Stazione Zoologica di Napoli. 4(1): 81-99.

“Larval *Ammodytes americanus* were the dominant ichthyoplankton, and these co-occurred in winter with increased abundances of larger adult copepods of species upon which *A. americanus* is known to feed.”

Keywords: *A. americanus*; Atlantic (northwest); food and feeding habits; larvae.

Turrell, W.R. 1992. New hypotheses concerning the circulation of the northern North Sea and its relation to North Sea fish stock recruitment. Journal du Conseil Conseil. International pour l'Exploration de la Mer. 49(1): 107-123.

Keywords: *A. marinus*; North Sea; environmental factors; recruitment.

Turuk, T.N. 1968. Seasonal changes in cod feeding in the Labrador and Newfoundland areas in 1964-66. Tr. PINRO. 23: 370-382.

Keywords: *Ammodytes*; Labrador; Newfoundland; predators (fish, cod).

Uchihashi, K. 1950. Sand eels and their fishing in Akashi waters. Bulletin Hyogo Regional Fisheries Research Laboratory. 6: 1-19.

Keywords: *Ammodytes*; Japan; fisheries.

U.S. Fish and Wildlife Service. 1988. Alaska Maritime National Wildlife Refuge summary. [Place of publication unknown]: U.S. Fish and Wildlife Service; final comprehensive conservation plan, wilderness review, and environmental impact statement. 175 p.

"Most Alaskan waters do not have commercial forage fisheries, with the exception of pollock, so Alaska is one of the few places where seabirds have a relatively intact food chain. In the Alaska Peninsula Unit walleye pollock, Pacific cod, sablefish, sand lance and herring are important marine fishes of this unit. Primary marine fishes occurring in the Gulf of Alaska Unit include walleye pollock, capelin, sand lance, herring, sablefish, halibut, salmon, and Pacific cod."

Keywords: *A. hexapterus*; Alaska; importance.

U.S. Fish and Wildlife Service. 1992. Alaska seabird management plan. Anchorage, AK: U.S. Fish and Wildlife Service. 102 p. Unpublished report. On file with: [unknown].

The following birds were mentioned as eating sand lance: Leach's storm-petrel, fork-tailed storm petrel, jaegers, gulls—in some places they depend for successful breeding on herring, capelin, and sand lance taken from the surface of waters near shore; black-legged kittiwakes depend on walleye pollock, capelin, and sand lance; both arctic and Aleutian terns feed primarily on capelin and sand lance—the breeding success of terns is highly vulnerable to yearly variations in prey. Common and thick-billed murres depend on fish such as walleye pollock, capelin, sand lance, and arctic cod. Pigeon guillemots feed on capelin, sand lance, cod, and bottom-dwelling fish; marbled murrelet, Kittlitz's murrelet, and ancient murrelet all feed on small fish including sand lance, capelin, and walleye pollock. Rhinoceros auklet feed primarily on fish such as herring, sand lance, and capelin. Tufted and horned puffins depend primarily on fish such as sand lance for feeding their young.

Keywords: *A. hexapterus*; Alaska; importance; predators (birds).

Uspenski, S.M. 1958. The bird bazaars of Novaya Zemlya. Canadian Wildlife Service Translation Russian Game Report. 4: 1-159.

Keywords: *Ammodytes*; predators (birds).

Uttley, J. 1992. Food supply and allocation of parental effort in arctic terns *Sterna paradisaea*. Ardea. 80: 83-91.

"Lesser sandeels *Ammodytes marinus* are the main prey of arctic terns in both Shetland and Orkney."

Keywords: *A. marinus*; Orkney; Shetland; importance; predators (birds, arctic tern).

Uttley, J. 1993. Seabirds and sandeels: a summary of research by Glasgow University since 1990. Shetland Bird Report. 1992: 93-95.

Keywords: *Ammodytes*; predators (birds).

Uttley, J.; Monaghan, P.; White, S. 1989. Differential effects of reduced sandeel availability on two sympatrically breeding species of tern. Ornis Scandinavica. 20: 273-277.

“Changes in the availability of sandeels *Ammodytes marinus* have been shown to be the cause of recent widespread breeding failure of some surface feeding seabirds in Shetland (Scotland, UK). In this paper we compare the breeding performance and chick diet of common and Arctic terns in Shetland in 1988 with a previous study of these species in north-east England, when prey availability and breeding success were good. In Shetland young saithe comprised 80% of the diet of common tern chicks in the first week of life. Chicks on this diet grew as well as those in north-east England. However, heavy predation of common tern young by avain predators appears to have occurred, and possible reasons for this are discussed. Arctic terns concentrated on sandeels; growth of their young was poor, and the majority died in the first week after hatching. We discuss potential explanations for the apparent inability of Arctic terns to exploit saithe, which may relate to the energetics of chick growth and foraging economics.”

Keywords: *A. marinus*; Scotland; Shetland; energetics; predators (birds, arctic tern, common tern).

Uttley, J.D.; Walton, P.; Monaghan, P.; Austin, G. 1994. The effects of food abundance on breeding performance and adult time budgets of guillemots *Uria aalge*. Ibis. 136: 205-213.

“In waters around the Shetland Island, to the northeast of the Scottish mainland, lesser sandeels *Ammodytes marinus* are the only high-energy prey available to most seabirds. Between the early and late 1980s, the total stock biomass and recruitment of sandeels in Shetland waters, as assessed by standard fisheries-based methods, declined to approximately one-third and one-fourth, respecitively, of their peak values. The effects of this change on breeding seabirds were manifested in reduced breeding success and prey switching to defferent extents in different species. It was initially thought that diving species such as the guillemot and shag *Phalacrocorax aristotelis* were less severely affected than surface-feeding species such as the Arctic tern, kittiwake and great skua *Catharacta skua*. In 1990, a detailed study of sandeels in the area between the southernmost point of mainland Shetland and Air Isle was initiated: this showed that in 1990 sandeel abundance in that area was the lowest on record but, in comparison, increased 40-fold in 1991, and the fish were much more widely distributed around the study area.

“Guillemots nearly always carry fish by holding them lengthwise in the bill, with the head down the bird’s throat. Thus most fish could be easily identified as sandeel or gadoid and their size was estimated. small = 100 mm, medium = 130 mm and large = 160 mm.

“Sandeels were the dominant prey item in each year, comprising 82% of identified prey items in 1990 and 80% in 1991. Most fish were small or medium.

“Lesser sandeels are the only high-quality prey available to most seabirds; adult herring are present during the breeding season, but these are too large for most seabirds to prey upon, and sprat have been absent from the northern North Sea since the late 1970s.”

Keywords: *A. marinus;* Scotland; importance; predators (birds).

Vader, W.; Barrett, R.T.; Erikstad, K.E.; Strann, K.B. 1990. Differential responses of common and thick-billed murres to a crash in the capelin stock in the southern Barents Sea. In: Sealy, S.G., ed. Auks at sea. Studies in Avian Biology. 14: 175-180.

Keywords: *Ammodytes*; Barents Sea; predators (birds, common murre, thick-billed murre).

Valtonen, T. 1964. Blatobisen, *Ammodytes lancea* Yarrel, allman i Bottenviken. Fisk Tidskr. Finl. 8(3-4): 86-87.

Keywords: *A. lancea*.

Van Pelt, T.I.; Piatt, J.F.; Lance, B.K.; Roby, D.D. 1997. Proximate composition and energy density of some north Pacific forage fishes. Comparative Biochemistry and Physiology. 118A(4): 1393-1398.

“Mature pelagic forage fish species (capelin, sand lance, squid) had greater lipid concentrations than juvenile age-classes of large demersal and pelagic fish species (walleye pollock, Pacific cod, Atka mackerel, greenling, prowfish, rockfish, sablefish). Myctophids preyed on by puffins have at least twice as much lipid per gram compared to mature capelin, sand lance and squid, and an order of magnitude greater lipid concentrations than juvenile forage fish. Energy density of forage fishes was positively correlated with lipid content, and negatively correlated with water, ash-free lean dry mass (mostly protein), and ash contents.”

Keywords: *A. hexapterus*; north Pacific; energetics; lipid content; proximate composition.

van Tets, G.F. 1959. A comparative study of the reproductive behavior of three sympatric species of cormorants (*Phalacrocorax auritus, penicillatus, pelagicus*) at Mandarte Island, B.C. Vancouver, BC: University of British Columbia. 86 p. M.A. thesis.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds).

Veit, R.R.; Braun, B.M.; Nikula, B. 1987. The influence of population growth of sand lance upon wintering seabirds in southeastern New England. Pacific Seabird Group Bulletin. 14(1): 38.

“The data we have presented illustrate a close correspondence between increases in sand lance stock size and increases in numbers of seabirds, especially herring gulls and black-legged kittiwakes wintering in southeastern New England.”

Keywords: *Ammodytes*; New England; importance; predators (birds, herring gull, black-legged kittiwake).

Verbeek, N.A.M. 1993. Glaucous-winged gull. In: Poole, A.; Stennheim, P.; Gill, F., eds. The birds of North America. Philadelphia: The Academy of Natural Sciences: Washington, DC: The American Ornithologist’ Union: 59.

Keywords: *A. hexapterus*; Alaska; predators (birds, glaucous-winged gull).

Verbeek, N.A.M.; Butler, R.W. 1989. Feeding ecology of shoreline birds in the Strait of Georgia. In: Vermeer, K.; Butler, R.W., eds. The ecology and status of marine and shoreline birds in the Strait of Georgia, British Columbia. Spec. Publ. Ottawa, ON: Canadian Wildlife Service: 74-81.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds).

Vermeer, K. 1963. The breeding ecology of the glaucous-winged gull (*Larus glaucescens*) on Mandarte Island, B.C. Occasional Papers British Columbia Provincial Museum. 13: 1-104.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds, glaucous-winged gull).

Vermeer, K. 1978. Extensive reproductive failure of rhinoceros auklets and tufted puffins. Ibis. 120: 112.

“The heavy rhinoceros auklet chick mortality in 1976 may be partly or wholly related to an unsuitable diet. Sauries may have been too large a prey, causing digestive difficulties. The pelagic sauries may not constitute the usual diet for rhinoceros auklet chicks. During other investigations in the northwest Pacific, rhinoceros auklets have been mostly observed to feed on sandlance *Ammodytes hexapterus*, anchovies, smelt and herring.”

Keywords: *A. hexapterus*; British Columbia; importance; predators (birds, rhinoceros auklet).

Vermeer K. 1979. Nesting requirements food and breeding distribution of rhinoceros auklets *Cerorhinca monocerata* and tufted puffins *Lunda cirrhata*. Ardea. 67(3-4): 101-110.

“The nesting preferences, food habits of the young, and breeding populations of rhinoceros auklets and tufted puffins were determined at Triangle Island, British Columbia [Canada] in 1975 and 1976. Rhinoceros auklets and tufted puffins showed latitudinal differences in principal food items along the eastern Pacific, except for sandlance which

was important for both species at all localities. Rhinoceros auklet and tufted puffin principal prey on Triangle Island consisted of sandlance, Pacific sauries and rockfishes. Bluethroat argentines occurred in the diet of both birds only in 1978. Rhinoceros auklets fed more on Pacific sauries and tufted puffins on sandlance . Possible factors determing differences in rhinoceros auklet and tufted puffin breeding distributions were discussed. In the northeastern Pacific, tufted puffins were most numerous in Alaska [USA], but rhinoceros auklets breed mainly from southeastern Alaska to Washington. In British Columbia, tufted puffins occur mostly offshore, but rhinoceros auklets are numerous inshore and offshore. Distribution differences between the species can be explained by differences in nocturnal and diurnal behavior, different predation pressures and nesting flexibilities."

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds, rhinoceros auklet, tufted puffin).

Vermeer, K. 1980. The importance of timing and type of prey to reproductive success of rhinoceros auklets, *Cerorhinca monocerata*. Ibis. 122: 343-350.

Keywords: *A. hexapterus*; predators (birds, rhinoceros auklet).

Vermeer, K. 1982. Comparison of the diet of the glaucous-winged gull on the east and west coasts of Vancouver Island. Murrelet. 63: 80-85.

Keywords: *A. hexapterus*; British Columbia; Vancouver Island; predators (birds, glaucous-winged gull).

Vermeer, K. 1992. The diet of birds as a tool for monitoring the biological environment. In: Vermeer, K.; Briggs, K.T.; Morgan, K.H.; Douglas, S.C., eds. The status, ecology, and conservation of marine and shoreline birds on the west coast of Vancouver Island. Occas. Pap. Delta, BC: Canadian Wildlife Service. 75: 41-50.

Keywords: *A. hexapterus*; importance; predators (birds, glaucous-winged gull, marbled murrelet, Cassin's auklet, rhinoceros auklet, tufted puffin, pigeon guillemot, common murre).

Vermeer, K.; Cullen, L. 1979. Growth of rhinoceros auklets and tufted puffins. Triangle Island. British Columbia. Ardea. 67: 22-27.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds, rhinoceros auklet, tufted puffin).

Vermeer, K.; Cullen, L. 1982. Growth comparison of a plankton- and a fish-feeding alcid. Murrelet. 63: 34-39.

Keywords: *A. hexapterus*; British Columbia; predators (birds, rhinoceros auklet).

Vermeer K.; Cullen L.; Porter, M. 1979. A provisional explanation of the reproductive failure of tufted puffins *Lunda cirrhata* on Triangle Island, British Columbia. Ibis. 121(3): 348-354.

"Data for reproductive success, growth, and feeding activity in the tufted puffin colony of Triangle Island from 1975-1977 were used to investigate the near-total breeding failure in the 1976 season. This could not be ascribed to bad weather, for rhinoceros auklets *Cerorhinca monocerata* bred successfully during the same year. However, the latter species was observed to switch its main food species from sandlance to sauries, which tufted puffins appear unable to do. It is suggested that the breeding failure was due to a failure of the sandlance population, which also brought about a decline of murrelets, *Synthliboramphus antiquus*. The failure of sandlance may in turn be traced to abnormally low oceanic temperatures."

Keywords: *A. hexapterus*; Canada; British Columbia; importance; predators (birds, ancient murrelet, tufted puffin).

Vermeer, K.; Devito, K. 1986. Size, caloric content, and association of prey fishes in meals of nestling rhinoceros auklets. Murrelet. 67(1): 1-9.

"The relationship between size, caloric content, and association of prey fishes in meals that adult rhinoceros auklets (*Cerorhinca monocerata*) carry to their nestlings was studied on Pine and Triangle islands, British Columbia from 1977 to 1979. Rhinoceros auklets carried wide fishes widthwise in their bills and slender fishes by their height or

width. The number of fish carried per trip was inversely related to their size. The longest fishes made up the largest meals in biomass and provided most energy to the nestlings. Four large species, Pacific saury (*Cololabis saira*), second-year Pacific herring (*Clupea harengus*), second-year Pacific sandlance (*Ammodytes hexapterus*), and bluethroat argentine (*Nansenia candida*), were negatively associated with other prey fishes."

Keywords: *A. hexapterus*; British Columbia; energetics; predators (birds, rhinoceros auklet).

Vermeer, K.; Fulton, J.D.; Sealy, S.G. 1985. Differential use of zooplankton prey by ancient murrelets and Cassin's auklets in the Queen Charlotte Islands. Journal of Plankton Research. 7: 443-459.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds).

Vermeer, K.; Moira, M.J.F. 1986. Nesting habits and habitats of ancient murrelets and Cassin's auklets in the Queen Charlotte Islands, British Columbia. Murrelet. 67: 33-44.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds).

Vermeer, K.; Morgan, K.H.; Butler, R.W.; Smith, G.E.J. 1989. Population, nesting habitat and food of bald eagles in the Gulf Islands. In: Vermeer, K.; Butler, R.W., eds. The ecology and status of marine and shoreline birds in the Strait of Georgia, British Columbia. Spec. Publ. Ottawa, ON: Canadian Wildlife Service: 123-130.

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds, bald eagle).

Vermeer, K.; Sealy, S.G.; Sanger, G.A. 1987. Feeding ecology of Alcidae in the eastern north Pacific Ocean. In: Croxall, J.P., ed. Seabirds: feeding biology and role in marine ecosystems. Cambridge. United Kingdom: Cambridge University Press: 189-227.

"Alcids eat mostly fishes and/or zooplankton. Large and intermediate-sized alcids such as murres, puffins, guillemots and small *Brachyramphus* murrelets prey mostly on fish. Small alcids, with wide beaks and broad fleshy tongues such as least, crested, whiskered and Cassin's auklets in the North Pacific and the dovekie in the North Atlantic, prey mostly on zooplankton. Some small alcids such as the ancient murrelet and parakeet auklet forage on both fishes and zooplankton.

"Rhinoceros auklets have been observed to herd sand lance by diving beneath a school, apparently causing it to form a tight cohesive ball and then driving this to the surface. Rhinoceros auklets and tufted puffins catch a fish by either the tail or head but, as in murres, they always swallow fish head first. In the Gulf of Alaska Pacific sand lance made up 21% of their diet.

"Marbled murrelet: At Langara Island, the most important foods present in 75 adult and sub-adult murrelets were Pacific sand lance and *Thysanoessa spinifera* in April and May, and Pacific sand lance in June and July. In Barkley Sound, 43 breeding adults and 26 molting birds from late summer and fall, fed primarily on Pacific herring and Pacific sand lance In Kachemak Bay in April and May capelin, Pacific sand lance and euphausiids were important, while from June to August, Pacific sand lance predominated. In the Gulf of Alaska from various locations Pacific sand lance were most important and made up 28% by volume followed by capelin at 27%.

"Carter (1984) observed 144 fish in the bills of marbled murrelets during the breeding season in Barkley Sound, which may have been carried to nestlings. Of those fish, 49% were Pacific sand lance. In summary the diet of adult marbled murrelets consisted mostly of capelin and Pacific sand lance in Alaska, and of Pacific sand lance and Pacific herring in British Columbia.

"The food of 16 Kittlitz's murrelets from the Bering Sea in spring and the Kodiak Island area in summer, consisted (by volume) of fish (70%) mostly unidentified but included capelin, Pacific sand lance and Pacific herring.

“Ancient murrelet: Sealy 1975, analysed the diets of 46 adults and 22 sub-adults near Langara Island during nesting and found that they had fed mainly on *Euphausia pacifica* and *Thysanoessa spinifera* from early April to late May, but mostly Pacific sand lance thereafter.

“Size of Pacific sand lance in mm (fork length) sample size in parenthesis= rhinoceros auklet: Pacific sand lance in 1st year 81 (4692), 35 to 105; 2nd yr and older 130 (1353) 105-185. Tufted puffin: 1st year 85 (80), 65-105; 2nd yr and older 135 (32), 105-175. Cassin’s auklet: Pacific sand lance 1st yr = 40.0 (5). 35.0-45.0.”

Keywords: *A. hexapterus*; Alaska; British Columbia; importance; predators (birds, rhinoceros auklet, tufted puffin, marbled murrelet, Kittlitz’s murrelet, ancient murrelet, Cassin’s auklet).

Vermeer, K.; Westrheim, S.J. 1984. Fish changes in diets of nestling rhinoceros auklets and their implications. In: Nettleship, D.N.; Sanger, G.A.; Springer, P.F. eds. Marine birds: their feeding ecology and commercial fisheries relationships. Ottawa, ON: Canadian Wildlife Service: 96-105.

“The diet of nestling rhinoceros auklets (*Cerorhinca monocerata*) was investigated on offshore Triangle Island (1976-79) and on inshore Pine Island (1977-80) and Lucy Island (1979-80), British Columbia. Variations in the diet occurred between years and within each summer. The annual variations include the early predominance of Pacific sauries (*Cololabis saira*) in 1976, fluctuations in abundance of age groups of Pacific sandlance (*Ammodytes hexapterus*) and Pacific herring (*Clupea harengus*), a change in rockfish (*Sebastes*) species, and the appearance of bathypelagic bluethroat argentines (*Nansenia candida*) in 1978. In a given summer sandlance and rockfish predominated in July, and herring and seuries in August. Changes in age and size of sandlance species, composition of rockfish, and occurrence of sauries and bluethroat argentines at Triangle and Pine Islands were synchronized over the years.”

Keywords: *A. hexapterus*; Canada; British Columbia; predators (birds, rhinoceros auklet).

Vermeer, K.; Ydenberg, R.C. 1989. Feeding ecology of marine birds in the Strait of Georgia. In: Vermeer, K.; Butler, R.W., eds. The ecology and status of marine and shoreline birds in the Strait of Georgia, British Columbia. Spec. Publ. Ottawa, ON: Canadan Wildlife Service: 62-72.

Keywords: *A. hexapterus*; British Columbia; Strait of Georgia; importance; predators (birds).

Vesin, J.-P.; Leggett, W.C.; Able, K.W. 1981. Feeding ecology of capelin *Mallotus villosus* in the estuary and western Gulf of St. Lawrence and its multispecies implications. Canadian Journal of Fisheries and Aquatic Science. 38: 257-267.

Keywords: *Ammodytes*; Gulf of Saint Lawrence; food and feeding habits.

Vitturi, R.; Zava, B.; Catalano, E. [and others]. 1988. Karyotypes in five Mediterranean fishes. Biologisches Zentralblatt. 107(3): 339-344.

Keywords: *A. cicerellus*; Mediterranean Sea; genetics; karyotype.

Vladykov, V.D. 1933. Biological and oceanographic conditions in Hudson Bay region (except the Coregoniidae). Contributions to Canadian Biology. 8(2): 13-61.

Keywords: *Ammodytes*; Hudson Bay; abundance; distribution.

Vliet, G. van. 1993. Status concerns for the “global” population of Kittlitz’s murrelet: Is the “glacier murrelet” receding? Pacific Seabird Group Bulletin. 20(1): 15-16.

Keywords: *A. hexapterus*; Alaska; predators (birds, Kittlitz’s murrelet).

Wada, K.; Hamanaka, T.; Nakaoka, T.; Tanahashi, K. 1992. Food and feeding habits of Kuril and Largha seals in southeastern Hokkaido. Mammalia. 56(4): 555-566.

“Stomach contents of Kuril and Largha seals netted in the autumn salmon trapnet fishery along the Nemuro Peninsula [Japan] during September and December were examined. Six food items were common in both seal species. Kuril seals mainly took inshore, benthic and rocky reef-living fishes such as Cottidae, Stichaenidae and *Sebastes* sp., and the cephalopod *Paractopus hongkongensis*. Largha seals fed on various types of fishes from pelagic fish such as *Cololabis sair*a, and *Sardinopus melanosticus* to benthic fish such as *Ammodytes personatus*, *Hypomesus pretiosus japonicus* and *Osmerus eperlaus mordax*. Body length and age of the prey species *Eleginus gracilis* were estimated from measurement of otolith found in the seal stomachs. Both species of seals took 1-year-old and 2-year-old fishes by different degrees. Both seals took octopus principally less than 2-year-old as determined by prey body weight measurement. From these observations it is concluded that Kuril seals are not so euryphagous as Largha seals and there is a difference of foraging habitat preference between the two species.”

Keywords: *A. personatus*; Japan; predators (mammals, Largha seal).

Waind, K.D.; Reay, P.J. 1971. Notes of biological aspects of the Irish sandeel fishery 1971. Bord Iascaigh Mhara, Resource Development Paper (December 1971).

Keywords: *Ammodytes*; Ireland; fisheries.

Waldron, K.D.; Vinter, B.M. 1978. Ichthyoplankton of the eastern Bering Sea. Seattle, WA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, OCSEAP; NWAFC final report. 88 p.

Keywords: *A. hexapterus*; Bering Sea; distribution; larvae.

Walsh, J.J.; Mcroy, C.P. 1986. Ecosystem analysis in the southeastern Bering Sea. Continental Shelf Research. 5(1-2): 259-288.

Keywords: *A. hexapterus*; Bering Sea; trophic interactions.

Walters, V. 1955. Fishes of western Arctic America and eastern Arctic Siberia: taxonomy and zoogeography—Ammodytidae. Bulletin of the American Museum of Natural History. 106(5): 311.

Keywords: Ammodytidae; taxonomy; zoogeography.

Wanless, S. 1984. The growth and food of young gannets (*Sula bassana*) on Ailsa Craig. Seabird. 7: 62-70.

“The growth and food of young gannets (*Sula bassana*) was studied on Ailsa Craig between 1974 and 1976. Additional data on food are available for 1979-83. Young gannets had a mean weight of 193 g on Day 4-6 and their increase in weight was linear until Day 56. They reached adult weight c. Day 40 and maximum weight between 67 and 75. Mean weight at leaving (of captive young) was 3850 g. Artificial twins survived less well spent longer in the nest and showed retarded weight increase compared to single young, but pairs with twins still reared more young than normal pairs. Mackerel formed the bulk of the diet in 1975, 1976 and 1979-82 but in 1983 sandeels were the dominant species. The growth rate between Day 37 to 59 of a captive young receiving limited food was similar to that of the chick on an unlimited diet. The latter apparently did not utilise all the food it consumed. Wild gannets received an average of 1.2 feeds/day and a maximum daily intake of 60 g which contained 2.2 KJ to 5.7 KJ of energy depending on whether pollock or mackerel was fed.”

Keywords: *Ammodytes*; Atlantic (northeast); predators (birds, gannet).

Wanless, S. 1987. A survey of the numbers and breeding distribution of the North Atlantic gannet *Sula bassana* and an assessment of the changes which have occurred since Operation Seafarer 1969/70. Research and Survey in Nature Conservation 4. Peterborough, [Country unknown]: Nature Conservancy Council.

Keywords: *Ammodytes*; predators (birds, gannet).

Wanless, S.; Corfield, T.; Harris, M.P. [and others]. 1993. Diving behaviour of the shag *Phalacrocorax aristotelis* (Aves: Pelecaniformes) in relation to water depth and prey size. Journal of Zoology. 231: 11-25.

“The durations of more than 4000 dives and recovery periods on the surface of 31 shags, *Phalacrocorax aristotelis*, were recorded using radio-telemetry, during three breeding seasons. Data were also collected on the depth of water where the birds were diving and the size of lesser sandeels, *Ammodytes marinus*, fed to young each year. On average, shags foraged in water 30 m deep; mean dive and recovery times were 62.0 ± 1.92 sec and 84.4 ± 5.02 sec, respectively. These times were much longer than those recorded in previous studies and also longer than those predicted from allometric relationships for dive and recovery times derived for cormorants. A large proportion (> 50%) of dives appeared to involve anaerobic metabolism. Dive and recovery times were examined in relation to water depth, time of day and position within the diving sequence (dive number). In each year, dive time was positively correlated with water depth; in 1987 dive number also had a negative effect. The relationship between recovery time and dive time was positively accelerated, suggesting that birds were diving anaerobically on longer dives. The percentage of the dive cycle spent underwater therefore decreased significantly as dive time and water depth increased. Average vertical rates of ascent and descent of shags were calculated to be between 1.46-1.87 m sec^{-1}. Estimated prey capture rates were significantly higher in 1989 (average 6.8 fish $dive^{-1}$) when adults were feeding their young on small, low energy value sandeels than the two previous years (averages 14 and 1.9 fish $dive^{-1}$, respectively) when birds were feeding on larger, higher quality fish. We calculated that, on average, birds spent 8-10 sec (36-48%) longer on the bottom at any given depth in 1989, which suggested that the higher prey capture rates were associated with an increase in duration of the bottom phase of the dive.”

Keywords: *A. marinus*; predators (birds, shag).

Wanless, S.; Harris, M.P. 1989. Kittiwake attendance patterns during chick rearing on the Isle of May. Scottish Birds. 15: 156-161.

Keywords: *Ammodytes*; Isle of May; predators (birds, kittiwake).

Wanless, S.; Harris, M.P. 1992. Activity budgets, diets, and breeding success of kittiwakes *Rissa tridactyla* on the Isle of May. Bird Study. 39: 145-154.

“We collected data on activity patterns (brood attendance, durations of feeding trips and feeding rates) of parent kittiwakes *Rissa tridactyla* and the food fed to chicks in 2 breeding seasons at the same colony. In 1989, trip duration increased markedly towards the end of the nestling period. Pairs attempted to increase the feeding rate of their young by both adults foraging simultaneously rather than alternately. This response was more pronounced in pairs with two chicks (b/2s), i.e. those with greater food requirements. Estimates of the energy value of food delivered by the pair to the brood suggested that, particularly for b/2s at the end of the season, amounts were insufficient to meet the chicks’ requirements. However, despite this shortfall most chicks survived to fledging. In 1990, kittiwakes fed their young on smaller sandeels *Ammodytes* spp. which had a lower energy density than those in 1989. Feeding rates were also low. We estimated that for most of the chick rearing period energy intakes for the young were below those required. Breeding success was only 0.17 chicks fledged/completed nest, the lowest value for at least 10 years.”

Keywords: *Ammodytes*; energetics; predators (birds, kittiwakes).

Wanless, S.; Harris, M.P.; Morris, J.A. 1991. Foraging range and feeding locations of shags *Phalacrocorax aristotelis* during chick rearing. Ibis. 133: 30-36.

“Presumably these year-to-year changes reflect differences in the availability of sandeels *Ammodytes* spp. which were the predominant prey item recorded in regurgitations from chicks prior to and during the study.

“Shags were highly selective in their feeding habitat, using <11% of the area potentially available to them. Feeding sites were mainly in water between 21 and 40 m deep, where the seabed was composed of sand, gravel or rock with a thin patchy sediment cover. These preferences accorded well with the habitat requirements of sandeels.”

Keywords: *Ammodytes*; Scotland; Isle of May; importance; predators (birds, shag).

Wanless, S.; Harris, M.P.; Russell, A.F. 1993. Factors influencing food-load sizes brought in by shags *Phalacrocorax aristotelis* during chick rearing. Ibis. 135(1): 19-24.

“Weights of food loads brought back to the colony by 26 shags *Phalacrocorax aristotelis* rearing chicks were determined using the water-offloading procedure. Loads consisted almost entirely of lesser sandeels *Ammodytes marinus*. Load size was extremely variable, ranging from 8 to 208 g with a mean load weight of 106 g. Data on foraging behavior collected concurrently demonstrated that shags brought back heavier loads when they were feeding farther away from the colony and when brood biomass was larger. These two variables together explained 70.3% of the variation in load size. We postulate that adults had already digested their own food requirements by the time they arrived back at the nest, and the contents of the loads were therefore primarily for the young. On 67% of trips, shags caught, on average, more than one fish per dive. This estimate ignores the food requirements of the adult, and therefore true prey-capture rates must have been higher.”

Keywords: *A. marinus*; Scotland; Isle of May; importance; predators (birds, shag).

Wanless, S.; Monaghan, P.; Uttley, J.D. [and others]. 1992. A radio-tracking study of kittiwakes (*Rissa tridactyla*) foraging under sub-optimal conditions. In: Priede, G.; Swift, M., eds. Wildlife telemetry. Ellis Harwood. UK: 581-590. [City unknown], United Kingdom: Ellis Harwood: 581-590.

Keywords: *Ammodytes*; predators (birds, kittiwake).

Warburton, K. 1982. Sandeels—the elusive species. Scottish Fisheries Bulletin. 47: 22-27.

“The rapidly expanding Shetland fishery for the lesser sandeel (*Ammodytes marinus*) should expand further in relation to fish plant processing capacity at Bressay. To assist fishery management, statistics on catch, fishing effort and population age composition are necessary. Biology of the species renders accurate stock assessment difficult: exploitation and knowledge are restricted through the sandeel’s burrowing and apparently static habits, through the presence of interspersed rocky bottoms, and through non-sampling of populations outside the exploited areas. Currents and sea bottom conditions affect the sandeel’s oxygen supply, geographical distribution, food availability and growth rate. There is a 3-4 month time-lag between spawning and hatching. Shetland sandeels have a slower growth rate than the rest of the North Sea.”

Keywords: *A. marinus*; Shetland; age; catch; fisheries; length-weight relationships.

Ward, J.G. 1973. Reproductive success, food supply, and the evolution of clutch-size in the glaucous-winged gull. Vancouver, BC: University of British Columbia. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (birds, glaucous-winged gull).

Ware, D. 1992. Joint Canada-Japan fisheries oceanography workshop. Fisheries Oceanography. 1(1): 108-110.

“Other presentations showed that interannual variations in water transport were probably important in controlling year-class strength in the Japanese sardine, Pacific and Atlantic cod, and Japanese sand lance. ‘Top-down’ processes, which act by modifying significant changes in predator-prey relationships (including the role of piscivorous fish, squid, and jellyfish), were also seen to be important in affecting the survival of many species.”

Keywords: *A. personatus*; Japan; fisheries; population dynamics.

Warner, I.M. 1981. Forage fish spawning surveys–southern Bering Sea. Environmental assessment of the Alaskan Continental Shelf: final reports of the principal investigators. [Place of publication unknown]: [publisher unknown]; 10: 1-64.

“Forage fish research in the Bering Sea was initiated in fiscal year 1976 and field work which began in May and continued until October consisted of aerial and ground truth investigations. In the spring of 1977 the present study was funded for the purpose of complementing the large bank of forage fish data accrued in 1976. This study considered

forage fish to be herring and sand lance or any form of the smelt family. The original purpose of the research was to study the nearshore spawning stocks of forage fish along the east coast of the Bering Sea in respect to relative abundance, spatial distribution, and basic life history facts concerning age and sexual maturity. It is known that surface borne pollutants are toxic to some species of forage fish. Although it is not presently known how certain crude oils would affect forage fishes in the Bering Sea, it is important to have an understanding of the temporal and spatial distribution and abundance of forage fish."

Keywords: *A. hexapterus*; Alaska; Bering Sea; abundance; distribution.

Warner, I.M.; Dick, M.H. 1981. A survey for spawning forage fish on the east side of the Kodiak archipelago by air and boat during spring and summer 1979. In: Environmental assessment of the Alaskan Continental Shelf, annual reports of principal investigators. Boulder, CO: National Oceanic and Atmospheric Administration, Environmental Research Laboratory.

Keywords: *A. hexapterus*; Alaska; Kodiak Island; abundance; distribution; spawning.

Warner, I.M.; Shafford, P. 1979. Forage fish spawning surveys—southern Bering Sea. Kodiak, AK: Alaska Department of Fish and Game; Project completion report; Alaska marine environmental assessment project. 33 p.

Keywords: *A. hexapterus*; Alaska; Bering Sea; abundance; distribution; spawning.

Warnes, S.; Jones, B.W. 1995. Species distributions from English Celtic Sea groundfish surveys, 1984 to 1991. Fisheries Research Technical Report Minister of Agriculture Fisheries Food (Lowestoft). 98: 42.

Keywords: *Ammodytes*; Atlantic (northeast); distribution.

Warzocha, J. 1988. Feeding of mackerel *Scomber scombrus* and herring *Clupea harengus* on the shelf of the northwest Atlantic. Biuletyn Morskieji Instytutu Ryback. 19: 12-18.

"The findings are presented of a study conducted in 1984 investigating the feeding behaviour of mackerel (*Scomber scombrus*) and herring (*Clupea harengus*) in the northwest Atlantic. The stomach contents of some 349 mackerels and 270 herrings were analyzed[;] the food compositions of various length groups are shown. Results indicate a predominance of planktonic organisms in the diets of these 2 fish species, and emphasise the importance of the sand lance (*Ammodytes*)."

Keywords: *Ammodytes*; importance; predators (fish, herring, mackerel).

Watanuki, Y. 1987. Breeding biology and foods of rhinoceros auklets on Teuri Island, Japan. In: Proceedings of 9th symposium on polar biology; 1986 Dec. 3-5; Tokyo. National Institute of Polar Research, Tokyo; (1): 175-183.

"Major food items brought to chicks by parents consisted of small pelagic fishes such as Japan Sea greenling, *Pleurogrammus aqonus*, sandlance, *Ammodytes personatus*, sardine, *Sardinops melanosticta*, Pacific saury, *Cololabis saira*, and Pacific herring, *Clupea pallasi*."

Keywords: *A. personatus*; Japan; predators (birds, rhinoceros auklet).

Watanuki, Y. 1988. Regional difference in the diet of slaty-backed gulls breeding around Hokkaido, Japan. Journal of the Yamashina Institute for Ornithology. 20(2): 71-81.

"Regional difference in the diet of slaty-backed gulls, *Larus schistisagus* was studied at the colonies around Hokkaido, Japan. They fed their chicks with sardines *Sardinops melanosticta*, rock fish *Sebastes* spp., and seabird chicks on Teuri Island, sardines on Daikoku Island and sardines and sandlances *Ammodytes* sp. on Yururi Island.

Keywords: *Ammodytes*; Japan; predators (birds, slaty-backed gull).

Webb, P.W.; Weihs, D. 1986. Functional locomotor morphology of early life-history stages of fishes. Transactions of the American Fisheries Society. 115(1): 115-127.

Keywords: *Ammodytes*; larvae; morphology.

Weber, W.; Ehrich, S.; Dahm, K.E. 1990. Influencing the North Sea ecosystem by fishing. In: Lozan, J.L.E.A., ed. Warnsignale aus der Nordsee: Warning signals from the North Sea. Berlin, Germany: Verlag Paul Parey: 252-267.

Keywords: *Ammodytes*; North Sea; ecosystem; fisheries.

Wehle, D.H.S. 1976. Summer foods and fledgling ecology of horned and tufted puffins on Buldir Island, Alaska—1975. Fairbanks, AK: University of Alaska. M.S. thesis.

Keywords: *A. hexapterus*; Alaska; predators (horned puffin, tufted puffin).

Wehle, D.H.S. 1978. Studies of marine birds on Ugaiushak Island. In: Environmental assessment of the Alaskan Continental Shelf, annual reports of principal investigators for the year ending March 1978: Receptors—birds. [Place of publication unknown]: National Oceanic and Atmospheric Administration. 3.

"Glaucous-winged gull—numerous regurgitated samples of food brought by adults to the young were examined from 8 July to 28 August. The predominant food item was Pacific sand lance which typically measured 5-10 cm in length. A single load of these fish brought in to young was typically composed of 20-40 individual fish. Adult birds continued to feed chicks fish of similar size throughout the nestling period. Although other fish species were occasionally observed, there was do doubt that Pacific sand lance were the most important source of food for gull chicks throughout the nestling period. Large schools of sand lance were observed in close proximity (within 3 km) to Ugaiushak Island during the month of August, and it was assumed that glaucous-winged gull adults confined their feeding effort to the waters immediately surrounding the island.

"Black-legged kittiwakes—feeding flocks of kittiwakes ranging from 50 to several hundred birds were observed within 3 km of Ugaiushak Island throughout the field season. During April, May, and June foraging flocks were concentrated at a greater distance from the island than during July and August. Large surface schools of *Ammodytes* and *Mallotus* were abundant in July and August within several hundred meters of the shore. During the first half of the nestling period, *Ammodytes* remained the most frequently observed food item. It appeared that the diet of small chicks was limited to *Ammodytes.* As chicks grew and were able to ingest larger fish, *Theragra* and *Mallotus* became more important parts of their diet.

"Horned puffin—No quantitative data on the food brought to nestlings by adults was obtained. However, Pacific sand lance was the most commonly noted prey species. Typical specimens measured 6-10 cm in length. Tufted puffin—of 350 individual food items brought to chicks sand lance comprised 287. Sand lance were present in 41 of 64 loads and were the only species represented in 33 samples in which an average of 8.0 fish were carried per load.... Of 124 sand lance measured from bill loads they ranged in length from 6.0 cm to 11.7 cm and averaged 7.9 cm. They weighed (n=27) an average of 1.6 grams."

Keywords: *A. hexapterus*; Alaska; importance; predators (birds, glaucous-winged gull, black-legged kittiwake, horned puffin, tufted puffin).

Wehle, D.H.S. 1980. The breeding biology of the puffins: tufted puffin (*Lunda cirrhata*), horned puffin (*Fratercula corniculata*), common puffin (*F. arctica*), and rhinoceros auklet (*Cerorhinca monocerata*). Fairbanks, AK: University of Alaska. Ph.D. dissertation.

Keywords: *Ammodytes*; predators (horned puffin, tufted puffin, puffin, rhinoceros auklet).

Wehle, D.H.S. 1982. Food of adult and subadult tufted and horned puffins. Murrelet. 63: 51-58.

Keywords: *A. hexapterus*; predators (horned puffin, tufted puffin).

Wehle, D.H.S. 1983. The food, feeding, and development of young tufted and horned puffins in Alaska. Condor. 85: 426-442.

Puffins capture prey by pursuit diving and feed whole prey to their semiprecocial young for 6 to 7 weeks. In food loads of tufted puffins on Ugaiushak in 1976 and 1977, sand lance comprised over 80 percent of all prey items. In food loads of horned puffins on Ugaiushak, sand lance appeared to be the most numerous prey in both years. Most sand lance in puffin bill loads were probably age classes 0 and 1 fish, with few fish in age class 2. Most had a median length of 61 to 82 millimeters.

Coupled with the need for a similar study in Alaska is the need for greater knowledge of the life histories of puffin prey species in Alaska waters. With the exception of the commercially exploited gadids, life history parameters of puffin prey are poorly understood.

Concluded that Pacific sand lance and capelin are the most important prey species for nestling tufted and horned puffins in Alaska. More information is needed on the life histories of these fish in Alaska waters and on the relations among certain aspects of their life histories; i.e., age, size, seasonal movements, and predation by puffins and other seabirds. A table summarizes data for feeding ecology of nestling tufted and horned puffins.

Keywords: *A. hexapterus*; Alaska; importance; predators (birds, tufted puffin, horned puffin).

Wei, S.; Weimin, J. 1992. Study on food web of fishes in the Yellow Sea. Oceanol. Limnol. Sin. 23(2): 182-192.

“Organisms such as *Engraulis japonica*, *Crangon affinis*, *Ammodytes personatus*, *Euphausia pacifica* etc. are almost exploited by all the carnivorous fishes. They are the key link for the middle and high carnivorous fishes with plankton playing a very important role in food web of fishes.”

Keywords: *A. personatus*; Yellow Sea; ecosytem; predators (fish); trophic relationships.

Weinrich, M.T.; Schilling, M.R.; Belt, C.R. 1992. Evidence for acquisition of a novel feeding behaviour lobtail feeding in humpback whales *Megaptera novaeangliae*. Animal Behaviour. 44(6): 1059-1072.

“The spread of an apparently normal surface feeding behavior (bubble feeding), which is proceeded by a tail slap, or lobtail (called lobtail feeding), was observed in individually identified humpback whales, *Megaptera novaeangliae*, feeding on sand lance, *Ammodytes americanus*, in New England waters during 1980-1989. The proportion of feeding events classified as lobtail feeding was consistent for each individual throughout the entire period that each whale was observed. Ninety-five of the 250 whales observed surface feeding used lobtail feeding. The percentage of animals lobtail feeding increased regularly from 0.0% in 1980 to 50.6% in 1989. Over 50% of whales first seen as calves, and later documented surface feeding, displayed lobtail feeding, although few of their mothers ever employed this behavior. Among animals that were first photographed before 1982 only 12.5% were ever seen lobtail feeding. In contrast, 56.2% of animals first photographed after 1982 used the behavior. No animal was seen to use lobtail feeding before it was 2 years old, although individuals are weaned and separated from their mothers at 1 year. Rudimentary lobtail feeding was witnessed several times among young post-weaning animals. No difference was seen in the frequency of lobtail feeding between sexes. It is hypothesized that this behavior was initiated as whales switched from feeding on herring to sand lance, and has spread through cultural transmission.”

Keywords: *A. americanus*; New England; predators (mammals, humpback whale).

Weins, J.S.; Heinemann, D.; Hoffman, W. 1978. Community structure, distribution and inter-relationships of marine birds in the Gulf of Alaska. In: Final reports of principal investigators. Boulder, CO: National Oceanographic and Atmospheric Administration. 3.

Keywords: *A. hexapterus*; Gulf of Alaska; predators (birds).

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. In: Forage fishes of the southeastern Bering Sea: Conference proceedings, OCS study; [dates of meeting unknown]; [location unknown]. [Place of publication unknown]: Mineral Management Service: 55-60.

“In the eastern Bering Sea the principal small pelagic species are walleye pollock, Pacific herring, capelin, Pacific sand lance, and rainbow smelt. Pacific sand lance are not exploited in the Bering Sea, but they are fished in other areas. Pacific sand lance in the Bering Sea have been found to occur in depths from shore to 100 m, but their greatest abundance is at depths inside of 50 m. They may be abundant along the Alaska Peninsula since they have been found to comprise 5 to 39% of the food of juvenile sockeye salmon and coho salmon leaving Bristol Bay. Pacific sand lance has also been found to be a major food of northern fur seals in the Unimak Pass area.”

Keywords: *A. hexapterus*, Bering Sea, distribution, importance, predators.

Westin, D.T.; Abernethy, K.J.; Meller, L.E.; Rogers, B.A. 1979. Some aspects of biology of the American sand lance, *Ammodytes americanus*. Transactions of the American Fisheries Society. 108: 328-331.

The length-weight relation for *Ammodytes americanus*, sampled from the New England coast, was determined and compared to the relations for five other sand lance species avialable from the literature. Postspawning *A. americanus* females weighed up to 45 percent less than prespawning females of the same length. Ovarian egg diameters were unimodal, which suggests once-a-year spawning for this species.

There are seven North Atlantic species of sand lance: *Ammodytes tobianus, A. dubius, A. marinus, A. americanus, Hyperoplus lanceolatus, H. immaculatus,* and *Gymnammodytes semisquamatus*. The latter three are restricted to European waters.

The data presented here for *Ammodytes americanus* are similar to those reported for its congeners. Age at first maturity appears to be 1 to 2 years, as is reported elsewhere for *A. marinus*. Spawning occurs once a year for *A. americanus*, probably at some time between December and March. *Ammodytes marinus* and *A. dubius* have been reported to be once-a-year spawners (winter-spring), and *A. tobianus* spawns during both autumn and spring. Some *A. tobianus* that spawned in autumn reached sexual maturity within the first year of life.

Keywords: *A. americanus*; Atlantic; New England; fecundity; length-weight; spawning.

Westrheim, S.J. 1977. Length-weight and length-girth relationships, maturity, spawning season and diet of Pacific cod (*Gadus macrocephalus*) collected in British Columbia waters during April 1975-February 1976. Fisheries Research Board of Canada, Manuscript Report Series. (1420): 1-70.

“Based on percentage incidence, principal invertebrate types were euphausids, pink shrimp, (*Pandalus*), brown shrimp (*Crangon*), and crab (*Emerita*) and principal fish types were sandlance (*Ammodytes*), and herring (*Clupea*). Relationship of stomach-content weight to fork length varied with fork length, area, and season. Stomachs of large (old) cod were mostly empty during February.”

Keywords: *A. hexapterus*; British Columbia; importance; predators (fish, Pacific cod).

Westrheim, S.J.; Harling, W.R. 1983. Principal prey species and periodicity of their incidence in stomachs of trawl-caught Pacific cod (*Gadus macrocephalus*), rock sole (*Lepidopsetta bilineata*), and petrale sole (*Eopsetta jordani*) landed in British Columbia 1950-1980. Canadian Manuscript Report, Fisheries and Aquatic Sciences. 1691: 1-38.

“Prey incidence was compiled from port liaison officers’ notes recorded while collecting length-frequency samples of Pacific cod (*Gadus macrocephalus*), rock sole (*Lepidopsetta bilineata*), and petrale sole (*Eopsetta jordani*) in trawl landings originating from three major offshore regions of British Columbia during 1950-80. Principal prey species were sandlance (*Ammodytes hexapterus*), herring (*Clupea harengus pallasi*), “shrimp” (assorted Crustacea) and

sablefish (*Anoplopoma fimbria*), the latter only in Pacific cod stomachs. Sandlance was an important prey species for all three predator species and in all three offshore regions. Incidence periodicity was demonstrated for sandlance ... herring off the west coast of Vancouver Island... and sablefish in Hecate Strait...."

Keywords: *A. hexapterus*; Canada; British Columbia; importance; predators (fish, Pacific cod, petrale sole, rock sole).

Wharfe, J.R.; Wilson, S.R.; Dines, R.A. 1984. Observations on the fish populations of an east coast estuary. Marine Pollution Bulletin. 15(4): 133-136.

Keywords: *A. lanceolatus*; Atlantic (northeast); abundance; distribution.

Wheatland, S.B. 1956. Oceanography of Long Island Sound, 1952-1954. VII: Pelagic fish eggs and larvae. Bulletin of the Bingham Oceanographic Collection. 15: 234-314.

Keywords: *Ammodytes*; Long Island Sound; abundance; distribution; eggs; larvae.

Wheeler, A. 1985. The Linnaean fish collection in the Linnaean Society of London. Zoological Journal of the Linnean Society. 84(1): 1-76.

Keywords: *Ammodytes*; taxonomy.

Wheeler, A. 1994. Field key to the shore fishes of the British Isles. Field Studies. 8(3): 481-521.

Keywords: *Ammodytes*; British Isles; taxonomy.

Wheeler, A.C. 1969. The fishes of the British Isles and north west Europe. London: Macmillan. 613 p.

Keywords: *Ammodytes*; British Isles.

White, A.W. 1981. Sensitivity of marine fishes to toxins from the red tide dinoflagellate *Gonyaulax excavata* and implications for fish kills. Marine Biology (Berlin). 65(3): 255-260.

"Marine fishes (Atlantic herring, American pollock, winter flounder, Atlantic salmon, and cod) were dosed orally and i.p. with paralytic shellfish toxins extracted from Bay of Fundy *G. excavata* (*G. tamarensis*) cells. The toxins are lethal to these fishes in low oral doses, and in extremely low i.p. doses. Symptoms are the same among these fishes, both for oral and i.p. administration including loss of equilibrium within 5-15 min, followed by immobilization and shallow arrhythmic breathing. Death generally occurs within 20-60 min of toxin administration. Dose responses are also similar among these fishes. Oral LD50 values are 400-750 µg saxitoxin (STX) equivalent kg^{-1} body weight. Intraperitoneal LD50 values are 4-12 µg STX equivalent kg^{-1} body weight. Intraperitoneal LD50 values are 4-12 µg STX equivalent kg^{-1}. Toxins are undetectable in fish muscle tissue following lethal oral doses. The similarity of symptoms and dose responses suggests that fish as a group are sensitive to *G. excavata* toxins. Results in combination with reports implicating these toxins in herring, sand lance and menhaden kills, show that the nearly worldwide blooms and red tides of *G. excavata* and its relatives may cause kills of a variety of fishes."

Keywords: *Ammodytes*; mortality; plankton bloom; toxicity.

White, C.M.; Emison, W.B.; Williamson, F.S.L. 1973. DDE in a resident Aleutian island peregrine population. Condor. 75: 306-311.

Keywords: *A. hexapterus*; Alaska; Aleutian islands; predators (birds, peregrine falcon).

Wiborg, K.F.; Bjorke, H. 1968. The distribution of copepods mainly *Calanus finmarchicus* at the coast and in some fjords south of Bergen in May-June 1968 and the possibilities to utilize zooplankton commercially. Fisken og Havet. 3: 11-15.

Keywords: *Ammodytes*; Atlantic (northeast); food and feeding habits.

Wiens, J.A. 1984. Modeling the energy requirements of seabird populations. In: Whittow, G.C.; Rahn, H., eds. Seabird energetics. New York: Plenum: 255-284.

Keywords: *Ammodytes*; predators (birds).

Wiens, J.A.; Hoffman, W.; Heinemann, D. 1977. Community structure, distribution, and interrelationships of marine birds in the Gulf of Alaska. In: Environmental assessment of the Alaskan Continental Shelf: receptors—birds. Boulder, CO. National Oceanic and Atmospheric Administration, Environmental Research Laboratories. 2: 383-401.

"Maps provide preliminary analyses of the distribution of the principal pelagic species of the Northeastern Gulf of Alaska study area. It is shown that feeding flocks occur wherever schools of forage fishes or invertebrates (usually euphausids) appear on the surface in the presence of the appropriate bird species. These flocks are nearly always located in shallow nearshore areas. In the Gulf of Alaska and eastern Aleutians the fish species most frequently involved are sandlance, herring, and capelin and other smelt. The flocks are commonest in protected areas such as bays inlets and fjords, and in areas of bathymetric turbulence. Bird flocks form over the fish schools, and while the fish schools are deeper below the surface, the birds frequently rest on the water in the convergence areas. Certain rip areas may apparently be used daily by the birds for periods of several months. The convergences are also characterized by collection and concentration of floating debris. Thus they are potentially areas of concentration for floating oil, and may form major hazards to the birds and their prey by concentrating the oil in favoured feeding spots."

Keywords: *A. hexapterus*; Gulf of Alaska; predators (birds).

Wilimovsky, N.J. 1964. Inshore fish fauna of the Aleutian archipelago. In: Proceedings of the 14th Alaska science conference; [dates of meeting unknown]; [location unknown]. [Place of publicatin unknown]: [publisher unknown]: 172-190.

Keywords: *A. hexapterus*; Alaska; Aleutian islands.

Wilimovsky, N.J. 1974. Fishes of the Bering Sea: the state of existing knowledge and requirements for future effective effort. In: Hood, D.W.; Kelley, E.J., eds. Oceanography of the Bering Sea. Occas. Publ. 2. Fairbanks, AK: University of Alaska, Institute of Marine Science: 143-156.

Keywords: *A. hexapterus*; Alaska; Bering Sea.

Wilimovsky, N.J.; Incze, L.S.; Westrheim, S.J. 1988. Species synopses: life histories of selected fish and shellfish of the northeast Pacific and Bering Sea. Seattle: University of Washington, Washington Sea Grant Program and Fisheries Research Institute: 1-111.

"This collection of seven papers covers the life histories of northern pink shrimp, Pacific sand lance, Pacific herring, walleye pollock, market squid and Pacific halibut in the Gulf of Alaska, the North Pacific and the Bering Sea, including literature surveys and bibliographies." [Also see Field 1988.]

Keywords: *A. hexapterus*; life history.

Wilke, F. 1957. Food of sea otters and harbor seals at Amchitka Island. Journal of Wildlife Managment. 21: 241-142.

Keywords: *A. hexapterus*; Alaska; Amchitka Island; predators (mammals, harbor seal).

Wilke, F.; Kenyon, K.W. 1952. Notes on the food of fur seal, sea lion and harbor porpoise. Journal of Wildlife Managment. 16: 396-397.

One sand lance (*Ammodytes tobianus personatus*) was found in the stomachs of each of 114 mammals that had food in those stomachs.

Keywords: *A. tobianus personatus*; predators (mammals, fur seal).

Wilke, F.; Kenyon, K.W. 1957. The food of fur seals in the eastern Bering Sea. Journal of Wildlife Management. 21(2): 237-238.

Keywords: *A. hexapterus*; Bering Sea; predators (mammals, fur seal).

Wilke, F.; Niggol, K.; Fiscus, C.H. 1958. Pelagic fur seal investigations—California, Oregon, Washington and Alaska. Seattle, WA: U.S. Fish and Wildlife Service, Marine Mammal Research. 96 p. Unpublished report. On file with: National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Keywords: *A. hexapterus*; predators (mammals, fur seal).

Willette, M.; Sturdevant, M.; Jewett, S. 1997. Prey resource partitioning among several species of forage fishes in Prince William Sound, Alaska. In: Forage fishes in marine ecosystems; Proceedings of the international symposium on the role of forage fishes in marine ecosystems: [dates of meeting unknown]; [location unknown]. Rep. 97-01. [Fairbanks, AK]: University of Alaska Fairbanks, Alaska Sea Grant College Program: 11-29.

Keywords: *A. hexapterus*; Alaska; Prince William Sound; food; resource partitioning.

Williams, G.C.; Richards, S.W.; Farnworth, E.G. 1964. Eggs of *Ammodytes hexapterus* from Long Island, New York. Copeia. (1): 242-243.

The sand lance eggs are not quite spherical and are slightly adhesive, with occasional sand grains still attached. They range in diameter (40 specimens) from 0.67 to 0.91 millimeter, with a mean of 0.825. The embryo at hatching is about 4 millimeters long. Eggs of *A. hexapterus* and *A. prolarva* are easily identified. Drawings of both are included.

Keywords: *A. hexapterus*; Atlantic; New York; eggs; embryo.

Willson, M.F.; Armstrong, R.H. 1998. Intertidal foraging for Pacific sand-lance, *Ammodytes hexapterus*, by birds. Canadian Field-Naturalist. 112(4): 715-716.

“Bald eagles, northwestern crows, common ravens, and glaucous-winged gulls forage for buried Pacific sand-lance in the intertidal zone near Juneau, Alaska, by digging or disturbing the sand so that the concealed fish emerged.”

Keyword: *A. hexapterus*; Alaska; predators (birds, bald eagle, northwestern crow, common raven, glaucous-winged gull).

Wilson, J.A.; Kleban, P.; McKay, S.R.; Townsend, R.E. 1991. Management of multispecies fisheries with chaotic population dynamics. International Council for the Exploration of the Sea, Marine Science Symposium. 193: 287-300.

Keywords: *Ammodytes*; fisheries; population dynamics.

Wilson, U.W. 1977. A study of the biology of the rhinoceros auklet on Protection Island, Washington. Seattle, WA: University of Washington. M.S. thesis.

Keywords: *A. hexapterus*; Washington; predators (birds, rhinoceros auklet).

Wilson, U.W.; Manuwal, D.A. 1986. Breeding biology of the rhinoceros auklet in Washington. Condor. 88: 143-155.

On the inshore islands, the two most important prey species were Pacific sand lance and Pacific herring, which comprised 89.4 to 96.6 percent of the total weight of fish delivered to chicks during the period 1974 to 1983. Pacific sand lance was always the predominant prey item, its relative frequency ranging from 63.8 to 90.7 percent.

In contrast, on the offshore island the single most important prey species was the northern anchovy. Rockfish, sand lance, herring night smelt, and Pacific saury also were major prey species. Sand lance and night smelt were the predominant species in 1975.

The three species of puffins in Alaska rely heavily on capelin as the primary prey and on sand lance as the secondary prey species. Capelin has not been found in auklet diets south of southeastern Alaska. Overall, the sand lance is the predominant species in nestling diets of the three puffins from Alaska to Washington. A more complete understanding of the biology of these puffins is possible with future detailed studies on behavior and on availability, distribution, and natural history of major prey species.

Keywords: *A. hexapterus*; Washington; importance; predators (birds, rhinoceros auklet).

Wing, B.L. 1977. Salmon food observations. In: Southeast Alaska troll log book program: 1976 scientific report. Alaska Sea Grant Report. 77-11: 20-27.

“For the whole season and area, sandlance, herring, and crustaceans ranked 1, 2, and 3 respectively in importance but did not differ greatly from each other.”

Keywords: *A. hexapterus*; Alaska; southeastern Alaska; importance; predators (fish, Pacific salmon).

Winslade, P.R. 1971. Behavioral and embryological investigations of the lesser sandeel, *Ammodytes marinus* Raitt. Norwich, England: University of East Anglia. Ph.D. dissertation.

Keywords: *A. marinus*; behavior; embryology.

Winslade, P.R. 1974a. Behavioural studies on the lesser sandeel *Ammodytes marinus* (Raitt). I: The effect of food availability on activity and the role of olfaction in food detection. Journal of Fish Biology. 6: 565-576.

“The behaviour of the lesser sandeel, *Ammodytes marinus* (Raitt), has been investigated using a photographic method of recording activity. Three main states of activity were recognized: (1) swimming, (2) partially emerged from the sand, or (3) completely buried in the sand. When food was present there was a basic diurnal rhythm of activity: during the dark period most of the fish remained buried in the sand and in the light period they emerged to swim and feed. In the absence of food the level of swimming activity during the light period was extremely low, while the level of partial emergence activity increased. The fish appear to be visual feeders and those which were buried in the sand did not appear to be able to detect the presence of food in the water by means of olfaction. There was usually a low level of partial emergence activity during the dark period, which tended to increase in the few hours before the lights were switched on. The timing of this increase was thought to be related to an internal clock. The basic diurnal rhythm of activity shown in the laboratory experiments is discussed in relation to the marked diurnal variation in the catch of sandeels in the fishery. It is concluded that the failure to catch sandeels at night is due to their remaining buried in the sand.”

Keywords: *A. marinus*; behavior.

Winslade, P.R. 1974b. Behavioural studies on the lesser sandeel, Ammodytes marinus Raitt. II: The effect of light intensity on activity. Journal of Fish Biology. 6: 577-586.

“The behaviour of the lesser sandeel, *Ammodytes marinus* (Raitt), has been investigated at light intensities of 1, 10, 100 and 1000 lux, using a photographic method of recording activity. The level of swimming activity was high at 1000 and 100 lux, declining to a very low level at 1 lux. It was concluded that this was due to the limiting effect of

light on feeding. The threshold light intensity for swimming activity in the tank was estimated as being approximately 20 lux but it was considered that in the area of the sandeel fishing grounds the threshold might be higher than this, in the region of 100 lux. The number of hours light per day above 20 and 100 lux at a depth of 15 m in the area of the Outer Dowsing sandbank was estimated for the various months of the year. It was shown that during the winter the light intensity does not normally reach 100 lux and only exceeds 20 lux for a few hours each day. It is suggested that this could limit swimming activity and accessiblity at this time of year. Measurements were made of the penetration of light into sand and it was concluded that fish which are buried might be able to detect light, possibly via the pineal gland."

Keywords: *A. marinus*; behavior.

Winslade, P.R. 1974c. Behavioural studies on the lesser sandeel, *Ammodytes marinus* Raitt. III: The effect of temperature on activity and environmental control of the annual cycle of activity. Journal of Fish Biology. 6: 587-599.

"The behaviour of the lesser sandeel, *Ammodytes marinus* (Raitt), has been investigated at 5, 10 and 15 C, using a photographic method of recording activity. The activity patterns at 10 and 15 C were very similar, there being a high level of swimming activity during the light period, which fell to a low level at 5 C. It was also lower at 10 C at the end of the experiment than at the beginning and it is suggested that this might have been due to an increase in the fat contents of the fish. The feeding rate of the fish was measured and showed a Q_{10} of 2.08 for the temperature range 5-15 C. The annual cycle of activity of *A. marinus* is discussed in relation to seasonal changes in food availability, light and temperature, and in the fat content of the fish. It is concluded that after spawning in the December-January period the fish remain buried in the sand until April, because of the limiting effect on swimming and feeding activity of the environmental factors in the intervening period. The proportion of fish available for capture at the start of the fishery in April is related mainly to temperature, but food (as measured by numbers of copepods) light intensity and photoperiod are by then increasing rapidly. After July the fishery ceases and it is thought that this is because the fish have entered an overwintering stage, during which they remain buried in the sand. This phase is also thought to be associated with the maturation of the gonads in readiness for the winter spawning. The factors causing the fish to enter this stage are as yet undetermined but may be related to the attainment of a certain level of fat content."

Keywords: *A. marinus*; behavior.

Winters, G.H. 1970. Meristics and morphometrics of sand launce in the Newfoundland area. Journal of the Fisheries Research Board of Canada. 27: 2104-2108.

"Analyses of meristic and morphometric data of sand launce in the Newfoundland area revealed that the Grand Bank and St. Pierre Bank specimens were slender with relatively short heads and high meristic counts whereas those from Trinity Bay and St. Mary's Bay were deep-bodied with relatively longer heads and low meristic counts. Consequently, offshore launce were provisionally assigned to *Ammodytes dubius* and inshore specimens as *Ammodytes hexapterus*. Differences in body form and meristics were also evident within the two groups."

Keywords: *A. dubius; A. hexapterus*; Newfoundland; meristics; morphometrics.

Winters, G.H. 1981. Growth patterns in sand lance, *Ammodytes dubius*, from the Grand Bank. Canadian Journal of Fisheries and Aquatic Sciences. 38: 841-846.

"Growth patterns in sand lance (*Ammodytes dubius*) from the Grand Bank were examined using back-calculated lengths from otolith measurements. Lee's phenomenon of apparent change in growth rate with age is clearly demonstrated as is the phenomenon of growth compensation. Lee's phenomenon is explained by discriminatory mortality of the faster growing sand lance whereas growth compensation is attributed to the differing ages of maturity of the initial faster-growing and slower-growing fish. The significant reduction in the standard deviation and the increasing degree of left skewness in length frequencies of older sand lance is explained by a combination of Lee's phenomenon and growth compensation acting together throughout the growth history of individual sand lance."

In the Grand Bank area, their role as an important prey species probably has been greatly enhanced in most recent years as a result of a substantial reduction in the abundance of capelin, which has traditionally been the major prey species in that area.

Keywords: *A. dubius*; Newfoundland; age and growth.

Winters, G.H. 1983. Analysis of the biological and demographic parameters of the northern sand lance. *Ammodytes dubius*, from the Newfoundland Grand Bank. Canadian Journal of Fisheries and Aquatic Sciences. 40: 409-419.

"Biological characteristics and population dynamics of northern sand lance (*Ammodytes dubius*) population on the Grand Banks were investigated in the period 1968-79. Sand lance were distributed mainly in the shallower areas of the Grand Banks, particularly in the northeast and southeast areas. Through an examination of reproduction parameters I conclude that spawning occurs principally during the period November-January. Growth rates of Grand Bank sand lance are within the range of those described for the Scotian Shelf and are well correlated with temperature variations. Abundance indices, derived from groudfish surveys, indicate a substantial increase in abundance since the 1960s, and this increase is attributable to increased recruitment and reduced natural mortality. From correlation analyses I suggest that the decline in the Grand Bank population of Atlantic cod (*Gadus morhua*) may be responsible for the reduced mortality rates and increased abundance of Grand Bank sand lance during the 1970s."

Sand lance shape and size render them ideal food items for most predators. *Ammodytes dubius* is the single most important prey species of American plaice (*Hippoglossoides platessoides*), comprising nearly 80 percent of the food spectrum of that species in the southern Grand Banks area. Sand lance also contribute to the diet of yellowtail flounder (*Limanda ferruginea*) on the Grand Bank, although not to such a substantial degree as in American plaice. In addition, sand lance form the dominant prey species of cod in the southern Grand Bank area and are important in the diet of cod in the northern Grand Bank area.

Sand lance are an important prey species in other areas of the northwest Atlantic. In the west Greenland area as well as around coastal Newfoundland waters, Atlantic salmon feed extensively on sand lance. On the Nova Scotian Shelf, Atlantic cod, (*Gadus morhua*) American plaice, silver hake (*Merluccius bilinearis*), and haddock (*Melanogrammus aeglefinus*) feed extensively on sand lance, and a similar predator-prey interaction occurs on the American continental shelf area. In addition such large marine mammals as fin (*Galaenoptera physalus*) and humpback (*Megaptera novaeangliae*) whales feed heavily on sand lance.

Given the sustantial attrition in the biomass of cod and flounder on the Grand Bank during the 1970s and the recent substantial reduction in capelin abundance, the role of sand lance in the ecology of the Grand Bank has probably been greatly altered. Main spawning season of sand lance on the Grand Bank occurs from November through January. However, the presence of spent fish in April and May indicates that minor peaks in spawning may occur in late winter.

Keywords: *A. dubius*; Newfoundland; abundance; distribution; importance; predators (fish, Atlantic cod).

Winters, G.H. 1988. Meristic composition of sand lance (*Ammodytes* spp.) from the coastal waters of eastern Newfoundland. Journal of Northwest Atlantic Fishery Science. 9: 5-11.

Keywords: *Ammodytes*; Newfoundland; meristics.

Winters G.H. 1989. Life history parameters of sand lances *Ammodytes* spp. from the coastal waters of eastern Newfoundland Canada. Journal of Northwest Atlantic Fishery Science. 9(1): 5-12.

"Estimates of various life history parameters of sympatric populations of *Ammodytes dubius* and *A. americanus* from coastal waters of Newfoundland are presented for the first time. Significant differences between the two species of sand lances were evident for length-weight and age-weight relationships. In addition, *A. americanus* tended to have a slightly earlier spawning season, and matured at a slightly earlier age than *A. dubius*. Similarities in these vital rates were noted between *A. americanus* populations in Newfoundland coastal waters and those in New England

waters. Likewise, populations of *A. dubius* from coastal Newfoundland water had similar vital rates as those published for *A. dubius* populations on the Grand Banks."

Keywords: *A. americanus; A. dubius*; age; growth; life history; spawning.

Winters, G.H.; Dalley, E.L. 1988. Meristic composition of sand lance (*Ammodytes* spp.) in Newfoundland waters with a review of species designations in the northwest Atlantic. Canadian Journal of Fisheries and Aquatic Science. 45(3): 516-529.

"Examination of new meristic data on sand lance (*Ammodytes* spp.) populations in Newfoundland coastal waters using a combination of discriminant function and modal analyses demonstrates for the first time that co-occurrence is a common feature of the distribution of the two species (*A. dubius* and *A. americanus*) provisionally considered to exist in the Northwest Atlantic. In addition, the consistency in the meristic counts of *A. dubius* between the offshore and inshore samples and the postulated spawning of *A. dubius* in Newfoundland coastal waters provides good evidence that *A. dubius* is reproductively isolated from *A. americanus*. Reanalysis of published data on the vertebral composition of sand lance in the Northwest Atlantic confirms the co-occurrence of *A. americanus* and *A. dubius* in inshore areas from West Greenland southwards to the Gulf of Maine. These new analyses taken together with a review of the major distinguishing characteristics of sand lance species in the North Atlantic waters lead us to conclude that the heterogeneous assemblage of sand lance found inshore from West Greenland southwards and offshore from Georges Bank southwards and which has traditionally been classified as *A. americanus* belongs to a single trans-Atlantic species, *A. marinus*."

Keywords: *A. americanus; A. dubius; A. marinus*; Newfoundland; Atlantic (northwest); meristic counts; taxonomy.

Wobus, U. 1964. Der Rothalstaucher (*Podiceps grisgena* Boddaeert). Neue Brehm-Bucheri 330. Wittenburg Lutherstadt: A. Ziemsen.

Keywords: *Ammodytes*.

Wolfe, D.A.; Kjerfve, B. 1986. Estuarine variability: an overview. In: Wolfe, D.A., ed. Estuarine variability. New York: Academic Press: 3-15.

Keywords: *Ammodytes*; estuaries.

Wooller, R.D.; Bradley, J.S.; Croxall, J.P. 1992. Long-term population studies of seabirds. Trends in Ecology and Evolution. 7: 111-114.

Changes in the breeding success of arctic terns (*Sterna paradisaea*) appear connected to sandeel stocks.

Keywords: *Ammodytes*; importance; predators (birds, arctic tern).

Wooster, W.S. 1993. Is it food? An overview. In: Is it food?: Addressing marine mammal and seabird declines: Workshop summary; [dates of meeting unknown]; [location unknown]. Alaska Sea Grant Rep. 93-01. Fairbanks, AK: University of Alaska, Fairbanks: [pages unknown].

Important prey species, such as capelin and sand lance, are not subject to commercial exploitation in Alaska, so their populations are not well estimated. The agenda for investigating the causes of pinniped and seabird declines should include studies not only of their feeding areas, food requirements, and food availability in those areas but also of all the major causes of variability in the food supply.

Keywords: *A. hexapterus*; Alaska; importance.

Wosnitza, C. 1975. The food of fish larvae in the western Baltic. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung. 24(1): 79-92.

Keywords: *Ammodytes*; Baltic Sea; food and feeding habits; larvae.

Wray, T. 1989. Danish firm sparkles with diamond trawl. Fishing News International (London). 28(5): 10-12.

Keywords: *Ammodytes*; fisheries; fishing methods.

Wright, P.; Barrett, R.T.; Greenstreet, S.P.R. [and others]. 1996. Effect of fisheries for small fish on seabirds in the eastern Atantic. International Council for the Exploration of the Sea Cooperative Research Report. 216: 44-45.

Keywords: *A. marinus*; Atlantic (northeast); anthropogenic impacts; fisheries; predators (birds).

Wright, P.; Tasker, M.L. 1996. Analysis of fish consumption by seabirds by age class of prey fish. International Council for the Exploration of the Sea Cooperative Research Report. 216: 42-44.

Keywords: *A. marinus*; predators (birds, fulmar, guillemot, kittiwake, puffin, razorbill, shag).

Wright, P.J. 1993. Otolith microstructure of the lesser sandeel, *Ammodytes marinus*. Journal of the Marine Biological Association of the United Kingdom. 73(1): 245-248.

“Daily increments were demonstrated in the sagittae of the lesser sandeel, *Ammodytes marinus*, maintained in outdoor enclosures. Daily increment formation was also inferred for wild sandeels from an analysis of changes in age composition within a series of field samples. A comparison between sagitta microstructure and morphological development of larval and juvenile sandeels indicated that the first sagitta increment was formed around the time of hatching. Yolk-sac absorption and larval metamorphosis were accompanied by changes in otolith microstructure.”

Keywords: *A. marinus*; age; morphology; otoliths.

Wright, P.J. 1996. Is there a conflict between sandeel fisheries and seabirds? A case study at Shetland. In: Greenstreet, S.P.R.; Tasker, M.L., eds. Aquatic predators and their prey: Royal Society of Edinburgh conference; 1994 Aug.; Edinburgh, Scotland. Oxford, England, United Kingdom; Cambridge, MA: Blackwell Scientific Publications: 20: 154-164.

“There has been concern that fishing may affect the availability of sandeels to seabirds, either through effects on the total stock, stock recovery or through local depletions near seabird colonies. This problem has been addressed through a study of changes in sandeel availability around Shetland.”

Keywords: *A. marinus*; Shetland; distribution; importance; predators (birds); recruitment.

Wright, P.J.; Bailey, M. 1993a. Biology of sandeels in the vicinity of seabird colonies at Shetland. Fisheries Res. Rep. 15/93. Aberdeen, [Scotland]: Scottish Office Agriculture and Fisheries Department, Marine Laboratory.

Keywords: Ammodytes; Shetland; biology.

Wright, P.J.; Bailey, M. 1993b. The influence of sandeel emergence behaviour on availability to foraging seabirds. Fisheries Res. Rep. 15/93. Aberdeen, Scotland: Scottish Office Agriculture and Fisheries Department, Marine Laboratory.

Keywords: *Ammodytes*; behavior; emergence; predators (birds).

Wright, P.J.; Bailey, M.C. 1992. The relation between hatching time and growth opportunity in the lesser sandeel, *Ammodytes Marinus* (Raitt). Journal of Fish Biology. 41(Supplement B): 182-183.

Keywords: *A. marinus*; growth; larvae; starvation.

Wright, P.J.; Bailey, M.C. 1996. Timing of hatching in *Ammodytes marinus* from Shetland waters and its significance to early growth and survivorship. Marine Biology (Berlin). 126(1): 143-152.

“The significance of hatch date for the growth and survival of the sandeel, *Ammodytes marinus*, was investigated using otolith microstructure. Hatch dates of 2 to 6 mo-old juvenile *A. marinus* caught near Shetland were compared between 1990 and 1992, during which period year-class strength varied by more than an order of magnitude. The hatch-date distribution of juveniles in the 1992 year-class was compared with that estimated directly from the abundance of newly emerged larvae on the spawning grounds. The extent of larval hatching periods in 1990 and 1991 was also estimated from continuous plankton-recorder data. There were significant differences in hatching periods between all three years, hatching in 1990 and 1992 being markedly earlier than the long-term meanpeak in hatching indicated from archival data. Most individuals from the 1991 year-class attained a larger size by July than those in other year-classes, despite hatching later. Variation in individual growth rates both within and between year-classes indicated that there was a seasonal cycle of growth opportunity in all years investigated. The study suggests that the degree of coupling between hatching and the onset of spring secondary production may be an important contributory factor to year-class variability in this species.”

Keywords: *A. marinus*; Shetland; eggs; hatching; mortality; otoliths; seasonal variation.

Wright, P.J.; Bailey, M.C.; Heath, M.R. [and others]. 1994. The impact of the Braer oil spill on sandeel availability to seabirds around Shetland. ESGOSS Rep. Edinburgh, [Scotland]: Scottish Office.

Keywords: *Ammodytes*; Shetland; impacts; oil spill; predators (birds).

Wyatt, T. 1971. Production dynamics of *Oikopleura dioica* in the southern North Sea and the role of fish larvae which prey on them. Thalassia Jugoslavica. 7(1): 435-444.

Keywords: *Ammodytes*; North Sea; food and feeding habits; larvae.

Wyatt, T. 1974. The feeding of plaice and sand eel larvae in the southern bight in relation to the distribution of their food organisms. In: Blaxter, J.H.S., ed. The early life history of fish. Oban, Scotland: Dunstaffnage Marine Research Laboratory of the Scottish Marine Biological Association; Springer–Verlag: New York, NY; Heidelberg, West Germany: 245-251.

Keywords: *A. marinus;* North Sea; food and feeding habits; larvae.

Xu, H.; Jia, S.; Li, Z.; Huang, W. 1983. Studies on the minke whale from the northern Yellow Sea. Acta Zoologica Sinica. 29(1): 86-92.

“The minke whale from the northern Yellow Sea feeds on *Ammodytes personatus* and *Euphausia pacifica* mostly. Feeding is usually at 500-1000 h and 1400-1800 h. The whale in general does not feed at night.”

Keywords: *A. personatus*; Yellow Sea; predators (mammals, minke whale).

Yamada, H. 1995. Survival strategies in feeding ecology of sand lance larvae. Bulletin of the Japanese Society of Fisheries Oceanography. 59(3): 320-322.

Keywords: *Ammodytes*; food and feeding habits; larvae.

Yamashita, Y. 1985. The early life history of marine fish. 9: The early life history of the Japanese sand eel, *Ammodytes personatu*s with special reference to the mortality. Aquabiology. 7(2): 94-99.

Keywords: *A. personatus*; Japan; diel migration; food and feeding habits; larvae; mortality.

Yamashita, Y.; Aoyama, T. 1985. Hatching time, yolk sac absorption, onset of feeding, and early growth of the Japanese sand eel *Ammodytes personatus*. Bulletin of the Japanese Society of Scientific Fisheries. 51(11): 1777-1780.

“The characteristics of incubation time, yolk absorption, onset of feeding, and early larval growth of the Japanese sand eel *Ammodytes personatus* was [sic] examined. Incubation time to the beginning of hatching and to the time of 50% hatching was respectively, 14 days and 20 days at 15.5 C, 18 days and 25 days at 10.5 C and 33 days and 51 days at 6.5 C. Eggs showed a markedly extended period of hatching, 12, 29, and 59 days at each of the above respective temperatures. Using the relationship between incubation time and temperature, the spawning season was estimated to be from mid-December to the end of January with a peak at the end of December. Newly hatched larvae commenced feeding at an age of 2 days and all larvae completed yolk sac absorption by 12 days at 6.5 C, indicating a long overlapping period of endogenous and exogenous nutrition. The average size of newly hatched larvae is 4.72 mm in standard length and 33.9 µg in dry weight. The specific growth of larvae up to 24 days old fed with field-collected microplankton and rotifier in the ration 2: 8 at 6.5 C was 4.2% per day in dry weight.”

Keywords: *A. personatus*; Japan; eggs; food and feeding habits; larvae.

Yamashita, Y.; Aoyama, T. 1986. Starvation resistance of larvae of the Japanese sand eel *Ammodytes personatus*. Bulletin of the Japanese Society of Scientific Fisheries. 52(4): 635-639.

“The starved larvae were all dead by day 14 at 15.5C, by day 20 at 10.5C, and by day 24 at 6.5C. A clear point of no return was not found and a long duration of recoverable starvation, about 9 days, was estimated. Even some of the larvae that were fed from day 17 ingested food and grew. These results show that the tolerance of starvation of the sand eel larvae has a wide range and that some of the larvae have high resistance to starvation. *A. personatus* is a commercially and ecologically important fish in the coastal waters of Japan, with 100,000 t-300,000 t caught a year. Compares tolerance to starvation of sand lance to other marine fish and concludes the Japanese sand eel is among the species more tolerant of starvation. Larvae of the sandlance *A. americanus* in the northwest Atlantic is also known to be highly resistant to starvation (Buckley et al. 1984). *Personatus* and *americanus* share the characteristics of laying demersal or adhesive eggs, or of having larger sized newly hatched larvae, or of hatching at low temperature. The adhesive nature of sand-eel eggs is thought to be an adaptation to story [sic] winter weather conditions. Fewer predators in winter.”

Keywords: *A. personatus*; Japan; larvae; starvation.

Yamashita, Y.; Aoyama, T.; Kitagawa, D. 1984. Laboratory studies of predation by hyperiid amphipod *Parathemisto japonica* on larvae of the Japanese sand-eel *Ammodytes personatus*. Bulletin of the Japanese Society of Scientific Fisheries. 50(7): 1089-1093.

“Predation, together with starvation, is one of the major causes of mortality in fish larvae. A variety of animals: pelagic fishes, hyperiid amphipods, euphausiid, copepods, squid, chaetognaths, jellyfishes etc., are reported to be predators of fish eggs and larvae. Up to 27.4 sand-eel larvae were consumed per 12 h under light condition by the hyperiid amphipod *Parathemisto japonica*.”

Keywords: *A. personatus*; Japan; eggs; larvae; predators (invertebrates, amphipods).

Yamashita, Y.; Kitagawa, D.; Aoyama, T. 1985a. A field study of predation of the hyperiid amphipod *Parathemisto japonica* on larvae of the Japanese sand eel *Ammodytes personatus*. Bulletin of the Japanese Society of Scientific Fisheries. 51(10): 1599-1607.

“A field study was carried out from January to April in 1981 and 1982 to estimate the effects of predation of the hyperiid amphipod *Parathemisto japonica* on larvae of the Japanese sand eel *Ammodytes personatus* in waters off the northeastern coast of the main island of Japan. The degree of vertical co-occurrence was similar during the day and at night and *P. japonica* fed on the larvae throughout the day. Overlap of the horizontal distributions of the two species increased from January to April. The proportion of sand eel larvae in the total stomach contents of *P. japonica* varied monthly in the range of 0-8.2% on a dry weight basis. The density of sand eel larvae decreased more

markedly in the area where *P. japonica* occurred in greater abundance. Preliminary estimates of the rate of daily loss of sand eel larvae caused by the predation yielded figures of 0.1% for January, 3.3% for February, 2.8% for March, and 45.2% for April, closely associaed with changes in the size and degree of overlap of distribution of the two organisms."

Keywords: *A. personatus*; Japan; larvae; predators (invertebrates, hyperiid amphipod *Parathemisto japonica*).

Yamashita, Y.; Kitagawa, D.; Aoyama, T. 1985b. Diel vertical migration and feeding rhythm of the larvae of the Japanese sand-eel *Ammodytes personatus*. Bulletin of the Japanese Society of Scientific Fisheries. 51(1): 1-5.

"The diel vertical movement and feeding rhythm of the larvae of the Japanese sand-eel *Ammodytes personatus* were examined from the data of 7-8 series of MTD net tows taken through one day-night cycle on 3 cruises in February and March 1981 and March 1982.

"MTD net samples demonstrated a size-related diel change in the vertical distribution of sand-eel larvae. Larvae less than 5 mm in standard length didn't demonstrate diel vertical migration, but migration became evident in larvae 5-6 mm in SL. They exhibited a pattern of vertical migration that was inverse to that commonly observed in other fish. Larvae were remarkably concentrated in 5- and 15-m tows during the day and were mainly caught in 30- and 50-m tows at night. Ascent and descent occurred at dawn and dusk, respectively. The range of diel migration increased with the size of the larvae. The diel changes in fullness of gut in both field-collected and reared larvae and the time to empty the gut in the laboratory indicated diurnal feeding activity. The advantage of this unusual pattern of migration is discussed from the point of view of feeding and predator avoidance."

In this area, the sand eels spawn in December and January, and larvae occur from mid January to early June. Juveniles 25 to 100 millimeters in standard length are commercially caught from late March to June with blanket nets and by using fish-luring lamps. The diel vertical migration pattern in Japanese sand eel larvae seems to be common in the genus *Ammodytes* because a similar pattern has been reported for *A. marinus* in the North Sea and for *Ammodytes* sp. off the northeastern coast of the United States. Termination of swimming followed by sinking of the larvae at night may reduce predation pressure for two reasons. First, inactivity is an effective way of avoiding attack by piscivorous predators such as carnivorous copepods and chaetognaths, which detect the vibration of their prey and attack mainly at night. Second, though the sinking movement is dangerous, they can leave the upper layer where predation pressure becomes higher at night due to the upward migration of carnivorous animals.

Keywords: *A. personatus*; Japan; behavior; larvae; migration.

Yamazaki, Y. 1995a. Coastal important fish species reproduction study: on sand lance. Ibaraki-Ken Suisan Shikenjo Jigyo Hokoku. 1993: 67-86.

Keywords: *A. personatus*; Japan; aestivation; biological rhythm; catch; distribution; dormancy; spawning.

Yamazaki, Y. 1995b. Distribution of the Japanese sand eel during estivating period in the coastal waters of Ibaraki Prefecture. Ibaraki-Ken Suisan Shikenjo Kenkyu Hokoku. 33: 59-66.

"Distribution of the Japanese sand eel, *Ammodytes personatus*, during estivating period, were studied in the coastal waters of Ibaraki Prefecture using the Korobashi-sampling gear. This gear was [more] efficient for gathering estivating fish than the beam trawl net used in former surveys. Sand eels were captured only where the grain size of the ground was from about 0.5mm to 2.0mm all around the coast, except the central region. However, most part of dis-

tribution was considered to be in the southern region, since both number of captured fish and the size of the estivating ground were dominant in this region. The size of the estivating ground in Ibaraki is estimated to be 249 km2, and that is 18% of all of them from Ibaraki to Miyagi Prefecture where the same subpopulation group lives."

Keywords: A. *personatus*; aestivation; biological rhythm; distribution; dormancy; fisheries; habitat.

Yamazaki, Y. 1995c. Transportation of juvenile sand lance from Sendai Bay to the coastal region of Ibaraki Prefecture. Suisan Kaiyo Kenkyu. 59(3): 310-312.

Keywords: *A. personatus*; Japan; catch; distribution; eggs; growth; habitat; larvae; juvenile; transport.

Yamazaki, Y.; Nihira, A. 1994. Regression analysis for the relationship between water temperature deviation from average and amount of catch of main fishes in Kashima-nada. Ibaraki-Ken Suisan Shikenjo Kenkyu Hokoku. 32: 101-109.

"This report examines the relationships between water temperature deviation from average at the coast of Nakaminato and amount of catch of eleven species in Kashima-nada. Increase of water temperature deviation produces the increase of catch of shirasu, bluefin tuna and yellow tail and the decrease of *Euphausia pacifica*, sand lance, japanese common mackerel, red sea bream, crimson sea bream and sea bass was not recognized."

Keywords: *A. hexapterus*; Japan; catch; temperature.

Yanagibashi, S.; Funakoshi, S.; Mukai, R.; Nakamura, M. 1997. Mechanisms of the maturation and spawning of Japanese sandeel *Ammodytes personatus* Girard in and around Ise Bay with special reference to their survival during the estivation period. Bulletin of the Aichi Fisheries Research Institute. 4: 23-31.

Keywords: *A. personatus*; Japan; aestivation; spawning; survival.

Yang, J. 1982. An estimate of the fish biomass in the North Sea. Journal du Conseil, Conseil International pour l'Exploration de la Mer. 40: 161-172.

Keywords: *Ammodytes*; North Sea; abundance.

Yang, J.; Zhou, M.; Li, J. 1995. Experiments on energy flow of a simple food chain. Marine Science, Haiyang Kexue. 1: 67-88.

"This study used 4 commercial value species, distributing in the coastal area of the Yellow Sea, to form an artificial food chain: *Isochrysis galbana-Artemia salina-Ammodytes personatus-Sebastodes fuscescens*. Aquarium experiments were respectively carried out for certain periods. Analysis of the data obtained during the run of the three conversion artificial food chain show that consumption of 235.2 kg fresh (148.3 kg dry weight) Isochrysis galbana produced 1 kg fresh weight (1 kg dry weight) *Sebastodes fuscescens*. Concentration of 1 J energy by *Sebastodes fuscescens* requires *Isochrysis galbana* containing 110.7 J energy. Since the alimentary canal of *Artemia salina* was not totally evacuated of food residues at the end of experiment their measured body weight increment would be slightly higher than the actual value."

Keywords: *A. personatus*; Yellow Sea; food chain; model.

Yang, M.S. 1987. Food habits and daily ration of Greenland halibut *Reinhardtius hippoglossoides* in the eastern Bering Sea. Seattle, WA: University of Washington. 57 p. M.S. thesis.

Keywords: *A. hexapterus*; Bering Sea; predators (fish, Greenland halibut).

Yaragina, N.A. 1985. Diurnal feeding rhythmicity and daily diet of cod consuming euphausiids. In: Feeding and food availability as related to fish abundance, growth and concentration formation. Tarverdieva, MI: [publisher unknown]: 19-28.

"The analysis of stomach contents of 449 individuals of *Gadus morhua* taken at 3 diurnal stations in July of 1978, 1979 and 1980 indicated that cod fed mainly on *Thysanoessa raschii* and consumed also sand lance, young capelin and redfish, shrimps, hyperiids and polychaetes. The daily diet of cod of the average weight of 0.7 kg made up 8.7% of the body weight in 1978 and it constituted 2.6-3.9% of the body weight in individuals weighing 1.1-1.5 kg in 1979-80."

Keywords: *Ammodytes*; predators (fish, cod).

Yarrell, W. 1836. A history of British fishes. 2: The sandeel. 1st ed. London, England: John Van Voorst: 317-321.

Keywords: *Ammodytes*; historical.

Ydenberg, R.C. 1988. Foraging by diving birds. Proceedings of the International Ornithology Congress. 19: 1831-1842.

Keywords: *Ammodytes*; predators (birds).

Ydenberg, R.C.; Forbes, L.S. 1988. Diving and foraging in the western grebe. Ornis Scandinavica. 19: 129-133.

Keywords: *A. hexapterus*; predators (birds, western grebe).

Yen, J. 1987. Predation by a carnivorous marine copepod, *Euchaeta norvegica* boeck, on eggs and larvae of the North-Atlantic cod *Gadus morhua*. Journal of Experimental Marine Biology and Ecology. 112(3): 283-296.

Keywords: *Ammodytes*; eggs; predators (invertebrates, marine copepod *Euchaeta norvegica boeck*).

Yin, M.C.; Blaxter, J.H.S. 1986. Morphological changes during growth and starvation of larval cod (*Gadus morhua*) and flounder (*Platichthys flesus*). Journal of Experimental Marine Biology and Ecology. 104(1-3): 215-228.

Keywords: *Ammodytes*; predators (fish, cod).

Yin, M.C.; Blaxter, J.H.S. 1987a. Escape speeds of marine fish larvae during early development and starvation. Marine Biology. 96(4): 459-468.

Keywords: *Ammodytes*; larvae; starvation; swimming speed.

Yin, M.C.; Blaxter, J.H.S. 1987b. Feeding ability and survival during starvation of marine fish larvae reared in the laboratory. Journal of Experimental Marine Biology and Ecology. 105(1): 73-83.

Keywords: *Ammodytes*; food and feeding habits; larvae; starvation.

Yin, M.C.; Blaxter, J.H.S. 1987c. Temperature, salinity tolerance, and buoyancy during early development and starvation of Clyde and North Sea herring, cod, and flounder larvae. Journal of Experimental Marine Biology and Ecology. 107(3): 279-290.

Keywords: *Ammodytes*; North Sea; predators (fish).

Yoklavich, M M.; Stevenson, M.; Cailliet, G.M. 1992. Seasonal and spatial patterns of ichthyoplankton abundance in Elkhorn Slough, California. Estuarine Coastal and Shelf Science. 34(2): 109-126.

“While more speciose, a winter and early-spring group comprised of larval *L. armatus, H. pretiosus*-osmerid, Atherinidae and *Ammodytes hexapterus* was not as abundant as the summer-fall assemblage. Egg densities were overwhelmingly high in summer, due almost entirely to *E. mordax*. Similarity in species composition was greatest between collections from the most inland stations; larval assemblages from near-ocean stations were least similar to the inland slough assemblages. These distribution are attributed to reproductive specializations (egg type and spawning origin of adults) and hydrographic conditions.”

Keywords: *A. hexapterus*; California; abundance; distribution; eggs; larvae.

Yoo, J.M.; Cha, S.S. 1988. Variation of abundances of ichthyoplankton in Kwangyang Bay South Korea. Ocean Research (Seoul). 10(1): 79-84.

“To study the variation of ichthyoplankton in Kwangyang Bay, ichthyoplankton were sampled biomonthly at 7 stations from February, 1983 to April, 1985. *Engraulis japonica* eggs accounted for 75.4% of the total eggs. Among 32 taxa of larvae Gobiidae larvae accounted for 67.3% of the total larvae; *Engraulis japonica* larvae, 14.9%; and *Leiognathus* sp. larvae, 6.0%. The abundances of pelagic eggs in 1984 increased as compared with those in 1983, but this phenomenon occurred only in *Engraulis japonica* eggs at certain stations. Those of other taxa decreased in numbers. The abundances of larvae in 1984 decreased to 10% of those in 1983. Larval abundances of the most taxa decreased, while the larval abundances of *Clupanodon punctatus*, Apogon sp., and *Ammodytes personatus* increased. Thus it was appeared that abundances of ichthyoplankton in Kwangyang Bay decreased continuously during this study period.”

Keywords: *A. personatus*; Korea; abundance; eggs; larvae.

York, A.E. 1987. Northern fur seal, *Callorhinus ursinus*, eastern Pacific population (Pribilof Islands, Alaska, and San Miguel Island, California). In: Croxall, J.P.; Gentry, R.L., eds. Status, biology and ecology of fur seals: Proceedings of an international symposium and workshop; [Place of meeting unknown]; Cambridge, England. Tech. Rep. NMFS 51. [Place of publication unknown]: National Oceanic and Atmospheric Administration: 9-21.

Keywords: *A. hexapterus*; Alaska; Pribilof Islands; predators (mammals, northern fur seal).

Yoshida, H.; Sakurai, Y. 1984. Relationship between food consumption and growth of adult walleye pollock *Theragra chalcogramma* in captivity. Bulletin of the Japanese Society of Scientific Fisheries. 50(5): 763-770.

“Food consumption rate and growth rate of the adult walleye pollock were measured at different temperatures (2°–7°, 4°–10° and 9°–15° C), body sizes (33-35, 35-39 and 39-45 cm) and foods (juvenile walleye pollock, squid and sandlance). The amount of daily intake indicated peaks at intervals of 5 days. The efficiency of assimilation was almost constant for range of temperature and body size, and for each food item adapted in these experiments. The efficiency of dissimilation increased with the increase in temperature. An empirical linear equation was established on the relationshp between daily feeding rate (R) and daily growth rate (G) at 2°–7°. C: G = 0.370R–0.225. Body weight and condition factor increased linearly with increase of ration, but body length increased asymptotically. Estimated food requirements of adult walleye pollock was 1.1% of body wt per day.”

Keywords: *Ammodytes*; predators (fish, walleye pollock).

Yoshida, K.; Minamisako, Y.; Morita, T. [and others]. 1995. Radioactivity survey of the marine organisms in the adjacent sea. Radioactivity survey of the marine organisms in the offshore areas of Sakhalin and Kamchatka. Norin Suisan–Sho Kankei Hoshano Chosa Kenkyu Nenpo. 1994: 35-36.

Keywords: *Ammodytes*; Russia; anthropogenic impacts; cesium; environmental pollution; radiation.

Zamarro, J. 1992. Feeding behaviour of the American plaice (*Hippoglossoides platessoides*) on the southern Grand Bank of Newfoundland. Netherlands Journal of Sea Research. 29(1-3): 229-238.

“Diet of American plaice 40-55 cm long mainly consists of *Ammodytes dubius* and brittlestars; the third most important prey is capelin *Mallotus villosus*. Daily feeding intensity measured using a mean weight fullness index, the percentage of empty stomachs and the daily ration, shows maxima related to the kind of prey consumed. *A. dubius* is consumed in larger amounts late in the day, between 18.00-24.00 h; *M. villosus* and brittlestars are preyed upon more intensely between 12.00-18.00 h. Maximum feeding activity is in April, with a summer period of relativley high values.”

Keywords: *A. dubius*; Newfoundland; predators (fish, American plaice).

Zolotov, O.G.; Balykin, N.P.; Naumenko, N.I. [and others]. 1997. Interannual fluctuations in some forage fish abundance in the western Bering Sea and waters off Kamchatka Peninsula. In: International symposium on the forage fishes in marine ecosystems: 14th Lowell Wakefield fisheries symposium; [dates of meeting unknown]; Anchorage, AK. [Place of publication unknown]: [publisher unknown].

“Among the most abundant fishes in the western Bering Sea and waters around Kamchatka Peninsula are such relatively small semipelagic schooling species as walleye pollock, Pacific herring, capelin, Pacific sand lance (*Ammodytes hexapterus*) and Atka mackerel. Some are of economic significance to the fishery, others are not commercially exploited; but they all have a substantial place in marine ecosystems as food for consumers of higher trophic levels. Very little data is available on sand lance ecology and stock abundance. This species is, undoubtedly, very important as food for piscivorous fish.”

Keywords: *A. hexapterus*; Alaska; Bering Sea; abundance; importance.

Keyword Index

Taxonomic Index

Geographic Index

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Robards, Martin D.; Willson, Mary F.; Armstrong, Robert H.; Piatt, John F., eds. 1999. Sand lance: a review of biology and predator relations and annotated bibliography. Res. Pap. PNW-RP-521, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 327 p.

Sand lance (*Ammodytes*) constitute a major prey for at least some populations of over 100 species of consumer, including 40 species of birds, 12 species of marine mammals, 45 species of fishes, and some invertebrates. Variation in the availability of sand lance (and other forage fishes) can have major effects on the breeding success and survival of their predators. Commercial fishing and other pressures on sand lance populations potentially have ramifying effects on many species of wildlife.

Keywords: Sand lance, sand eel, *Ammodytes, personatus, hexapterus, americanus, dubius, tobianus, marinus,* forage fish.

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