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Annotated Bibliography of the Ocean Quahog, *Arctica islandica* (Linnaeus)

by

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ANNOTATED BIBLIOGRAPHY ON THE OCEAN QUAHOG, ARCTICA ISLANDICA

By J. Brownlow and J. Ropes

Introduction

The bibliography represents many years of literature collection. An earlier version was prepared by the librarian at the NMFS Oxford laboratory, Helen Lange in 1975. John Ropes is largely responsible for collecting the literature and has authored many papers on population assessment and ageing of the ocean quahog. It has been brought up to date by the inclusion of all available papers found by the compilers. The MBL and NMFS libraries were searched, numerous interlibrary loans were obtained, and current journals were scanned. Several online literature searches were done over the years. "Grey" literature has been included: laboratory reference documents, ICES CM papers, newspaper articles and cruise reports. The bibliography presently contains over 400 citations with abstracts. There are some Russian language articles which have not yet been translated.

The ocean quahog fishery began in 1943, but for three decades annual landings were less than 1,000 MT. A 2,500 MT landing in 1976 was followed by significant increases to an annual mean of 15,800 MT for 1979 to 1983. During 1976 - 1980, the ocean quahog resource supplemented stocks of surf clams reduced by overfishing. Most of the landings have been off beds from New Jersey and the Delmarva Peninsula, but a very abundant amd largely unfished U.S. ocean quahog resource occurs on Georges Bank, off Southern New England and Long Island, N.Y. The distribution and abundance of ocean quahogs gradually declines south of Long Island to its limit off Cape Hatteras.

Longevity is an interesting recent discovery about the ocean quahog. One probably lived for 225 years, making it the longest lived bivalve yet known. Many in the population attain 100 or more years of age. Several reports in 1980 and thereafter have assessed ages for ocean quahogs from annually formed internal growth lines seen in acetate peel replicas off radially sectioned valves. The validity of an annual periodicity of the growth lines has been confirmed by an extensive NMFS mark-recapture experiment. The age information gained from these studies has been invaluable in management plans for the fishery.

Abbott, R.T. 1974.

American seashells. Second Edition. Van Nostrand Reinhold Co., N.Y., 663 pp.

Arctica islandica is described in a systematic list of American marine mollusks.

Ackman, R.G., and M.G. Cormier. 1967.

a-tocopherol in some Atlantic fish and shellfish with particular reference to live-holding without food. J. Fish. Res. Bd. Canada, 24: 357-373.

The percent lipid and α-tocopherol content of several fish and shellfish held for various periods of time were analyzed, since these may affect flavor. Ocean quahogs were found to be very low (-0.6%) in lipid, but relatively high in α-tocopherol in proportion to lipid (230μg/g).

Ackman, R.G., and H.J. Hingley. 1968.

The occurence and retention of dimethyl-β-propiothetin in some filter-feeding organisms. J. Fish Res. Bd. Canada, 25: 267-284.

Determination of dimethyl-β-propiothetin (DMPT) levels are reported for 10 filter-feeding organisms, 1 browsing mollusc, 1 carnivorous mollusc, and 1 crustacean. Mature oysters, scallops, and the pteropod *Limacina helicina* showed high (ca. 0.1 mg/g) DMPT levels, mussels showed generally lower levels, and quahogs and a tunicate showed negligible amounts of DMPT. The periwinkle accumulated DMPT only when feeding on an alga rich in DMPT. Retention of DMPT over prolonged periods was studied in the oyster and in mussels.

Seasonal variations, year-to-year variations, and variations with locations were studied for oysters and to a limited extent for mussels. The findings are discussed in terms of food availability and feeding habits and indicate that together with tocopherol it may be possible to correlate DMPT levels with the availability of phytoplankters in the food intake or some species. It is suggested that phagocytes may be responsible for prolonged retention of DMPT in oysters. (Authors' Abstract) *Arctica islandica* was one of the quahogs used in the study.

Ackman, R.G., S. Epstein, and M. Kelleher. 1974.

A comparison of lipids and fatty acids of the ocean quahaug (*Arctica islandica*) from Nova Scotia and New Brunswick. J. Fish. Res. Bd. Canada 12: 1803-1811.

Lots of ocean quahaugs, *Arctica islandica*, respectively from Nova Scotia and New Brunswick, were compared to see if fatty acid compositions might reflect local food sources and thus explain alleged flavor problems. Lipid contents increased from May to July, but detailed fatty acid comparisons including those from flesh and hapatopancreas, gave similar results except with minor details indicative of active feeding. A holding experiment with New Brunswick quahaugs gave essentially the basic lipid composition but after

10 wk compositional variations in fatty acid were suggestive of the effect of nonfeeding. The close fatty acid resemblence among several samples suggests that the ocean quahaug eventually converts ingested fatty acids to a species-specific composition based on those acids common to other northwestern Atlantic shellfish. Certain details of these fatty acid analyses suggest particulate matter sources for some ingested fatty acids. No correlation between flavor and lipid or fatty acid composition could be obtained because flavor problems were not observed in these samples. (Authors' Abstract)

Adams, W.N., Capt. 1977.

Bacteriological analysis. Operation Mogul-February 1977. *In*: Lear, D.W. et al. (ed.) 1977. Effects of ocean dumping activity Mid-Atlantic bight--1976 interim report. U.S. Environ. Protect. Agency. Reg. III. Philadelphia, PA. EPA 90319-77-029, p. 161-166.

Describes bacteriological (coliform) analysis performed aboard ship. *Arctica* found to have relatively higher concentrations of coliforms than was indicated by water or sediment samples.

Allen, J.A. 1965.

Records of mollusca from the northwest Atlantic obtained by Canadian fishery research vessel, 1946-61. J. Fish. Res. Bd. Canada 22: 977-997.

In the course of investigations into the fish and shrimp resources of an area from the southern edge of the Grand Bank and the Gulf of St. Lawrence to Cape Dyer, Baffin Island, numbers of Mollusca were taken. Commercial trawls were used for the great majority of the hauls and because of mesh selection most of the Mollusca taken were specimens of the larger species. The majority of the 45 species collected are well known and the value of the present list lies in the records of distribution from an area where climatic conditions have severely restricted past sampling endeavour. (Author's Abstract)
Lists new Canadian records for *Cyprina islandica*.

Anderson, B.G. 1976.

Glacial geology of Northern Nordland, North Norway. Nor. Geol. Unders. Bull. 33: 1-74.

Marginal moraines representing most of the Weichsel sequence were mapped. The oldest moraines, Egga I and II, are large submarine ridges on the continental shelf. Tromso-Lyngen moraines of Younger Dryas age lie at the mouths of several main fjords, and Pre-Boreal moraines radiocarbon-dated at 9000-10,000 yr B.P. lie near their heads. The Pre-Boreal moraines were correlated with glacial events in other areas, and they probably represent significant climatic fluctuations. A main shore-line (level P_{12}) and a marine shell fauna with *Portlandica arctica* correspond with the Tromso-Lyngen moraines, and shorelines between levels P_{12} and P_6 and marine faunas with *Bathyarca glacialis* or *Yoldiella lenticula* correspond with the Pre-Boreal moraines. [*Balanus balanus*, *Hiatella arctica*, *Macoma calcarea*, *Arctica*

islandica, *Leda pernula*, *Mya truncata* and *Chlamys islandicus* are mentioned.] The glaciation limits were 550 ± 50 m and 275 ± 50 m below the modern glaciation limits during the Tromso-Lyngen and the Pre-Boreal events, respectively. This corresponds well with observations in other parts of Norway. (Author's Abstract)

Anonymous. 1963.

Surf clam survey, progress report no. 1. Mimeographed report by the Oyster Institute of North America, Eastern Sea Clam Committee and the U.S. Bureau of Commercial Fisheries, 2 pp.

Black quahogs were caught at more stations and in larger numbers than surf clams during a survey off the New Jersey coast.

Anonymous. 1963.

Sea herring and surf clam survey conducted. Commer. Fish. Rev. 25(9): 35-37.

Describes tests of clam sampling equipment and fishing results on Georges Bank.

Anonymous. 1965.

Clams. Progress report of 1964 surf clam survey off Atlantic coast. Commer. Fish. Rev. 27(2): 18-20.

Very few black quahogs were found in samples yielding the best catches of surf clams during a survey off the Maryland and Virginia coasts.

Anonymous. 1965.

Surf clam survey continued: M/V DELAWARE Cruise 65-2. Commer. Fish. Rev. 27(6); June: 28-30.

BLACK QUAHOGS: Very few black quahogs were taken in the areas where the best catches of clams were made. They were also absent from 108 of the 130 tows from which no surf clams were taken. The best catches of black quahogs were made in the area at north end of the offshore grid lines in water depths of 22 to 24 fathoms; the numbers taken per tow varied from 1 to 567. Smaller quantities of black quahogs were taken in the catches from the southern end of those same grid lines and at depths of 20 to 24 fathoms. Considerable numbers of quahog shells were also taken in some of the tows made in those areas.

Anonymous. 1965.

North Atlantic fisheries explorations and gear development. Surf clam survey continued. Commer. Fish. Rev. 27(6): 28-30.

Mentions catching black quahogs during survey off Maryland and Virginia.

Anonymous. 1967.

DELAWARE finds more clam beds off Massachusetts. Commer. Fish. Rev. 29 (8-9): 24-26.

Mentions finding exceedingly large catches of *Arctica* off Cape Cod and New Jersey.

Anonymous. 1973.

Ocean quahog resource. Marine Fishery Management Section, Progress Report, Resource Development Branch. Sep., p. 4.

Anonymous, 1965.

North Atlantic fisheries explorations and gear development. Surf clam survey continued: M/V DELAWARE Cruse 65-2 (February 19-March 18, 1965). Commer. Fish. Rev. 27(6): 28-30.

Very few black quahogs were found in samples yielding the best catches of surf clams during a survey off the Maryland and Virginia coasts.

Anonymous. 1965.

North Atlantic fisheries explorations and gear development. Surf clam survey continued: M/V DELAWARE Cruise 65-4 (May 3-June 3, 1965). Commer. Fish. Rev. 27(9): 34-36.

Black quahogs were found in small quantities during a survey off the Virginia coast.

Anonymous. 1966.

North Atlantic fisheris explorations and gear development. DELAWARE completes clam survey. Commer. Fish. Rev. 28(11): 14-16.

Ocean quahogs (*Arctica islandica*) were frequent and of large volume in some samples during a survey off New Jersey, Delaware, and Maryland.

Anonymous. 1967.

Gloucester lab taps a new shellfish resource. Commer. Fish. Rev. 29(12): 32.

Reports the interest of industry and potential use of mahogany clams (*Arctica islandica*) in commercial clam products.

Anonymous. 1968.

Ocean quahog. Fishing Gazette 85(5): 30.

Brief description of distribution and uses of the ocean quahog and industrial interest.

Anonymous. 1969.

Demand for ocean quahogs grows. Commer. Fish. Rev. 31(4): 4-5.

Reports on the growing interest in the ocean quahog (*Arctica islandica*) resource by industry and the State of Massachusetts. "Clambo," a product made from minced ocean quahogs, is briefly described.

Anonymous. 1969.

A use for the mahoganies. Shellfish Soundings 34(12): 6.

Anonymous. 1970.

Ocean quahog survey. Cruise report, DELAWARE II Cruise 70-1, January 26-February 5, 1970; February 11-18, 1970. March 11, 1970. 7 pp.

Extensive commercially usable concentrations of ocean quahogs (*Arctica islandica*) were located during a survey off the coast of southern New England. A description of the sampling gear and details of the catches are given.

Anonymous. 1970.

Ocean quahog survey. Cruise report DELWARE II Cruise 70-5, July 17-23, 1970. July 30-August 7, 1970. 6 pp.

Extensive commercially usable concentrations of ocean quahogs (*Arctica islandica*) were located during a survey off the coast of southern New England. A description of the sampling gear and details of the catch are given.

Anonymous. 1970.

DELAWARE II finds ocean quahogs off New England. Commer. Fish. Rev. 32(4): 14-18.

A survey of the ocean quahog resource conducted in January-February 1970 is reviewed. A modified stern-haul system of operating a hydraulic dredge is described.

Anonymous. 1970.

Large ocean quahaug stocks are found off New England. National Fisherman. June, p. 15-B.

Describes surveys for ocean quahogs off southern New England (cf. Cruise Report DELAWARE II 70-1 and 70-5 and Commer. Fish Rev. 32(4): 14-18).

Anonymous. 1971.

Catch of ocean quahogs increases in New England. NOAA Week 2(52): 2.

A small but growing fishery for the ocean quahog has been developed with the aid of the National Marine Fisheries Service. The potential of this fishery as a replacement for the traditional--and more expensive--hardshell, softshell, and surf clam is considered.

Anonymous. 1970? 1971?

File 46-11-0, St. Andrews Biological Station. Memo date January 26, 1970? 1971?. Pesonal communication, Dr. Medcof.

Sable Island (From Hiltz, 1977)

Survey Date:
December, 1969
Data:
File 46-11-0. Coordinates of sites where Dr. Lewis H. King found ocean quahaugs.
Site Locations:
West by south of Sable Island on Sable Island and Western banks where bottoms are described on charts as "sand and shell."
Size of Quahaugs:
Ranged from 3 to 3 1/2 ' long.

Decca Coordinates	Depths (fath)	Corresponding Lats. and Longs.	
C40 green E61 purple	20	43°50'	60°35'
C45 green E50 purple	32	43°39.5'	60°33'
D62 purple C47 green	30	43°40'	61°01'
C68 purple D36 green	39	43°30'	61°14.5'

Anonymous. 1971.

NMFS protects more "Continental Shelf creatures." Commer. Fish. Rev. 33(6): 5.

Announcement of the enactment by the National Marine Fisheries Service to prohibit foreign vessels from taking 10 more species of marine animals it classified "creatures of the Continental Shelf." Ocean quahogs were among the amimals added to the list.

Anonymous. 1971.

Living organisms of the continental shelf. FR Doc. 71-8779, 36(2): 11923.

Recommends adding the ocean quahog (*Arctica islandica*) to a list reserving harvesting of it to United States nationals, except as provided by international agreement.

Anonymous. 1971.

Ocean quahog survey. Fishing trawler JO-ANN April 18-May 6, 1971. Charter cruise report, 4 pp.

Reports the potential for ocean quahog resources in the Gloucester, Mass., area and success in adapting a small New England dragger for fishing with a hydraulic jet dredge.

Anonymous. 1971.

Fisherman turns from trawling to clam dredging to earn living in Gloucester. N.E. Mar. Resour. Inf. 23, April 1971, p. 1, 3, 4.

Exploratory fishing for the ocean quahog off the New England coast brings hope for the Gloucester fishermen.

Anonymous. 1971.

NMFS helps Gloucester fisherman switch from trawling to clam digging. Commer. Fish. Rev. 33(5): 15-16.

The introduction of a Gloucester fisherman to the new fishery for ocean quahogs is reported, with a description of types of gear used.

Anonymous. 1971.

Ocean quahog survey. National Marine Fisheries Service, Fishery Market News Report. B-140, Boston, Mass., July 21. p. 3

Describes results of charter vessel JO-ANN locating beds of ocean quahogs off Ipswich and Gloucester, Mass. (cf. Commer. Fish. Rev. 33(5): 15-16; 33(7-8): 20-22).

Anonymous. 1971.

Ocean quahog takes on new importance as surf and bay clam supply (sic) dwindle. N.E. Mar. Resour. Inf. 22, March 1971, p. 1-2.

Clam processors and fishermen are encouraged to utilize the ocean quahog. Various improvements on harvesting gear and processing methods are discussed.

Anonymous. 1971.

Ocean quahog becomes more important as surf and bay clams dwindle. Commer. Fish. Rev. 33(4): 17-19.

Progress in developing the ocean quahog resource is discussed, and methods of processing the clam are reviewed.

Anonymous. 1971.

Clams found. World Fishing. April, p. 40.

Ocean quahogs were found in search for minerals off Canada.

Anonymous. 1971.

Find ocean quahogs abundant off Massachusetts. Commer. Fish. Rev. 33(7-8): 20-22.

In an investigtion of underutilized clam resources in the Gloucester, Mass., area a small New England dragger was modified to use a hydraulic jet dredge. Significant commercial quantitites of ocean quahogs were found in the four areas sampled; the Ipswich Bay area was considered most productive.

Anonymous. 1977.

Low oxygen causes high surf clam losses. Mar. Fish. Rev. 39(1): 26-27.

Briefly summarizes low oxygen conditions off New Jersey in 1976 and highlights losses of surf clams. Mortalities of ocean quahogs, although lower than surf clams, were included.

Anonymous. 1975.

The ocean quahog. New England Fish. Devel. Prog. Bull. No. 2.

Briefly describes resource and involvement of an industry advisory committee in product development and related research.

Anonymous. 1971.

The Financial Post. Vol. LXV, No. 52, 25 December 1971. p. 1 and 2.

Anonymous. 1971.

Ocean quahog survey--R/V RORQUAL. Aug. 16-30, 1971. Research vessel cruise report. 5 pp.

This National Marine Fisheries Service effort extended earlier survey results on the distribution and abundance of ocean quahogs in lower Ipswich Bay. The optimum ratio of tow line length to water depth when operating a hydraulic jet dredge was also investigated.

Anonymous. 1971.

Small N.E. dragger effective on beds of inshore quahogs. National Fisherman, September. p. 21A and 27A.

Describes results of charter vessel JO-ANN locating beds of ocean quahogs off Ipswich and Gloucester, Mass. (cf. Commer. Fish. Rev. 33(5): 15-16; 33(7-8): 20-22.

Anonymous. 1971.

Survey of Ipswich Bay. U.S. Fisheries Service, Fishery Market News Report B-225, Boston, Mass., 22 Nov. p. 4.

Describes results of charter vessel JO-ANN locating beds of ocean quahogs off Ipswich and Gloucester, Mass. (cf. Commer. Fish. Rev. 33(5): 15-16; 33(7-8): 20-22.

Anonymous. ____.

The ocean quahog. NOAA, NMFS, Food Fish Facts, No. 48, 1 p.

Briefly describes the ocean quahog, *Arctica islandica*, its habitat, fishery, processing techniques, and uses.

Anonymous. 1977.

The ocean quahog fishery of Maine. Maine Dept. Mar. Res., 47 pp.

Includes an introduction describing the east coast ocean quahog fishery, interest in harvesting the clam in Maine, hydraulic dredge plans, survey areas, underwater observations, processing, and market potential.

Anonymous. 1977.

Century-old clams may flavor chowder. NOAA News 2(5): 2, (March).

Describes preliminary results of research on aging ocean quahogs.

Anonymous. 1977.

Growth, mortality rates of ocean quahog sought. NOAA/NMFS Developments. Mar. Fish. Rev. 39(5): 29-30.

Describes preliminary results of research on aging ocean quahogs.

Ansell, A.D. 1967.

Leaping and other movements in some cardid molluscs. Anim. Behav. 15: 421-426.

In discussing leaping, his invariable failure to induce this activity in *Cyprina islandica* is noted and an earlier reference of such a reaction for the family Cyprinacea is given.

Ansell, A.D. 1969.

Leaping movement in the Bivalvia. Proc. Malacol. Soc. Long. 38: 387-399.

Notes that in earlier work he was unable to demonstrate leaping by *Cyprina islandica* and an earlier reference of this activity by the clam.

Arcisz, W., and W.C. Neville. 1945.

Description of the fishery. *In*: Neville, W.C. (coordinator). The ocean quahog fishery of Rhode Island. R.I. Dept. Agric. Conserv., Div. Fish Game, p. 7-14.

Describes fishing grounds, fishing methods and equipment, fishing season, and production data for the Rhode Island ocean quahog fishery.

Arcisz, W., and H.W. Nilson. 1945.

Market outlook. *In*: Neville, W.C. (coordinator). The ocean quahog fishery of Rhode Island. R.I. Dep. Agric. Conserv., Div. Fish Game, p. 26-27.

An expansion of the market for ocean quahogs is believed dependent upon favorable competitive prices and applicable methods of packaging and marketing the product.

Arcisz, W., and L.A. Sandholzer. 1945.

Bacteriological and sanitary survey of the ocean quahog industry. *In*: Neville, W.C. (coordinator). The ocean quahog fishery of Rhode Island. R.I. Dep. Agric. Conserv., Div. Fish Game, p. 16-25.

Specific recommendations are made regarding sanitary practices in the ocean quahog industry of Rhode Island. Included are methods of handling the clams on fishing vessels, trailer trucks, in storage rooms, shucking rooms, and packing rooms.

Arcisz, W., and L.A. Sandholzer. 1947.

A technological study of the ocean quahog fishery. Commer. Fish. Rev. 9(6): 1-21.

Reports the ocean quahog (*Arctica islandica*) as an excellent source of food. Technological aspects discussed include catching, processing, marketing, and certain economic considerations.

Sanitation problems of the industry were discussed. Bacteriological data were presented to determine the major sources of difficulty. Methods of storage, lack of adequate refrigeration, and certain plant practices were considered responsible for most reported losses in sanitary quality. Methods for eliminating these difficulties were reported.

Arntz, W.E. 1974.

A contribution to the feeding ecology of juvenile cod (*Gadus morhua* L.) in the western Baltic. Rapp. P.-V. Reun. Cons. Int. Explor. Mer, 166: 13-19.

The importance of *Cyprina islandica* as food for the cod is reported. Otter boards used in an intensive trawl fishery make a very large stock of rather thin-shelled clams available to the fish.

Arntz, W.E., and W. Weber. 1970.

Cyprina islandica L. (Mollusca, Bivalvia) als Nahrung von Dorsch und Kliesche in der Kieler Bucht. [*Cyprina islandica* L. (Mollusca, Bivalvia) as food for cod and dab in Kiel Bay.] Ber. Dtsch. Wiss. Komm. Meeresforsch. 21: 193-209.

From January, 1968 to May, 1969 the abundance of *Cyprina islandica* L. (Mollusca, Bivalvia) and its importance as food for cod (*Gadus morhua* L.) and dab (*Limanda limanda* L.) were investigated in Kiel Bay by means of bottom grab samples and standard trawl catches. In July and September, 1969, also diving operations were carried out for getting a clearer picture of the way *Cyprina* is taken by these fish. A new hypothesis for the problem is given. (Authors' Abstract)

Arntz, W., and D. Brunswig. 1975.

An approach to estimating the production of macrobenthos and demersal fish in a western Baltic *Abra alba* community. Meremtutkimuslaitoksen. Julk./Havforskninginst. Skr. No. 239: 195-205.

On the basis of the investigations carried out in recent years in Kiel Bight it now seems possible to form a preliminary idea of the mutual ecological and production relations between the macrobenthos and demersal fish in this area.

The ecological situation at the bottom of Kiel Bight is compared with the conditions in other well-explored areas, the differences are considered and a working model is suggested. The parts of this model that are already known are described, e.g., data are given on the biomass of the benthos and the composition of the food of the individual poulations of demersal fish. Existing and future methods for the derivation of benthos production figures for biomass data and autecological parameters are illustrated. Comparison of such figures with statistics on the composition and size of the demersal fish stocks clearly demonstrates the great significance of the bottom fauna for the production of fish in Kiel Bight. (Authors' Abstract) *Cyprina islandica* was the largest component of the macrobenthos biomass by weight.

Arntz, W.E. 1978.

The food of adult cod (*Gadus morhua* L.) in the western Baltic. Meeresforsch. 26: 60-69.

From January 1968 through May 1969, a total of 1803 stomachs of cod >35 cm, *Gadus morhua* L., from six trawling areas in the deeper parts of Kiel Bay was investigated. The material was worked up on board the research vessels.

The bivalve *Cyprina islandica* was found to be the most important food in terms of weight, followed by fish (Gadidae, Clupeidae, Pomatoschistus). Crustecans, mainly *Diastylis rathkei*, still contribute considerably to the adult cod's diet, as also do polychaetes (*Harmothoe sarsi*). The paper also gives some data on the seasonal course of food intake and discusses the reasons for the rather high food coincidence with young cod and dab. (Author's Abstract)

Arntz, W.E. 1978.

Predation on benthos by founders, *Platichthys flesus* (L.) in the deeper parts of Kiel Bay. Meeresforsch. 26: 70-78.

As part of an extensive investigation into the food of demersal fish in the Kiel Bay *Albra alba* community, the guts of 1170 flounders, *Platichthys flesus* (L.) were examined. The percentage of empty guts was very high (75.8%). The food consisted mainly of small crustaceans, with *Diastylis rathkei* holding a share by weight of 35.8% of the identifiable gut contents, and of polychaetes.

Large numbers of flounders are present in the deeper parts of Kiel Bay only in late winter and spring when the fish gather for spawning. An estimate of the amount of flounders feeding in the trawl path shows that in 1971 predation on macrobenthos was strongest during and shortly after spawning despite the fact that the percentage of empty guts is highest at this time as well. The total amount of macrobenthos consumed by flounders in the deeper parts of Kiel Bay is rather insignificant as compared with that taken by other demersal fish like cod and dab. (Author's Abstract) *Cyprina islandica* was one of the least important food species of flounder during the investigation period.

Bagge, O. 1966.

Cyprina islandica as food for cod in the western Baltic. ICES. C.M. 1966/D:15, 3 p. mimeo.

Cyprina islandica is an important food item for cod in western Baltic. The consumption of *Cyprina islandica* does not seem to be seasonally dependent. It is most often consumed by cod of 33-40 cm length group. It becomes decreasingly important as a food item in larger fish.

Bakal, A., W.F. Rathjen, and J. Mendelshon. 1978.

"Ocean quahog takes supply spotlight as surf clam dwindles." *Food Product Development* (February), Part 1.

After studying distribution, availability and quality of raw ocean quahogs, *Arctica islandica*, with respect to color, meat yield, average clam weight, odor of raw clams, and flavor and texture of fried clam strips, no major problems were identified.

Bakal, A., P. Garber, and J. Mendelshon. 1978.

"Ocean quahog invades surf clam domain, wins quality objectives." *Food Products Development* (April), Part 2.

Sensory tests were conducted on products prepared from ocean quahogs, *Arctica islandica*, and surf clams, *Spislula solidissima*. The data suggested a high probability of consumer acceptance. Processing problems were discussed. It was concluded that ocean quahogs can be substituted for surf clams in a variety of products.

Bearse, D.T. 1976.

Density and distribution of the ocean quahog (*Arctica islandica*) in Rhode Island waters relative to various environmental factors. M.S. thesis, University of Rhode Island. 90 pp.

The ocean quahog, *Arctica islandica* (Linné, 1767) is an important underutilized fisheries resource about which relatively little is known. It is widely distributed along the Atlantic Coast and is found in a variety of sediment types. This study was undertaken to determine those physical characteristics of the environment which most significantly affect the distribution and abundance of this species.

Reviews of the literature on *A. islandica* and on animal-sediment relationships in the marine environment are presented as background for the research. The sampling sites off Pt. Judith and Block Island, Rhode Island, are described, and the field and laboratory techniques are outlined.

During the summer and fall of 1975, 112 grab samples were taken at 58 stations off Pt. Judith and Block Island, Rhode Island. Eighteen variables relating to the sedimentary characteristics, depth, and organisms were measured for each grab. Measurements of length, width, whole weight, meat weight and condition index were made on each of the 129 *A. islandica* recovered from the grabs.

Simple and multiple linear regression and multivariate analysis (specifically discriminant analysis) of the data revealed distinct differences in the importance of certain measured variables in explaining the distribution and abundance of *A. islandica* between the two areas studied. These differences between Pt. Judith and Block Island suggest that no clear-cut extrapolations to other locations can be made concerning the distribution and abundance of this species relative to the variables measured. (Author's Abstract)

Belopol'skii, L.O. 1957.

Ekologiya morskikh kolonial'nykh ptits Barentsova morya. Izd-vo AN SSSR. (Ecology of marine gregarious birds of the Barents Sea. Publishing House of the Academy of Sciences of the USSR).

Bennett, J.T., K.K. Turekian, W.J. Shaul, and J.W. Ropes. 1982.

Using natural radionuclides to measure shell growth rates and ages of the bivalves *Arctica islandica* (Linné) and *Panope generosa* Gould. (Abstract) 1981 Annual Meeting, August 2-6, 1981, Williamburg, Virginia. *In*: J. Shellfish Res. 2: 88-89.

Shells of the bivalves *Arctica islandica* (Linné) and *Panope generosa* Gould were analyzed for natural radionuclides as part of a study to determine growth rates of marine organisms.

An *Arctica* having 19 to 21 growth bands collected off the coast of Long Island, NY, had been marked 2 years earlier and returned to its habitat. The two new growth bands formed since marking indicated that banding in this specimen could be annual. The quantities of unsupported PB-210 (22-year half-life) and Ra-228 (5.7-year half-life) present in the total shell are consistent with the growth bands being annual for a constant shell mass deposition and unsupported PB-210 and Ra-228 contents of the shell at the time of formation equal to that measured in the portion of shell formed during the last 2 years. An *Arctica* collected off Cape May, NJ posses 95 to 98 growth bands and at least the most recent 72 bands deposited were dificient in Pb-210 relative to Ra-226 (1,622-year half-life). Growth of Pb-210 toward secular equilibrium with Ra-226 in progressing back from the growing margin of the shell again suggests the growth bands are annual.

The external shell layers near the umbo often contained much higher concentrations of natural radionuclides than did layers near the growing margin. These findings usually indicate secondary additions of natural radioncuclides to the older shell from which the periostracum had been partially eroded. Radiometric dating of shells requires complete removal of any secondary additions of the diagnostic radionuclides. When this was done for *Arctica* and *Ponope* shells, the radiometric ages were found to be compatible with growth band ages. (Part of Authors' Abstract related to *Arctica*)

Bissell, G.E. 1972.

Review of the east coast quahaug fishery. (Guidelines for development.) Condensed Rept., Industrial Develop. Br., Fish. Mar. Serv., Environment Canada. Tech. Rept. Ser. No. 76, 47 pp.

The report examines the east coast clam fishery, and in particular the bay quahaug (*Mercenaria mercenaria*) and ocean quahaug (*Arctica islandica*), to provide a basis for the development of a Canadian quahaug industry. Practices and trends in marketing likely to affect future development are summarized as they affect product distribution. Obstacles to and opportunities for development of the fisheries are discussed, based primarily on experiences of United States producers, processors and distributors.

Boesch, D.F. 1979.

Chap. 6, Benthic Ecological Studies: Macrobenthos. *In*: Spec. Rep. Applied Mar. Sci. Ocean Engin. No. 194, Vir. Inst. Mar. Sci., pp. 1 - .

Arctica islandica was the largest contributor to mlluscan biomass in central and outer swales and elsewhere on the outer continental shelf.

Bøggild, O.B. 1930.

The shell structure of the mollusks. Kgl. Danske Videnskab. Selskabs, Skrifter Naturvidenskab. math. Afdel. 2: 232-325.

Describes the shell of *Cyprina islandica* as having an obscure homogeneous structure that may have small traces of other structures.

Boss, K.J., and A.S. Merrill. 1965.

Degree of host specificity in two species of *Odostomia* (Pyramidellidae: Gastropoda). Proc. Malac. Soc. Lond. 36: 349-355.

O. bisutularis given a choice between several bivalves became attached to all but one. *Arctica* was a species it attached to.

Boss, K.J. 1969.

Nomenclatorial Note: Articidae versus Cyprinidae (Mollusca; Bivalvia). Nautilus 83: 61-64.

It is proposed that the nomen Cyprinidae should not be used in malacological literature for the ocean quahog, *Arctica islandica*, but should be replaced by the junior synonym, Arcticidae Newton 1891.

Bourne, N., E.I. Lord, and A.R. McIver. 1961.

Gulf of St. Lawrence Scallop Survey 1961. Fish. Res. Bd. of Canada. MRS (Biol) No. 807.

Study Date: 1961 (From Hiltz, 1977)

Survey Objective:
Scallop Survey - records were kept of dominant bottom invertebrate species where scallop beds were located; among those recorded was the *Arctica islandica* or ocean quahaug.

Areas Surveyed:
Region I: Northumberland Strait: the area bounded on the northwest by a line from Point Escuminac, N.B. to North Point, P.E.I. and on the southeast by a line from Cape George, N.S. to East Point, P.E.I.
Region II: Southeast Gulf of St. Lawrence: George's Bay and the west coast of Cape Breton Island.

Region III: North Coast of Prince Edward Island: extends from East Point to North Point.
Region IV: Western Gulf of St. Lawrence: the area from Escuminac Point, N.B. to Shippegan Island.
Region V: Chaleur Bay: the beds in Chaleur Bay and east coast of Miscou Island.

Page 23, MRS (Biol) No. 807 summarizes survey; records type of bottom.
Charts B outline survey results.

Conclusions

Indicated substantial stocks of ocean quahaugs in five areas and bar clams in three areas.
Richibucto Bed Tows: Made in approximate areas outlined in 1961 Scallop Survey (Bourne & McIver, 1961. MRS #807) and during submarine exploration by Dr. John Caddy (Caddy, J. 1970. Fish. Res. Bd. of Canada 27:545).
Dredge performance: not working properly.
Escuminac Bed Tows: Conducted in areas where large quantitites of empty bar clam shells had been reported. Toothed scallop drag and rocker dredge compared in paired tows. Dredge performance: not digging properly.
Richibucto Harbor Tows: Rocker dredge performed in soft bottom but in areas where sand intermingled with mud, dredge would not perform.
Summary of tows made with rocker dredge and toothed scallop dredge in Richibucto and Escuminac areas: see attached Charts E and F.

Conclusions

Although few living ocean quahaugs were found this should not be taken as an indication that ocean quahaugs were not present; hard bottom contributed to poor dredge performance; if commercial exploration is considered a hydraulic dredge should be used and successful fishery of ocean quahaugs and bar clams are reasonable expectations.

Bourne, N., E.I. Lord, and A.R. McIver. 1961.

Gulf of St. Lawrence Scallop Survey - 1961. Fish. Res. Bd. Canada, MRS (Biol), No. 807.

July 1969 (From Hiltz, 1977)

Area:

Richebucto and Escuminac, N.B. Based on indications (empty ocean quahaug shells) observed and reported MRS #807 (Bourne & McIver).

Survey Conducted by:

St. Andrews Biological Station and Dept. of Fisheries and Foresty Industrial Development Service, Ottawa.

Vessel Used:

M.V. PANDALUS II

Dredge Used:

(a) St. Andrews FRB rocker dredge; (b) toothed Digby dredge.

Bourne, N., and T.W. Rowell. 1965.

Gulf of St. Lawrence Scallop Survey - 1963. Fish. Res. Bd. Canada, MRS (Biol) No. 808.

Survey Date: 1963 (From Hiltz, 1977)

Survey Objective:
As part of a gear research program, a comparison was made of five scallop drags. When completed a brief survey of scallop populations of four beds in Gulf of St. Lawrence conducted. *Arctica islandica* (ocean quahaugs) and empty shells of this species were identified along with several other invertebrates.
Refer pg 5: MRS (Biol #808), Richebucto Bed, Area II.
Refer pg. 5-6: MRS (Biol #808), Pictou Island, West Bed.

Bourne, N., and T.W. Rowell. 1965.

Gulf of St. Lawrence Scallop Survey - 1964. Fish. Res. Bd. Canada, MRS (Biol) No. 809.

Survey Date: 1964 (From Hiltz, 1977)

Survey:
Scallop Survey. Attempts were continuing to establish presence of scallops; ocean quahaugs were identified in a number of locations along with other bottom invertebrates in the eleven beds tested.

Bousfield, E.L. 1958.

Littoral marine arthropods and mollusks collected in Western Nova Scotia, 1956. Proc. Nova Scotia Inst. Sci. 24(3)(1956-57): 303-325.

Sixty-three species of marine molluscks collected in western Nova Scotia are recorded and discussed in connection with the main feature of intertidal ecology and faunal composition of the region. *Arctica islandica* is listed from off Cape Sable Island, near Absolom Point; Round Bay; and Western Head, Lockeport Region as an occasional clam of outer sand beaches.

Bowden, J., and D. Heppell. 1968.

Revised list of British mollusca. 2. Unionacea - Cardiacea. J. Conch. 26: 237-272.

Includes *Arctica islandica* in the list.

Brand, A.R., and A.C. Taylor. 1974.

Pumping activity of *Arctica islandica* (L.) and some other common bivalves. Mar. Behav. Physiol. 3: 1-15.

Thermistor flowmeters were used to investigate the pumping activity of *Arctica islandica* together with five other subtidal and three intertidal bivalves. The subtidal species, with the exception of *Chlamys opercularis*, show an intermittent pattern of pumping activity of several minutes' periodicity which is independent of phasic shell adduction. In contrast the intertidal species and the subtidal *Chlamys* pump more or less continously. The pumping behavior of *Arctica* is modified under conditions of respiratory stress; the time spent pumping increases from 40-60% to over 95% as the PO_2 of the ambient water is reduced from 160 mm Hg to 30-35 mm Hg. Continuous recordings were made of the PO_2 of the mantle cavity water of *Arctica* during normal pumping activity. The possible mechanism controlling pumping behavior is discussed, together with the problems of determining bivalve respiration rates at defined levels of activity. (Authors' Abstract)

Brooke, R.O., J.M. Mendelsohn, and F.J. King. 1968.

Significance of dimethyl-sulphide to the odour of soft-shell clams. J. Fish. Res. Bd. Canada, 25: 2543-2460.

In 12 samples of fresh soft-shell clam meats which were collected over their spawning period, the average concentration of dimethyl sulfide (DMS) was 3 ppm. Odor evaluations were made to determine the range of concentration of pure DMS that a panel recognized as a clamlike odor. Since the concentration of DMS in our clam samples was within this range (0.08-40 ppm), it is suggested that DMS dominates the odor of fresh soft-shell clams. *Arctica* contained a negligible amount of DMS in its aroma. (Authors' Abstract)

Brotskaya, V.A., and L.A. Zenkevich. 1939.

Kolichestvennyi uchet donnoi fauny Barentsova morya.- Trudy Vses. nauchno-issled. in-ta morsk. rybn. khoz-va i okeanogr., t. IV, No. 8. (Quantitative counts of the Barents Sea benthic fauna. Transactions of the All-Union Scientific Research Institute of Maritime Fisheries and Oceanography, volume 4, No. 8).

Brown, M. 1977.

Gear design, market report. Results of the DMR quahog fishery research. Maine Commer. Fish. 6 pp.

Popular report on harvesting with plans of a small hydraulic dredge and recipes.

Bruce, J.R., J.S. Colman, and N.S. Jones. 1963.

Marine Fauna of the Isle of Man and its Surrounding Seas. L.M.B.C. Memoir No. 36, Liverpool University Press, p. 214.

Cyprina islandica reported as abundant in part of the area.

Braunberg, L. 1964.

On the nemertean fauna of Danish waters. Ophelia 1: 77-111.

Arctica islandica included as a host for the commensal nemertean *Malacobdella grossa*.

Buelow, R.W. 1968.

Ocean disposal of waste material. Trans. Nat. Symp. Ocean. Sci. Eng. Atl. Shelf, Mar. 19-20. p. 311-337.

The trace metals Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn were found in samples of black quahogs from the New York Bight, as well as MPN and fecal coliform values. Danger of indiscriminant dumping of wastes near clam beds is discussed.

Burnette, J.A., G.J. Flick, J.R. Miles, R.L. Ory, A.J. St. Angelo, and H.P. Dupuy. 1983.

Characterization and utilization of ocean quahog (*Arctica islandica*) clam juice as a liquid and dehydrated flavoring agent. J. Food Sci. 48: 353-359.

Ocean quahog (*Arctica islandica*) juice produced from mechanical shucking operations was vacuum evaporated, freeze-dried, or spray-dried for use as a natural clam flavoring agent. The flavorings were judged equal or superior to several commercially available flavors when used in prepared dishes. Gas chromatographic profiles indicated high volatile concentrations in the effluent from the heat shocking and first washing process. Almost no volatiles were present in successive washings. The use of dextrins was not required since the natrual chloride salts of potassium and sodium aides in obtaining powders of acceptable quality. (Authors' Abstract)

Bush, K.J. 1885.

List of deep-water Mollusca dredged by the United States Fish Commission Steamer Fish Hawk in 1880, 1881, and 1882, with their range in depth. *In*: U.S. Comm. Fish and Fisheries, Part XI. Rep. Comm. for 1883. Appen. D. Natural History and Biological Research, p. 701-727.

Range of living specimens of *Cyprina islandica* given as from 8 to 128 fathoms; dead shells only from 130-349 fathoms.

Caddy, J.F. 1970.

Records of associated fauna in scallop dredge hauls from the Bay of Fundy. Fish. Res. Board Can., Tech. Rep. No. 225, 11 pp.

Cyprina islandica is an occasional mud-dwelling bivalve found in scallop dredge samples from the northern part of the Bay of Fundy and around the Wolves.

Caddy, J.F. 1970.

A method of surveying scallop populations from a submersible. J. Fish. Res. Bd. Canada. 27(3): 535-549.

Quahaug Resouce: (From Hiltz, 1977)

Richibucto Bed Tows:

Made in approximate areas outlined in 1961 Scallop Survey (Bourne and McIver, 1961. MRS #807) and during submarine exploration by Dr. John Caddy (Caddy, J. 1970. Fish Res. Bd. of Canada 27:545). Dredge performance: not working properly.

Escuminac Bed Tows:

Conducted in areas where large quantities of empty bar clam shells had been reported. Toothed scallop drag and rocker dredge compared in paired tows. Dredge performance: not digging properly.

Richibucto Harbour Tows:

Rocker dredge performed in soft bottom but in aras where sand intermingled with mud, dredge would perform.

Summary of tows made with rocker dredge and toothed scallop dredge in Richibucto and Escuminac areas: see attached Charts E and F.

Conclusions:

Although few living ocean quahaugs were found, this should not be taken as an indication that ocean quahaugs were not present; hard bottom contributed to poor dredge performance; if commercial exploration is considered, a hydraulic dredge should be used and successful fishery of ocean quahaugs and bar clams are reasonable expectations.

Caddy, J.F. 1970.

A method of surveying scallop populations from a submersible. J. Fish. Res. Bd. Canada 27: 535-549.

A system is described for continuously recording density changes across a population of benthic organisms from a submersible. This system was tested in the Northumberland Strait over a population of scallops (*Placopecten magellanicus*). A continuous record of scallops visible from the viewport of the submersible was registered on a chart recorder, concurrently with a series of exposures by an externally mounted automatic camera. Transects up to 4 km long were completed in a single dive.

A distance trace provided by a towed odometer wheel allowed visual counts to be expressed as linear densities (numbers seen per unit distance travelled) independently of submersible speed. An estimate of the width of visual field at a known height off bottom enabled linear densities to be converted into population densities (numbers seen per unit area of sea floor).

Scallop distribution in the area was markedly contagious. Areas of high scallop density (up to 4.8 scallops/m^2), of the order of 0.5 km across, on sand, were separated by stretches of mud where scallop density was below 0.1/m^2.

Arctica shells seen and areas of maximum shell abundance seemed to coincide spatially with areas where siphon holes of living ocean quahogs were abundant. (Author's Abstract)

Caddy, J.F., R.A. Chandler, and D.G. Wilder. 1974.

Biology and commercial potential of several underexploited molluscs and crustaceans on the Atlantic coast of Canada. A paper presented to the Federal-Provincial Fisheries Committee Meeting on *Utilization of Atlantic Resources*, Monteal, February 5-7, 1974. (A processed copy available at NMFS, Woods Hole Laboratory).

Includes a description of *Arctica islandica* in Northern Atlantic waters; its life history; habitat and geographical range; notes on toxicity, disease, and predators; growth and natural mortality; history of commercial exploitation and estimated stocks; harvesting methods; and processing and commercial exploitation.

Caracciolo, J.V., and F.W. Steimle, Jr. 1983.

An atlas of the distribution and abundance of dominant benthic invertebrates in the New York Bight Apex with Reviews of their life histories. NOAA Tech. Rept. NMFS SSRF-766, 58 p.

Distribution, abundance, and life history summaries are given for 58 important species of benthic invertebrates collected in the New York Bight apex during five sampling cruises in 1973 and 1974. These species showed affinities to major community types that have been previously identified in the Middle Atlantic Bight and some showed varying degrees of tolerance of areas in the apex where the dumping of New York Harbor dredge spoils and New York metropolitan area sewage sludge occurs. *Capitella capitata*, a species often associated with pollution stress, dominated the sewage sludge dump site. (Authors' Abstract) *Arctica islandica* was an important species collected in the area.

Carter, J.G. 1976.

The ecologic and phylogenetic significance of the periostracum in the Bivalvia. Thesis, Yale University, 169 p.

Information has been assembled from the literature on resemblance, similarity, shell amino acid relationships, ancestral relatives, possession o minute periostracal thorns, and microstructural features of the shells of Arcticacea, the superfamily which includes *Arctica islandica*; specifically for *A. islandica* the periostracum has been described as a thin, homogeneous layer and a laminated layer and it incorporates vescicles within its folds by fusion of inner periostracal laminae.

Carter, J.G., and M.J.S. Teresz. 1978

The shell structure of *Ptychodesma* (Cyrtodontidae; Bivalvia) and its bearing on the evolution of the Pteriomorpha. Phil. Trans. R. Soc. Lond. B. 284: 367-374.

The inner shell of *Ptychodesma knappianum* is of complex crossed lamellar (c.c.f.) structure varying locally from cone c.c.l. to irregular and fine c.c.l. and is a variety known to occur in Arcticacea, which includes *Arctica islandica*

Carter, J.G. 1979.

Comparative shell microstructure of the Mollusca, Brachiopoda and Bryozoa. Scanning Electron Microscopy, SEM Inc., O'Hare, IL. Vol. 2: 439-456.

The diversity of microstructural elements for molluscs as opposed to brachiopods and bryozoans is presented in relation to evolution. Microstructural elements of *Arctica* shell are included and photographed.

Caspers, von H. 1939.

Die Bodenfauna der Helgolander Tiefen Rinne. (The bottom fauna of the Helgoland ____, Rhine). Helgolander Wiss. Meeresunters 2: 1-112.

Reports one large *Cyprina islandica* taken in the research area.

Chaisson, D., T. Mclane, T. Martin, and V.Nams. 1982.

The distribution, abundance, and biological analysis of ocean quahogs (*Arctica islandica*) from southwestern Nova Scotia. Vol. II, Final Report, Cont. No. 07SC. FP-0-0973, Bio-Atlantic Ltd., 25 pp. with appendix (23 Figs. and 6 Tables).

Biomass estimates, density, maturation and age analysis, sediment analysis, length vs. weight analysis and maximum sustainable yield estimates are given for *Arctica islandica*.

Chandler, R.A. 1965.

Shoal-water relaying of ocean quahaugs before canning. Fish. Res. Bd. Canada. Orig. Manuscript of St. Andrews Biological Station. No. 1017.

Chandler, R.A. 1965.

Ocean quahog resources of southeastern Northumberland Strait. Fish. Res. Bd. Can., MS Rep. (Biol.), No. 828, 32 pp.

Reports finding a commercial resource of ocean quahogs during 1958 explorations of southeastern Northumberland Strait. Commercial catches of 160 bushels per day were recorded in 1959. Indicates that a fishery could be established if markets were established and a remedy found for an offensive "iodine" flavour.

Preliminary trials carried out November, 1956: (From Hiltz, 1977)

Area:
Cape Bear, P.E.I. and Pictou Island.
Survey Conducted by:
St. Andrews Biological Station, N.B. - Fisheries Research Board of Canada
Vessel used:
Murray Harbour I
Dredges used:
Two small dredges without attachments:
a. Fall River Dredge (Terry Crawford modifications)
b. Local Dredge
Quahaug Resource:
Indications of marketable quantitites if suitable hydraulic dredge used.
Quahaug Resource:
-- Marketable resource located east of Cape Bear Light (areas explored Attached Chart A)
-- Pictou Island, catches low
-- Merigomish Island, no quahaugs
-- Cape George, a few quahaugs
-- Livingstone Cover, one bushel per 10-minute tow recorded
Important operating principles obtained from this trial:
1. Dredge blades need not be set to dig below 4-5 inches as quahaugs are not deep burrowers
2. Dredge efficiency (digging rate) directly related to capacity of water jets

Chandler, R.A. 1969.

Ocean quahog exploration with rocker dredge off Cape Sable Island, N.S., May 20-23. MRS #1068. *In*: Medcof, J.C., D.F. Alexander, and R.A. Chandler. 1969. Promising places to look for ocean quahogs and bar clams and trial fishing with a rocker dredge off Richibucto, N.B. and Clark's Harbour, N.S. Fish. Res. Bd. of Canada. MRS No. 1068: 31 pp.

Survey Date: May, 1969 (From Hiltz, 1977)

Area:
Cape Sable Island. Survey conducted based on reports in August, 1966, that ocean quahaugs were abundant on ocean floor in the area.
Survey conducted by:
St. Andrews Biological Station, Fisheries Research Board.

Vessel Used:
M.V. Pandalus II.
Dredge Used:
Fall River rocker dredge.
Objective:
To determine (1) location, (2) position, breadth and depth of beds (3) size composition and abundance of population.
Areas Explored:
Charts C and D (attached).
Quahaug Resource:
-- Unfavorable weather limited tows to only 8.
-- Tows substantiated quahaugs are abundant in the area.
-- Quahaugs were of commercial size for steaming and mincing but too small for "stuffed clams."
-- Annual recruitment judged as irregular, based on absence of small quahaugs.
-- Ocean bottom dictates: hydraulic dredge must be used for harvesting or surveying.
-- No definite position established on position of beds or density of population.

Chene, P.A. 1972

Growth, paralytic poison accumulation and other features of ocean clams (*Arctica islandica*). Fish. Res. Bd. Canada, Orig. MRS St. Andrews Biological Station. No. 1104. 34 pp.

Crandall, D. 1968.

Food experts test "brand new" ocean quahog *In*: The Boston Globe, Tuesday, March 12, p. 17.

Crossen, J.M., and R.J. Smolowitz. 1980.

Power system requirements of an electro-hydraulic clam dredge. Reprinted from Marine Technology, October 1980, Sixteenth Ann. Conf., p. 433-438.

An electrically driven submersible pump that is mounted on a commercial style surf clam dredge is provided power via a specially designed controller, cable, and connector system. The 17-foot long, 7000 pound dredge has a 60-inch wide cutting knife and uses 2000 gallons per minute of water supplied to the jet manifold. The pump power requirement is 100 amps of 460 VAC 3 phase current provided by one of the ship's 150 KW generators. The dredge has been used successfully during clam surveys along the Northeast Coast of the United States in water depths to 50 fathoms. Advantages of the system compared to conventional surface supplied hydraulic dredges are ease of handling, consistency of operation, and efficiency in power transmission. The history of the system development is covered including problems encountered in providing reliable electric power to ruggedly fished gear. The various controllers, cables, and connectors are described. (Authors' Abstract) The dredge has been used to sample *Arctica*.

Cummins, R., Jr. 1966.

Hard clam explorations off southeastern United States. Comm. Fish. Rev., December, p. 33-42.

Noted small numbers of *Arctica* captured during two cruises and only in deeper water (20 to 25 fm) north of Oregon Inlet, but none were caught south of Oregon Inlet.

Dall, W.H. 1913.

Note on *Cyprina islandica*. Proc. Malacol. Soc. London 10: 286.

Brief discussion of the use of the genus name *Cyprina* or *Arctica*. (See also Boss, 1969).

Darling, D.B., C.F. Lee, and H.W. Nilson. 1945.

Nutritive value of ocean quahogs. *In*: Neville, W.C. (coordinator). The ocean quahog fishery of Rhode Island. R.I. Dep. Agric. Conserv., Div. Fish Game, p. 25-26.

The nutritive value of ocean quahogs (simmered) was 24.8% dry weight, 18.2% protein, 0.3% fat, 2.2% mineral matter, and 2.8% glycogen. These values were compared with bay quahogs. Thiamine and riboflavin were assayed and only the latter was found. High nutritive value was claimed in tests using ocean quahog meats as a food for rats.

Davis, F.M. 1923.

Quantitative studies on the fauna of the sea bottom. No. 1 - Preliminary investigations of the Dogger Bank. Fish. Invest. Ser. II, Mar. Fish., G.B. Minist. Agric. Fish. Food 6(2): 1-54.

Lists *Arctica islandica* as another Lamellibranchiata found at some locations.

Deryugin, K.M. 1915.

Fauna Kil'skogo zaliva i usloviya ee sushchestvovaniya. -Zap. Akad. Nauk, seriya 8, t. 34, vyp. 1. (The fauna of the Kola Bay and conditions of its existence. Transactions of the Academy of Sciences series 8, volume 34, No. 1).

Deryugin, K.M. 1928.

Fauna Belogo Morya i usloviya ee sushchestvovaniya. -Issledovaniya morei SSSR, vyp. 7-8. (The fauna of the White Sea and conditions of its existence. Investigations of the seas of the USSR, No. 7-8).

Deryugin, K.M., and A.V. Ivanov. 1937.

Predvaritel'nyi obzor rabot po izucheniyu bentosa Beringova i Chukotskogo morei. -Tam zhe, vyp. 25. (A preliminary review of papers on the investigation of benthos in the Bering and Chukchi Seas. -*Ibidem*, No. 25).

DeWolf, R.A., and V.L. Loosanoff. 1945.

Biology of the ocean quahog. *In*: Neville, W.C. (coordinator). The ocean quahog fishery of Rhode Island. R.I. Dep. Agri. Conserv., Div. Fish Game, p. 14-16.

The shell, meat color, and anatomy of *Arctica islandica* are briefly described. Ecological notes are included about the habitat of the clam, gonad development and spawning, and size composition.

Dexter, R.W. 1947.

The marine communities of a tidal inlet at Cape Ann, Massachusetts; a study in bioecology. Ecol. Monogr. 17: 262-294.

Arctica islandica is a bottom invertebrate included in dredgings in Ipswich Bay.

Dexter, R.W. 1968.

Distribution of the marine molluscs at Cape Ann, Massachusetts. Mar. Biol. Assoc. India, Proc. Symp. on Mollusca [Cochin]. January 12 to 16, 1968, Symp. Ser. 3, p. 214-222.

Surveys of marine life at Cape Ann were made particularly in 1933-37 and 1956-61. Incidental collecting was done at certain other years through 1967. Molluscs totalled 81 species (34 gastropods, 3 amphineurans, 1 scaphopod, 39 pelecypods, 4 cephalopods). Species distribution in the five natural areas was as follows: Ipswich Bay (64); North branch--Annisquam River (45); Little River (28); South branch--Annisquam River (26); Gloucester Harbor (41). Fourteen species were found in all five areas; 9 in all but one area; 13 in all but two areas; 14 were found in two areas; 31 were found in only one area. The latter were largely uncommon species of those with restricted habitat preference. Twenty species were predominantly intertidal and 61 predominantly subtidal. They occurred primarily in the following habitats: pelagic (4); ubiquitous bottom (3); solid surfaces (14); seaweeds (6); in wood (3); sediments (22); sand (22); mud (2); hard clay (1); marsh (4). Sand dwellers were more common in Ipswich Bay; mud dwellers were more common in Gloucester Harbor. Nudibranchs were more common in the harbor because of wharf pilings. Differences in the mollusc fauna are attributed largely to uncommon species of limited distribution and those with restricted habitat preferences. (Author's Abstract) *Arctica islandica* occurred in deeper waters and more oceanic habitat of Ipswich Bay and Gloucester Harbor.

Dolan, J.W. 1969.

Creates demand for new products. Food Engineering, 41(1): 50-51.

Drinnan, R.E., M.L.H. Thomas, S.E. Vass, and L.L. MacLeod. 1965.

The annual report, oyster and quahaug investigations, Biological Sub-Station, Ellerslie, P.E.I. Jan. 1, 1964 - Dec. 31, 1964. FRB MS No. 1014.

Detweiler, J.D. 1915.

Preliminary notes on the mollusca of St. Andrews and vicinity, New Brunswick. Contri. Can. Biol. 1911-1914: 43-46.

Cyprina islandica was one Pelecypod identified during one month of dredging activity in the late summer of 1912. It was dredged in muddy bottom off Pendleton's Island in 40 fathoms, August 29. (J.B.)

Dewar, A.B., R.L. Selfridge, and G.G. Sims. 1976.

A. processing and general observations. *In*: Experimental canning of ocaen quahogs (*Arctica islandica*). Dep. Environ. Canada, Fish. Mar. Serv., Tech. Rep. No. 673, p. 1-16.

A study was undertaken to determine the effectiveness of hydrogen peroxide as a dip for Ocean Clams (*Arctica islandica*) meats to prevent or retard blue or black discolouration in the canned product. Shucked and washed clam meats were dipped in 800 and 400 P.P.M. H_2O_2 solutions for 10 minutes. The clam meats were then dipped in cold water for an additional 10 minutes, drained and canned. Chemical analyses were carried out on the dips and also on the canned product to determine hydrogen peroxide residues, if any. As an alternative treatment, 0.1% citric acid was added to untreated clams before canning. The effects of citric acid and hydrogen peroxide treatments wee than compaed to a control group.

The effects of storage conditions and precooking were also studied.

No hydrogen peroxide residue was detected in the final canned product. The addition of citric acid (0.1% of the total can contents) was more effective in preventing or retarding the formation of blue or black discolouration in canned Ocean Clams, than the use of hydrogen peroxide dips. In addition, the use of citric acid was found to be easier, cheaper and safer than the use of hydrogen peroxide.

The other treatments used in this study are discussed and summarized. (Authors' Abstract)

Dries, R.R., and H. Theede. 1974.

Sauerstoffmangelresistenz mariner Bodenevertebraten aus der Westlichen Ostsee (Resistance to oxygen deficiency in marine bottom invertebrates of the Western Baltic Sea). Marine Biology 25, 327-333.

Among the macrobenthos fauna of the Western Baltic Sea, lamellibranchs occurring in poorly oxygenated soft sediments exhibit especially high tolerances to temporary oxygen deficiency. Such tolerance is less well developed in mobile species of various systematic groups than in more or less immobile forms. Commonly, tolerance to oxygen deficiency tends to increase with decreasing temperature. Different qualitative relations between tolerance to oxygen deficiency and temperature may be correlated with the distributional range of the species. (Authors' Abstract) *Arctica islandica* was a species studied.

Edwards, R.L., and K.O. Emery. 1968.

The view from a storied sub the "Alvin" off Norfolk, Va. Commer. Fish. Rev. 30(8-9): 48-55.

Includes photographs of an ocean quahog graveyard.

Ekman, S. 1967.

Zoogeography of the sea. Sidgwick and Johnson, Ltd. London, 417 pp.

Reviews recent geological history of *Cyprina islandica* and other invertebrates. Includes *C. islandica* as an immigrant to the Mediterranean during the early Quaternary Period. He considers the clam is a distinctly boreal species and notes shifts in habitat related to changes in temperatures during geological time.

Emery, K.O. 1968.

Positions of empty pelecypod valves on the continental shelf. J. Sediment. Petrol. 38: 1264-1269.

The commonest and most stable position of the empty valves of large pelecypods (such as *Arctica islandica*) on the wave-washed zone of beaches is concave down; this position is due to the presence of fast currents and the absence or inadequacy of bioturbation. In contrast, most large pelecypod valves on the surface of the continental shelf lie in a concave up position in response to the action of carnivores and scavengers and to powerful bioturbation and the absence of fast currents. These observations of preferred positions can be applied to paleoecological studies of ancient strata. (Author's Abstract)

Emery, K.O., A.S. Merrill, and J.V.A. Trumbull. 1965.

Geology and biology of the sea floor as deduced from simultaneous photographs and samples. Limnol. Oceanogr. 10: 1-21.

During 1963, 260 paired photographs and large bottom samples were taken on the continental shelf and slope off northeastern United States. The photographs revealed surface characteristics of the sediments and natural attitudes of benthic animals; the samples retrieved specimens for geological and biological examination and identification. Dominant shells in an area of angular to rounded gravel to 7 cm diameter and medium to coarse-grained sand included *Arctica islandica*. (Abridged Authors' Abstract)

Energy Resource Co., Inc., 1978.

New England OCS Environmental Benchmark Draft Final Report Vol. II. May 19, 1978. Contr. AA550-CT6-51. p. IV-483-IV-568.

Reports the distribution of *Arctica islandica* in a wide band along the southern edge of Georges Bank. Hydrocarbon analyses of benthic macrofauna showed that petroleum hydrocarbons were present in significant concentrations over most areas of the Bank. Miniature tar balls were the major source of contamination. *Arctica* was the most contaminated of all macrofauna sampled for analysis. High values of cadmium, chromium, iron, lead and zinc were found in the adductor muscles of *Arctica*, along with average values of copper and nickel.

Engle, J.B. 1970.

Oyster and clam management. *In*: Benson, N.G. (ed.), A Century of Fisheries in North America. Amer. Fish. Soc., Spec. Publ. No. 7, p. 263-276.

The mahogany clam or ocean quahog is mentioned as a relatively untouched resource of potential future use. Occurrence of stocks at 20 to 30 fathom depths present problems for harvesting operatins. Its flavor is different from that of other clams.

Environment Canada. 1973.

Environment Canada, Departmental Manual of Acts and Regulations 51. Nova Scotia Regulations, p. 51-1, 51-10, 51-30, 51-31, 51-32.

Erlenkeuser, H., H. Metzner, and H. Willkomm. 1975.

University of Kiel radiocarbon measurements VIII. Radiocarbon 17(3): 276-300.

Measurements are reported of ^{14}C in the shell carbonate and flesh of *Cyprina islandica* collected alive in Kiel Bight, W. Baltic Sea.

Fahlen, L.A. 1967.

Deck equipment layout on M/V Delaware for surf clam survey. Comm. Fish. Rev., October, p. 87-89.

Describes deck equipment used with a hydraulic surf clam dredge.

Fahlen, L.A., and P.S. Parker. 1968.

Special small-clam retainer and bottom sampler design. Comm. Fish. Rev. 30(2), February: 23.

Describes a retainer bag mounted in a hydraulic surf clam dredge useful in catching small clams.

Filatova, Z.A. 1957.

Obshchii obzor fauny dvustvorchatykh mollyuskov severnykh morei SSSR. -Trudy in-ta okeanol., t. 20 (A general review of the fauna of bivalvic molluscs of the northern seas of the USSR. Transactions of the Institute of Oceanology, volume 20).

Fish, C.J. 1947.

The black quahog, *Arctica islandica*, in Rhode Island waters. *Ex* "The Conservation of Marine Resources in Rhode Island." April 10, 2 pp.

Popular account of a possible marine resource.

Fletcher, G.L. 1971.

Accumulation of yellow phosphorus by several marine invertebrates and seaweed. J. Fish. Res. Board Can. 28: 793-796.

In an experiment, selected marine invertebrates (including *A. islandica*) and seaweed were exposed to solutions of yellow phosphorus for 48 hr. Detectable amounts of the phosphorus were absent in the experimental specimens 7 days after they were placed in seawater free of the chemical. This indicated that this element is cleared rapidly from these animals.

Fogarty, M.J. 1981.

Distribution and relative abundance of the ocean quahog *Arctica islandica* in Rhode Island Sound and off Martha's Vineyard, Massachusetts. Journal of Shellfish Research, Vol. 1, No. 1, 33-39.

Estimates of minimum biomass (total wet weight and meat weight) were derived for *Arctica islandica* in parts of southern New England. Total harvestable biomass for the survey area was estimated at 1.004×10^6 metric tons (mt) total wet weight and 1.33×10^5 mt meat weight. Stepwise linear discriminant analysis was used to isolate sediment components which contribute to separation of regions of high- and low-ocean quahog densities (arbitrarily assigned values of ≥ 0.75 kg/m^2 and ≤ 0.10 kg/m^2 total wet weight, respectively). The percentage of four sediment fractions: gravel, coarse sand, medium sand, silt/clay, and the percentage of shell in the sample were sufficient to significantly ($P<0.01$) discriminate between the two levels of ocean quahog densities. Size composition data and shell length-meat weight regressions for three depth intervals within the survey area are presented. (Author's Abstract)

Forster, G.R. 1981.

A note on the growth of *Arctica islandica*. J. Mar. Biol. Assoc. U.K. 61: 817.

Observations on three tagged *Arctica* indicated slow growth (ca. 0.1 mm per year).

Fosshagen, A. 1965.

Bunnevert ebratlarven over et *Venus* - samfunn i Oresund. Thesis (in Norwegian). University of Bergen, Norway, 70 pp.

Snell D. Foster, Inc. 1977.

Presentation on the "evaluation of the potential for more aggressive use of the ocean quahog." Prepared for the United States Department of Commerce, National Oceanic and Atmospheric Admin., National Marine Fisheries Service. Contract No. 03-6-043-35129.

Foster D. Snell, Inc., a Division of Booz, Allen, and Hamilton was contracted to gather background information on the clam industry on the East Coast of the U.S. Their objective was to generate and disseminate information about the ocean quahog to industry and potential investors who may take the lead in commercial utilization of this species. Foster D. Snell generated some suggested research needs for the ocean quahog: I. Resource Studies, II. Raw Materials Studies, III. Processing Studies, IV. Product Development Studies, and V. By-Product Utilization (J.B.).

Foster-Smith, R.L. 1975.

Some mechanisms for the control of pumping activity in bivalves. Mar. Behav. Physiol., Vol. 4, p. 41-60.

1) Filtration rates of a number of bivalves are compared on a basis of the porosity of their gills. There is no obvious difference in the performance of infaunal, siphonate bivalves and epifaunal, non-siphonal bivalves.
2) The exhalant aperture may control water flow in three ways:
   a) periodic closure of the exhalant aperture;
   b) restriction of the exhalant aperture to a small size;
   c) rapid and repeated expansion and contraction of the exhalant aperture.
3) In high concentrations of suspension of *Phacodactylum*, a reduction in the time spent pumping accounted for reduced filtration rates up to concentrations of 1 million cells/ml in the cases of *Mytilus edulis* and *Mya arenaria*, and up to concentrations of 1/2 million cells/ml in the cases of *Cerastoderma edule* and *Venerupis pullastra*.
4) Water flow in a bivalve has been examined from a theoretical standpoint and suggests that an 80% reduction in the size of the exhalant aperture is required before greatly affecting the total resistance to flow through the system. (Author's Conclusions) *Arctica* was included in the discussion, but it was not a principal species studied.

Franz, D.R., and A.S. Merrill. 1980.

Molluscan distribution patterns on the continental shelf of the Middle Atlantic Bight (Northwest Atlantic). Malacologia, 19(2): 209-225.

A zoogeographic analysis of the inner continental shelf fauna of the Middle Atlantic Bight (Cape Cod, Massachusetts, to Cape Hatteras, North Carolina, U.S.A.) is presented based on the geographical and depth distributions of the 184 mollusk species collected by the R/V DELAWARE II in 1960 (Cruise 60-7). The Middle Atlantic Bight fauna contains fewer than 4% of species endemic to this zone, and is composed of a mixture of northern and southern species. The former comprises two faunal groups, an Arctic-Boreal group containing species which extend northward into arctic waters, and a Boreal group, which reaches northern limits near the south of Labrador. Species of both faunal groups reach their southern limits in the Middle Atlantic zone.

The faunal component of predominantly southern species is designated the Transhatteran faunal group, a term which emphasizes the capability of these species to transgress the ecological barrier of Cape Hatteras.

Many arctic-boreal and boreal species exhibit submergence south of Cape Cod, i.e., they track cold isoterms into the deeper shelf waters. Species showing submergence tend to be amphi-Atlantic in distribution. Endemic boreal species generally do not show submergence in the Middle Atlantic Bight and are thus more tolerant of warm summer temperatures which characterize the inshore waters of this area. Transhatteran species do not show submergence, although they are variable in their depth distributions. (Authors' Abstract) Includes *Arctica*, a boreal species which shows submergence as indicated by occurrence at increasing minimum depths with decreasing latitude.

Franz, D.R., and A.S. Merrill. 1980.

The origins and determinants of distribution of molluscan faunal groups on the shallow continental shelf of the northwest Atlantic. Malacologia, 19(2): 227-248.

An analysis of the extended geographical ranges, and endemicity, of the most prominent gastropod and bivalve species of the shallow ($\leq$ 150 m) continental shelf of the northwest Atlantic is presented. Three faunal groups, the Arctic-Boreal, Boreal and Transhatteran, broadly overlap in the zone between Cape Hatteras, North Carolina, and northern Labrador. The hypothesis that these faunal groups differ in their origins and paleoecology is examined. The hypothesis is supported for the Arctic-Boreal and Transhatteran faunal groups. The former consists of Pliocene trans-arctic migrants into the North Atlantic; the latter comprises species which are derived from the Miocene/Pliocene Atlantic fauna. The Boreal faunal group is of mixed origins, including trans-arctic migrants, species of Atlantic origins and species of Miocene American progenitors.

Paleo-oceanographic factors are discussed in relation to the probable Pliocene emergence of the endemic boreal component; and the glacial environment off the northwest Atlantic shell zone is described as it relates to the probable survival of boreal species during the Pleistocene. Information on Holocene range adjustments is reviewed, and evidence on the re-establishment of boreal species is presented.

The overlapping faunal groups of the northwest Atlantic shelf are discussed within the framework of the traditional marine provinces of this zone. Traditional biotic provinces between Labrador and North Carolina lack predictive value for continental shelf mollusks because of the broad overlapping nature of the faunal groups. (Authors' Abstract) *Arctica* is included as an amphi-Atlantic boreal species which apparently evolved in the Atlantic and survived through the Pleistocene.

Frommhagen, L.H., M.J. Fahrenbach, J.A. Brockman, Jr., and E.L.R. Stokstad. 1953.

Heparin-like anticoagulants from Mollusca. Proc. Soc. Exp. Biol. Med. 82: 280-283.

Heparin-like polysaccharides with high anticoagulant activity were isolated from *Arctica islandica*. The polysaccharides were purified and termed mactin-A and mactin-B, but were not considered identical to mammalian heparin. A greater *in vivo* activity and favorable therapeutic index was claimed when compared with heparin preparations of equal *in vitro* activity.

Fritsch, H.A.R. 1973.

Ueber den Einfluss des hydrostatischen Druckes auf die Altrastruckturen von Zellen and Geweben: I. Untersuchungen am Kiemenepithel mariner Muscheln. (Concerning the effect of hydrostatic pressure on the ultrastructure of cells and tissues: I. Investigations on the gill tissue of marine mollusks.) Mar. Biol. 20: 71-77.

The effect of high hydrostatic pressure on the ultrastructures of gill tissues of a variety of marine bivalves (including *Cyprina islandica*) has been investigated employing a new technique of pressure fixation. The degree disintegration of some cell organelles is augmented by increasing pressure. Pressure effects on the plasmalemma of the cell surface, with its microvilli and the shaft of the cilia, as well as on the microtubuli of the cilia themselves, can be made visible. At low pressure (400 atm), the plasmalemma forms small vesicular elements. At high pressure (700 atm), large oedematous expansions can be observed. The microtubuli of the cilia disintegrate at 700 atm, so that the cross-section only reveals homogeneous electron-dense material. The results indicate that some cell organelles are sensitive to pressure, and underline the importance of hydrostatic pressure as physiological-ecological factor in the marine environment. (Author's Abstract)

Gertsenshtein, S.M. 1885.

Materialy k fauna Murmanskogo berega i Belogo morya. -Trudy C.- Peterb. ob-va estestvoispyt., t. XVI, vyp. 1. (Materials on the fauna of the Murmansk seashore and of the White Sea. -Transactions of the St. Petersburg Society of Naturalist, volume 16, No. 1).

Ghiselin, M.T., E.T. Segens, D.W. Spencer, and R.H. Parker. 1967.

A phylogenetic survey of molluscan shell matrix proteins. Bervoria, No. 262, 35 pp.

Chemical, statistical, and systematic methods were used to survey several molluscan shell matrix proteins. *Arctica islandica* was among the pelecypods studied. Its placement in a natural group with *Corbicula* is discussed.

Gibbons, M.C., and M. Castagna. 1984.

Serotonin as an inducer of spawning in six bivalve species. Aquaculture, 40(2): 189-191.

Serotonin induced spawning in six bivalve species using individual spawning techniques without any additional stimuli. Intragonadal injection of serotonin induced spawning in the bay scallop *Argopecten irradians*, the American oyster *Crassostrea virginica*, and the surf clam *Spisula solidissima*. Injection of serotonin into the anterior adductor muscle of the ocean quahog *Arctica islandica*, the ribbed mussel *Geukensia demissa*, and the hard clam *Mercenaria mercenaria* induced spawning. The dosage of 0.4 ml of 2 m*M* serotonin solution used in this study stimulated bivalves to spawn within 15 min. (Author's Abstract)

Gibson, R. 1967.

Occurrence of the entocommensal rhynchocoelan, *Malacobdella grossa*, in the oval piddick, *Zirfaea crispata*, on the Yorkshire coast. J. Mar. Biol. Assoc. U.K. 47: 301-317.

Cyprina islandica included in a table listing it as a host for the nemertean, *Malacobdella grossa*. Numerous authorities are given in the table as references for this host and commensal relationships.

Golikov, A.N., and O.A. Scarlato. 1973.

Method for indirectly defining optimum temperatures of inhabitancy for marine cold-blooded animals. Mar. Biol. 20: 1-5.

Temperature conditions of existence were analyzed for 7 biographical groups of coastal mollusks near the peripheries of their distributional areas. *Cyprina islandica*, an example of an Atlantic-boreo-subtropical species, is among species having an optimum temperature for inhabitancy of from 6 to 16°C and for reproduction of from 4 to 16°C. Northern boundaries of distribution are limited by 6°C temperatures in the summer and below 0°C in the winter; southern boundaries are limited by 20°C temperatures in the summer and 16°C in the winter.

Gould, A.A. 1870.

Report on the Invertebrata of Massachusetts. Edited by N.G. Binney. Second Edition, Comprising the Mollusca. Wright and Potter, Boston. 524 pp. and plates.

Arctica islandica is included and described as *Cyprina islandica* in this report. In a brief account on its distribution, it is said to be found abundantly in the stomachs of fishes taken in Massachusetts Bay.

Guidice, R., and A. Weeks. 1973.

Grooming bit players for stardom. NOAA 3(1): 10-13.

Mentions ocean quahogs, among other seafoods being developed for the American fish market, as a species thought to be too strongly flavored until technological processing proved otherwise.

Gulland, J.A. 1970.

The fish resources of the oceans. FAO Fish. Tech. Paper No. 97. (FIRS/T97), Q - Molluscan Fisheries, p. 218-250.

Included comments on the ocean quahog, *Arctica islandica*, fishery in Rhode Island, USA, pointing out that only about 300 tons are fished.

Gulland, J.A. 1971.

The fish resources of the ocean. Fishing News (Books) Ltd., West Byfleet, Surry, England. p. 185.

Arctica listed as a vast resource, only about 300 tons fished, but a potential harvest of 50,000 tons of meat per year.

Gorbunov, G.I. 1952.

Dvustvorchatye mollyuski *Bivalvia* Chukotskogo morya i Beringovo proliva. -V.sb. "Krainii severo-vostok Soyusa SSR," t. II. (Bivalve molluscs *Bivalvia* of the Chukchi Sea and Bering Strait. In the collection of papers: "The Far North-East of the USSR," volume 2).

Gosner, K.L. 1971.

Guide to identification of marine and estuarine invertebrates - Cape Hatteras to the Bay of Fundy. Interscience, John Wiley & Sons, N.Y., London, Sydney and Toronto. 693 pp.

Arctica listed as similar to quahog in shape but lacking pallial sinus. Found Newfoundland to Cape Cod and deepwater to North Carolina. Subtidal to 500 ft (150 m).

Govbert, L.I. 1974.

Holocene molluscs of the White Sea. Oceanology 14: 547-551.

Formation of the recent bivalved molluscan fauna in the White Sea is discussed. Apparently there was a succession and further development in the appearance of molluscs in the White Sea basin during the Holocene. The maximum variety diversity and largest numbers of these molluscs are characteristic of Atlantic time (the climatic optimum). *Arctica* appeared during the Atlantic through Sub-Atlantic climatic periods.

Habe, T. 1962.

Lyonsisade, Poromyidae, Arcticidae and Gaimardiidae in Japan. Illust. Cat. Jap. Shells (No. 21) 153-160 (in Kuroda, T., Ed.).

Hanks, J.E. 1952.

The effect of changes in water temperature and salinity on the feeding habits of the boring snails, *Polinices heros* and *Polinices duplicata*. *In*: Fifth Rep. Investigations Shellfish. Mass., Commonw. Mass., Dept. Conserv., Div. Mar. Fish., p. 33-37.

Notes feeding by *P. heros* on *Arctica* in the cold bottom waters offshore.

Hazelton, R. 1972.

Nova Scotia unveils new industry: Port Medway's ocean clam fishery. National Fisherman 52(9): 12-C (January).

Discusses the development of a new fishing industry for ocean quahogs by Nova Scotia fishermen, the use of hydraulic dredges, processing techniques, and marketing in the United States.

Henderson, J.T. 1929.

Lethal temperatures of Lamellibranchiata. Contrib. Can. Biol. Fish. N.S. 4: 399-411.

Notes a lethal temperature for *Cyprina islandica* of somewhere below 38°C, since the cilia ceased to beat at that point.

Hess, E. 1946.

Canning Shellfish. Circular No. 32. Fish. Res. Bd. Canada, Fish Canning Series No. 5, 3 pp.

Hiltz, D.F., and T.E. Lightle. 1970.

β-Glucuronidase and arylsulphatase in some marine invertebrates of the Canadian Atlantic coast. J. Fish. Res. Bd. Canada. 27: 1898-1900.

β-Glucuronidase and arylsulphatase activity in the digestive gland tissue varied widely among 15 invertebrate species examined. β-Glucuronidase activity was highest in three algae-feeding species of Gastropoda, *Littorina littorea, L. obtusata*, and *Acmaea testudinalis*, with successively lower levels in lamellibranchs, carnivorous gastropods, crustaceans, and echinoderms. The sea scallop *Placopecten magellanicus*, the clam *Mya arenaria*, and a freshwater mussel *Elliptio compianatus* were particularly rich in arylsulphatase. No apparent correlation existed between β-glucuronidase and arylsulphatase activity among the species studied. (Authors' Abstract) *Arctica* was among the lamellibranchs tested.

Hiltz, L.L. 1977.

The ocean clam (*Arctica islandica*): a literature review. *In:* Mack, G.E. (editor), Fisheries and Marine Service Technical Report No. 720, Fish. and Mar. Serv. Tech. Br., Halifax, N.S., Canada. 161 p. + 16 p. Bibliography.

This literature review outlines studies to define the extent of the ocean clam (*Arctica islandica*) resource of the Atlantic coast of Canada and the United States, on the biology and anatomy of the species and on attempts at commercial exploitation and processing of this clam for human food use. The bibliography contains 206 references. (Author's Abstract)

Hinds, B. 1971.

These gold miners are landing clams. The Halifax Chronicle Herald.

Holme, N.A. 1973.

The biomass of bottom fauna of the English Channel off Plymouth. J. Mar. Biol. Assoc., U.K. 32: 1-49.

Cyprina islandica was found in samples of the bottom fauna of the English Channel off Plymouth. Concentrations of 1.2/10 m^2 taken in 1922-23 compared favorably with 1.4/10 m^2 in 1950. Young *C. islandica* were rare or absent in the samples of 1950 on grounds where the adult was quite common. The observed populations may have been from a set occurring 20 years earlier.

Holmsen, A.A. 1973.

Potential utilization of underexploited species in southern New England. University of Rhode Island, Mar. Memo. Ser. No. 32. n.p.

Mentions the limited use of ocean quahogs in southern New England, low ex-vessel price, and need for consumer education.

Holmsen, A.A. 1974.

New England fisheries with a future: Some underexploited species. Maritimes. University of Rhode Island 18(1): 9-11.

Mentions gross underutilization of ocean quahog resources, its use in canned products, low ex-vessel price, and need for consumer education.

Homans, R.E.S. 1950.

Canning clams. Circular No. 24. Dept. of Fisheries, Fish Inspection Laboratory, Halifax, N.S. Nov. 3. 4 pp.

Howe, F., Jr. 1901.

Report of a dredging expedition off the southern coast of New England. Bull. U.S. Fish. Comm., 19: 237-240.

Among other invertebrates, lists *Cyprina islandica* Lamarck (sic) as having a range of from 8 to 128 fathoms and notes capturing one live specimen in a trawl.

Idler, D.R., and P. Wiseman. 1972.

Molluscan sterols: a review. J. Fish. Res. Bd. Canada, 29(1): 385-396.

Many studies on mollusc sterols were made before the advant of modern techniques such as gas chromatography and mass sepctrometry, and several structures ascribed to such sterols were incorrect because the preparations lacked homogeneity.

The Monoplacophora are extremely rare and the sterols have not been investigated. Cephalopods are believed to contain cholesterol by they have not been investigated in recent years. Among the Amphineura, Aplacophora have not been studied while Polyplacophora contain Δ^7-cholestenol sometimes accompanied by cholesterol and brassicasterol.

Among the least evolved pelecypods, two protobranchs studied contained cholesterol and one also had cholestenol. Septibranchia have not been investigated. A dozen species of filobranchs and eulamellibranchs have been found to have complex mixtures with the same predominant sterols. All sterols of the sea scallop have now been identified, and the most recent are 22-*trans*-24-norcholesta-5,22-dien-3β-01, and a novel C-30 compound, 29-methyliso-fucosterol, neither of which has been found elsewhere in nature. A primitive bivalve, the lamp shell, has an almost identical sterol composition to the modern pelecypods.

Gastropods contain predominantly cholesterol and sometimes its precursor, desmosterol. (Authors' Abstract) *Arctica* was among the pelecypods tested.

Idel'son, M.S. 1930.

Materialy po kolichestvennomu uchety donnoi fauny Shpitsbergenskoi banki (Barentsovo more). -Trudy Mosk. nauchn. in-ta, t. 4, vyp. 3. (Materials on quantitative registration of benthic fauna on the Spitsbergen Bank (Barents Sea). -Transactions of the Moscow Scientific Institute, volume 4, No. 3).

Ivanova, S.S. 1957.

Kachestvennaya i kolichestvennaya kharakteristika bentosa Onezhskogo zaliva Belogo morya. -Materialy po kompl. izucheniyu Belogo morya, vyp. 1. (Qualitative and quantitative characteristics of benthos in the Onega Bay of the White Sea. -Materials on complete investigation of the White Sea, No. 1).

Jensen, A.S. 1902.

Studier over nordiske Mullusker. II, *Cyprina islandica*. Naturh. Forening Kjobenhaven Vid. Medd.: 33-42.

Johansson, J. 1945.

Oxidases and peroxides in the crystalline style of the molluscs. Artiv. Zool. 36A(13): 1-7. In German: Chem. Abst. 42, 236 od. (Vol. 42).

Johnson, C.W. 1915.

Fauna of New England. 13. List of the Mollusca. Occas. Pap. Boston Soc. Nat. Hist. 7, 231 pp.

Cyprina islandica is listed with references of occurrence by depth in waters off Maine, Massachusetts, and Rhode Island.

Johnson, C.W. 1934.

List of marine Mollusca of the Atlantic coast from Labrador to Texas. Proc. Boston Soc. Nat. Hist. 40(1): 203 pp.

C. islandica Linné 1758 listed as occurring from the Atlantic Ocean to North Carolina at 6-90 fathoms.

Jones, N.S. 1951.

The bottom fauna off the south of the Isle of Man. J. An. Ecol. 20(1): 132-144.

Notes the rare occurrence of *Cyprina islandica* in samples (<10% of hauls).

Jones, D.S. 1979.

The nemertean, *Malacobdella grossa*, in the ocean quahog, *Arctica islandica* (Bivalvia). The Nautilus, Vol. 93(1).

The commensal relationship between the marine bivalve, *Arctica islandica*, and the nemertean *Malacobdella grossa* along the Atlantic coast of North America has not heretofore been reported, although it has been documented in European specimens. A single *M. grossa* was found living in a small Ocean Quahog dredged from offshore New Jersey. In addition, the nemertean occurred in the venerid clam, *Pitar morrhuana*, from the same locality with a frequency of 28%. Examination of numerous specimens of *A. islandica* for *M. grossa* with negative results suggests this occurrence is atypical. (Author's Abstract)

Jones, D.S. 1980.

Annual cycle of shell growth increment formation in two continental shelf bivalves and its paleocologic significance. Paleobiology, 6(3), p. 331-340.

The bivalves *Spisula solidissima*, the Atlantic surf clam, and *Arctica islandica*, the ocean quahog, from the continental shelf off New Jersey, contain repeating structures in their shells. By analyzing the growing shell margins in living specimens at bi-weekly (or sometimes monthly) intervals throughout two consecutive years, it was possible to define an annual cycle of shell growth increment formation in both species. The shell increments in each species are microstructurally distinct units that form over a period of several months at select seasons of the year. Each species has two

alternating shell growth increments, GI I and GI II. GI I (the annual growth line of previous studies) is formed annually in the late summer-fall in *S. solidissima* and in the fall-early winter in *A. islandica*. These periods correspond to the spawning phase of the reproductive cycle in both species. No winter rings were found. The annual increments were used to determine age and growth rate in both Recent and Pleistocene specimens. They may also be useful in determining season of death. Because shell growth increments are formed in synchrony among living populations in these species, mass mortalties may be distinguished in the fossil record. Accurate age and growth rate determinations in fossils are important in many paleobiologic contexts, such as deciding between increased longevity or growth rate in cases of phyletic size increase. (Author's Abstract)

Jones, D.S. 1981.

Reproductive cycles of the Atlantic surf clam *Spisula solidissima* and the ocean quahog *Arctica islandica* off New Jersey. Journal of Shellfish Research, Vol. 1, No. 1, 23-32.

Annual reproductive cycles of two commercially important bivalves, the Atlantic surf clam *Spisula solidissima* and the ocean quahog *Arctica islandica*, were investigated using specimens collected off the New Jersey coast. Specimens of both species were recovered from commercial port landings during two consecutive years, April 1977 through March 1979. Gonadal tissues were prepared by standard histological techniques for a microscopic examination of seasonal gametogenesis, and for determination of time and duration of spawnings.

A similar pattern of gemetogenic development was observed in the ocean quahog. All gonads contained morphologically ripe eggs or sperm by August. However, spawning activity in this species was highest in the fall and often persisted into the winter months, particularly in 1978-1979.

Temporal differences between reproductive cycles of consecutive years may be related to differences in environmental factors. Comparison of results obtained here with previously published studies revealed important similarities and differences. (Author's Abstract)

Jones, D.S. 1983.

Schlerochronology: Reading the record of the molluscan shell. Am. Sci. 71: 384-391.

Schlerochronology is the study of determining the age of an organism in the marine realm using periodic features in a skeletal portion. The method is used for corals and was developed in the 1970's.

Many bivalve molluscs have been shown to have long life spans from the annual increments of rings on their shells. *S. solidissima* is now known to attain ages of 30+ years, *M. arenaria* 28+ years, and etc. Growth increments of 150 and 220 have been reported for individual *Arctica islandica*. *A. islandica* may represent the longest lived member of the animal kingdom. (J.B.)

Jorgensen, C.B. 1946.

Lamellibranchia. *In*: Thorson, G. (ed.). Reproduction and larval development of Danish marine bottom invertebrates. Medd. Dan. Fish. Havunders, 4 (Ser. Plankton), p. 277-311.

Arctica islandica found spawning at Kristineberg, Denmark in July. The eggs measured about 75 in diameter, prodissoconchs of juveniles varied from 270 to 300 . The small size of the egg and metamorphosed larva was considered typical of larvae that develop as part of the plankton.

Kennedy, W.J., J.D. Taylor, and A. Hall. 1969.

Environmental and biological controls on bivalve shell mineralogy. Biol. Rev. 44: 499-530.

Arctica islandica is classified in a group (Superfamily Arcticacea) with entirely aragontic two-layered shells and both layers have a homogenous structure.

Kerr, R.G. 1945.

Ocean quahog cookery. *In*: Neville, W.C. (coordinator), The ocean quahog fishery of Rhode Island. R.I. Dept. Agri. Conser., Div. Fish Game, p. 27-29.

Methods of preparing the clam for cooking and several recipes are given.

Kindle, E.M. 1916.

Bottom control of marine faunas as illustrated by dredging in the Bay of Fundy. Amer. J. Sci. 41: 449-461.

Dredging for the purpose of ascertaining the influence of bottom type on the distribution of marine invertebrates was undertaken in the summer of 1914 on the coast of western Nova Scotia. The pelecypod *Cyprinia islandica* was found chiefly in sandy mud. Dredging stations were from 6-7 fathoms at low tide. Invertebrate gastropods and pelecypods show a definite preference for certain sediment types and the distribution of samples shows the preferences. (J.B.)

Kindle, E.M., and E.J. Whittaker. 1918.

Bethymetric check list of the marine invertebrates of eastern Canada with an index to Whiteoves' Catalogue. Contrib. Can. Biol. 1917-1918: 228-294.

A bathymetric chart of all marine invertebrate found off the coast of Canada is presented. *Cyprinia islandica* (L.) ranged from 6-90 fathoms. Sources used for the depth distributions were Whiteaveas catalogue (1901).

King, Lewis H. 1970.

Surficial geology of the Halifax Sable Island map area Dept. Energy, Mines and Resources, Mar. Science Branch. 16 pp.

(Abstract not yet available)

Kinne, O. 1966.

Physiological aspects of animal life in estuaries with special reference to salinity. Neth. J. Sea Res., 3: 222-244.

In a review article, *Cyprina islandica* was included as a species having low cellular resistances.

Knipovich, I.M. 1901.

K poznaniyu geologicheskoi istorii Belogo morya. -Trudy Mineral. ob-va, 2-ya seriya, t. 38, No. 1 (On the knowledge of geological history of the White Sea. -Transactions of Mineralogical Society, Second series, volume 38, No. 1).

Kuhlmorgen-Hille, Gevig. von. 1963.

Quantitative Untersuchungen der Bodenfauna in der Kieler Buchy und ihre jahreszeitlichen Veränderungen. (Quantitative investigations of the bottom fauna in the Kiel Bay and its seasonal variations). Kiel. Meeresforsch. 19: 42-66.

From November 1952 to December 1953, 11 cruises were carried out; at 19 stations with depths of 9-36 m, bottom samples were taken by means of a Van Veen grab. A total of 106 species was recorded: 52 polychaetes, 28 molluscs, 20 crustaceans, 3 echinoderms, 2 priapulids, and 1 anthozoon. Their frequency and distribution are described, with special regard to size-variation and condition of domicile, 4 kinds of bottom sediments are distinguished: sand, muddy fine sand, sandy mud, dark mud. All figures are given except for the large lamellibranch *Cyprina islandica* because of its very irregular distribution. (Part of Author's Summary)

References on food of *C. islandica*, spawning, shell measurements, and age are given. Observations of its preference for silty (clay) sand, size range, preponderance of older adults, and growth are described for Kiel Bay.

Lamy, E. 1920.

Révision des Cypricardiacea et des Isocardiacea vivants du Muséum d'Histoire naturelle de Paris. J. Conchyl. 64: 259-307.

(Abstract on yet available)

Landers, W.S. 1972.

Early development in the ocean quahog, *Arctica islandica* (L.). Proc. Nat. Shellfish. Assoc. 63: 3 (Abstract).

The normal spawning season of ocean quahogs in southern New England waters is late summer. Attempts to ripen mahogany clams out of season in the laboratory produced limited success. Clams obtained from the field in late fall and subjected to a water temperature of 10°C and ample algal food for 10 weeks failed to ripen. However, clams obtained from the fishery in late winter and subjected to the same regimen ripened in about 5 weeks.

Ripe clams could not be induced to spawn by rapidly increased temperature, rapidly decreased temperature or a sperm suspension. A few untreated, stripped eggs were found to be fertilizable by stripped sperm; however, fertilization and the percent development of stripped eggs to normal larvae were significantly increased when the eggs wer exposed to dilute ammonium hydroxide before fertilization was attempted.

The earliest, fully developed, straight-hinge larvae are about 110 long and 80 wide and have an unusually long hinge line. Metamorphosis takes place when the larvae are approximately 200 long. Larvae were reared to metamorphosis at 10°C in about 60 days.

Landers, W.S. 1976.

Reproduction and early development of the ocean quahog, *Arctica islandica*, in the laboratory. Nautilus 90: 88-92.

The ocean quahog, *Arctica islandica*, normally spawns in summer in southern New England. Attempts to ripen these bivalves out of season in the laboratory produced limited success. Clams obtained from the Rhode Island fishery in late winter and kept in seawater ranging from 10°C to 15°C ripened significantly in five weeks, but clams subjected to the same temperatures, plus supplemental feeding with cultured algae in the fall, failed to produce gametes. Ripe clams could not be induced to spawn by rapidly increasing temperature, rapidly decreasing temperature, changing the salinity, or by sperm suspension. Fertilization and the per cent development of stripped eggs to normal larvae were significantly increased when the eggs were exposed to dilute ammonium hydroxide before fertilization was attempted. The eggs developed to the veliger larva stage best at a temperature of about 15°C. The larvae were reared to metamorphosis at 12°C ± 2°C. Early straight-hinge stages have an unusually long hinge line. Older larvae have low-profile umbones that barely rise above the hinge line; consequently the larval outline is always round. Larvae metamorphose must commonly at a length of 190-200 . The color throughout larval development ranges from colorless to a pale yellow. (Author's Abstract)

La Rocque, A. 1953.

Catalogue of the recent Mollusca of Canada. Natl. Mus. Canada, Bull. No. 129, 406 pp.

Lists *Cyprina islandica* (L.) as having a range from the Arctic Ocean to North Carolina and in depths of 6 to 90 fathoms. From a reference, he notes that this species has not been found so far in the Gulf of St. Lawrence north of the Baie des Chaleurs.

Larmond, E. 1970.

Methods of sensory evaluation of food. Publication 1284. Canada Dept. Agriculture. p. 32-35.

(Abstract not yet available)

Lavrova, M.A. 1946.

O geograficheskikh predelakh rasprostranenii boreal'nogo morya i ego fiziko-geograficheskom rezhime. -Trudy In-ta geografii, vyp. 37. (On geographical limits of the extension of the boreal sea and on its physico-geographical regime. -Transactions of the Institute of geography, No. 37).

Larsen, P.F. 1979.

The shallow-water macrobenthos of a northern New England estuary. Marine Biology 55, 69-78.

In November 1973 the benthic macrofauna of two shallow-water areas in the lower Sheepscot River estuary (New England, USA) was quantitatively sampled. Numerical classification of the data, in both the normal and inverse modes, produced 4 site-groups and 7 species-groups. Each site-group was characterized by at least one of the species-groups. The fauna of the site-groups differed in several community parameters, particularly the patterns of dominance, but it was not possible to correlate these differences with any of the several extrinsic factors measured. A factor, or factors, related to water-column stability is the probable overriding ecological determinant of the observed community patterns. Comparisons with an earlier investigation in 1955 demonstrate changes in density, dominance and species composition. (Author's Abstract) *Arctica islandica* was taken in the samples.

Lear, D.W., S.K. Smith, and M.L. O'Malley. 1973.

Environmental survey of two interim dumpsites Middle Atlantic Bight. Operation "Fetch." Cruise Report 5-10 November, 1973. U.S. Environ. Protection Agency, Office of Res. and Devel., Reg. III, Philadelphia, PA. 141 pp.

A second oceanographic survey cruise was made to an interim municipal sludge dumpsite and initially to an interim dumpsite for the disposal of industrial acid waste in the fall of 1973. Both sites are located on the continental shelf in the Middle Atlantic Bight. Observations were made of hydrographic and bathymetric conditions, major circulation patterns, water quality, sediment composition, heavy metals in sediments and biota, bacteriology, phytoplankton and zooplankton communities, vertebrates and benthic invertebrates. (Authors' Abstract) *Arctica islandica* was one of the benthic invertebrates studied.

Lear, D.W. 1973.

Supplemental report. Environmental survey of two interim dumpsites Middle Atlantic Bight. Operation "Fetch." Cruise Report 5-10 November 1973. U.S. Environ. Protection Agency, Office of Res. and Devel., Reg. III, Philadelphia, PA. 53 pp.

Supplemental data from an environmental survey of two interim dumpsites in the Mid-Atlantic Bight are reported. Carbon and iron distribution in the water column, zooplankton populations, metals in echinoderm and mollusc tissues are reported, and the significance of their distribution discussed. (Author's Abstract) *Arctica islandica* was one of the molluscs studied.

Lear, D.W. 1974.

Environmental survey of two interim dumpsites Middle Atlantic Bight. Supplemental report. Environ. Protect. Agency. PB-239 257. 29 p.

Observations were made over a period of approximately one year on two mid temperature, mid-continental shelf ocean dumpsites. There was evidence of accumulation of toxic metals in benthic organisms, notably the mahogany clam, *Arctica islandica* and the scallop, *Placopecten magellanicus*. There were indications of mortalities of the mahogany quahog. (J.B.)

Lear, D.W. 1975.

Effects of ocean disposal activities on mid-continental shelf environment off Delaware and Maryland. U.S. Environ. Protect. Agency. Region III. Philadelphia, PA. Publicatin EPA 903/-75-015, Jan. 1975. 213 pp.

Observations were made over 1 year on 2 mid-temperate mid-continental shelf ocean dumpsites. The hydrographic regime generally approximated the classic winter isothermal-summer stratified system, but incursions of fresher water from the Delaware Estuary and intrusion of offshore slope water influenced the regime. Distribution of metals in bottom sediments and organisms indicated potentially toxic materials persist in bottom materials, and are apparently translocated as a result of hydrographic forces. There was evidence of accumulation in benthic organisms, notably the mahognay clam and the scallop. Dumping operations of the acid waste source and of the sewage sludge materials were apparently separately distributed in the environment. An area of at least 1,000 nm^2 was affected.

Lee, R. 1971.

Ocean quahog and surf clam survey using a hydraulic dredge. Final Report. Prepared for Dept. Fisheries and Environment, Province of New Brunswick and Industrial Development Branch, Dept. of Fisheries and Forestry, Ottawa. 1972.

New Brunswick (From Hiltz, 1977)

Survey Date:
1971
Area:
New Brunswick, eastern coast. Objective to survey from BaieVerte to Bay of Chaleur for the species *Spisula solidissima* (surf clams) and *Arctica islandica* (ocean clams).
Conducted by:
Province of New Brunswick, Dept. of Fisheries and Environment, Fredericton, and Industrial Development Branch, Dept. of Fisheries and Forestry, Ottawa.
Vessel Used:
M.V. Crestline
Quahaug Resource:
Tows were restricted to areas with a sandy bottom, without eel grass, heavy mud or rocks. Conclusions reached dealt with recommendations for improved equipment. It was felt, however, a hydraulic dredge would be helpful in harvesting the species of shellfish, ocean clams and surf clams if sufficient quantities could be located.

Leibson, R.G. 1939.

Kolichestvennyi uchet donnoi fauny Motovskogo zaliva. -Trudy Vses. nauchno-issled. In-ta morsk. rybn. khoz-va i okeanogr., t. IV. (Quantitative registration of benthic fauna in Motovo Bay (Motovskii Zaliv). Transactions of the All-Union Scientific Research Institute of Maritime Fisheries and Oceanography, volume 4).

Lewy, Z. 1975.

Early diagnosis of calcareous skeletons in the Baltic Sea, Western Germany. Meyniana 27: 29-33.

The distribution and preservation of molluscs in the sediments of the Baltic Sea, West Germany, were studied. Carbonate dissolution apparently occurs mainly on the sea bottom; extraction of organic matter, probably by microorganisms, from within the skeleton proceeds in the sediment. Previous theories on carbonate dissolution are discussed. *Arctia islandica, Abra alba, Macoma balthica, Corbula gibba, Eggerella scabra*, gastropods and foraminferans are discussed.

Lipton, L. 1971.

New products development. Progress Report File 46-11-0 St. Andrews; File 9-1 Halifax Lab. June 28, 1971.

(Abstract not yet avaiable)

Lipton, L. 1971.

Report of results of experimentation in the use of the ocean clam (*Arctica islandica*) for marketable consumer products. Industrial Dev. Branch, Fisheries Service, Canada. Dept. of Fisheries and Forestry, Halifax, N.S.

This paper discusses the problem of the objectionable color and odor which develops in untreated ocean quahaugs when they are cooked and how to eliminate both. Also included are procedures for processing the shells both dead and fresh to remove the fungus-like growth found on them and make them usable as containers for finished products. Recipes have been developed for production of several high quality marketable items.

Loosanoff, V.L. 1953.

Reproductive cycle in *Cyprina islandica*. Biol. Bull. 104: 146-155.

Spawning of ocean quahogs off Rhode Island began in late June or early July when temperatures were about 13.5°C, reached a maximum in August, continued during September when the water was at a high of 15°C, and diminished early in October as the temperature slowly declined. The main period of gonadal recovery was in late fall and early winter, but resumed at a rapid rate with the spring incrase in temperature.

Loosanoff, V.L. 1946.

Commercial clams of the Atlantic coast of the United States. U.S. Dep. Interior, Fish & Wildlife Serv., Fish. Leaflet 13, 12 pp.

Briefly discusses the development of a fishery for ocean quahogs.

Lona, F., and R. Bertoldi. 1972.

Discovery of *Arctica (Cyprina) islandica* in a continuous pliople istocenic series near Castell'Arquato (Placenza) in connection with palynological sequences. Ateneo Parmense Acta Nat. 8(1): 35-44. Illus.

A continuous series containing the upper part of Pliocene and the initial part of Pleistocene with *A. islandica*, was found near Castell'Arquato (Italy). Palynological studies revealed the plio-pleistocenic boundary corresponding to our Tiberian boundary. The climatological sequence is in agreement with previous observations. (Authors' Abstract)

Lona, F., and R. Bertoldi. _____?

The story of the Italian Plio-Pleistocene in some lacustrine and marine vegetation sequences. Atti Accad Naz Lincei Mem Cl Sci Fis Mat Nat Sex III 11(1): 1-45. Illus.

New studies based mostly on palynological sequential records pertaining to Upper Pliocene and Lower Plaistocene sediments are reported. The Tiberian boundary, first found in the lacustrine Tiber basin, near Perugia, is characterized by a sharp disappearance of the most typical tertiary elements like the Taxodiaceae, following a great peak of their fluctuating expansion, and the consequent establishment of an impoverished vegetation indicating a particular period of climatic deterioration (cold phases, continental-steppic and/or montaine-boreal phase). This significant event, as a definitive climax alteration, was also found in the vegetational sequences of marine deposits and indeed just before the appearance of a fauna (*Arctica islandica*, *Hyalinea balthica*, *Globigerina pachyderma*) characteristic of the Calabrian stage. The Tiberian boundary practically correlates with the beginning of the Calabrian stage. This substantiates the assumption of the Tiberian boundary as a Plio-Pleistocene boundary. Possible causes are discussed for a certain delay in the appearance of the northern fauna with respect to the floristic change. The boundary should be strictly attached to the vegetational-climatic event. The vegetational-climatological sequence of the Calabrian parallels the glacial/non-glacial phases of the Leffe sequence (lower part). A particular post-Tiberian vegetational biozone, with chronostratigraphic significance, which appeared to occur in both sequences during the temperate-warm phases was sought. This biozone is predominantly made up of a quantitatively and qualitatively distinct assemblage *Eucommia-Celtis* including archaic types and other Ulmaceae, along with other guide-entities (relicts of *Pinus haploxylon* s.s., *Keteleeria*, *Podocarpus*, *Carva terrtiarya*, *Pterocarya paliurus* type, cir, *Platycarva-Engelharditia*, *Myrica*, and other tertiary elements, and moreover some typical tertiary spores). With this biozone, the synchronization of the initial phases of the Stirone Calabrian sequence and the Leffian lower part

(Donau I-III) was feasible. Some Upper Pliocenic cold periods, possibly related to particular glaciations, can be found in the sequences of Pietrafitta, Castell'Arquato-paese (village), Castell'Arquato-Campile and Stirone. They may possibly be correlated in part with the Biber "glaciation."

Loven, P.M. 1929.

Beitrage zur Kenntnis der *Cyprina islandica* L. in Oresund: K. Fysiogr. Sallsk. Lund Forh. 41: 1-38. (Contribution to knowledge of *Cyprina islandica* L. in Oresund.) (From Thorson, G. Bottom Communities, *In*: Hedgpeth, J.W. (ed.) Treatise on marine ecology and paleoecology. Geol. Soc. Amer., Mem. 67, Vol. 1, p. 498, 1957).

Cyprina islandica in the Oresund were investigated during 1924 to 1928 to assess the ratio between living and dead, distribution, growth rate and living conditions. At 16 stations, only 6% of 2,837 specimens were alive. Variation in shell length, shell height, and height-length indices were reported. Distinct rings found on the valves of *Cyprina* less than 50-60 mm long were related to a period of no growth during November to March or April; up to 10 to 11 rings were counted on some large specimens. The rings were considered to be the "wintering" or "annual ring." "Disturbance rings" formed at other times of the year were thought to be from environmental conditions arresting growth. A mean duration of existence for dead shells at one station was calculated to be about 90 years. From an examination of the form and structure of *Cyprina* shells, a three-layered valve was described and sharply marked, darkish lines were found in a shell.

Lutz, R.A., and D.C. Rhoads. 1980.

Chap. 6. Growth patterns within the molluscan shell. *In*: D.C. Rhoads and R.A. Lutz (editors), Skeletal growth of aquatic organisms. Plenum Publ. Corp., N.Y. p. 203-254.

Discusses aragonitic prisms in the shell of *Arctica* that may represent microsturctural elements reflecting anaerobic environmental conditions.

Lutz, R.A., and D.C. Rhoads. 1977.

Anaerobiosis and a theory of growth line formation. Sci. 198: 1222-1227.

Microstructural growth increments within the shells of numerous Recent and fossil molluscs are interpreted as reflections of alternating periods of shell deposition and dissolution, occurring during aerobic and anaerobic respiration, respectively. The acidic end products of anaerobic metabolism are neutralized by calcium carbonate from the shell, leaving a relatively insoluble organic residue at the mantle-shell interface. With the return of oxygenated conditions and resumption of aerobic respiration, this organic material is reincorporated within the shell. Inasmuch as metabolic changes are often synchronized with lunar or solar cycles (or both), we are led to the nearly paradoxical conclusion that, as a result of shell destructive processes, a relatively complete and detailed record of both short- and long-

term growth is often preserved within the molluscan exoskeleton. Analyses of relationships between ambient oxygen concentrations and shell *structural types* may eventually prove useful, in paleoecological studies, for determination of dissolved oxygen gradients in Phanerozoic marine environments, and aragonitic prisms in the shell may represent microstructural elements reflecting anaerobic environmental conditions. (Authors' Summary) *Arctica* was included in this report.

Lutz, R.A., and D.C. Rhoads. 1980.

Chap 6. Growth patterns within the molluscan shell. *In*: Rhoads, D.C. and R.A. Lutz (eds.). Skeletal Growth of Aquatic Organisms. Plenum. Publ. Corp. p. 203-254.

Reviews studies of growth in molluscan shells from patterns found on the external valve surface and more recent examinations of internal microgrowth increments and shell structural changes. Shell microstructures of *Arctica* are discussed in relation to exposure to low oxygen conditions.

Lutz, R.A., R. Mann, J.G. Goodsell, and M. Castagna. 1982.

Larval and early post-larval development of *Arctica islandica*. J. mar. biol. Ass. U.K. 62: 745-769.

Mature eggs were stripped from ripe adult specimens of *Arctica islandica* and exposed to a dilute solution of ammonium hydroxide for various lengths of time before addition of stripped sperm. Larval and early post-larval stages were cultured under experimental laboratory conditions using standard bivalve rearing techniques. Larval cultures were maintained at various controlled temperatures ranging from 8.5 to 14.5°C. Minimum time to settlement was 32 days at a temperature of approximately 13°C; at temperatures between 8.5 and 10.0°C, settlement was not observed until approximately 55 days after fertilization. Larval growth rates were significantly faster at temperatures between 11.0° and 14.5°C than at temperatures between 8.5 and 10.0°C. Morphometry of the larval shell and morphology of the larval hinge apparatus were independent of larval growth rates and experimental culture conditions.

The smallest shelled veliger observed had length and height dimensions of 95 and 75 μm, respectively. Prodissoconch I lengths ranged from 98 to 118 μm (= 50). As shell lengths reached 150-165 μm, the hinge-line was obscured by the appearance of a low, rounded umbo. The smallest metamorphosing larva observed in any of the cultures had a shell length of 240 μm. Prodissoconch II lengths, as determined from measurements made on 100 early post-larval specimens, ranged from 232 to 289 μm. Shell lengths of juvenile specimens, reared under laboratory conditions and in outdoor flow-through tanks, ranged from 1.0 to 6.5 mm approximately 7 1/2 months after metamorphosis.

Optical and scanning electron micrograph sequences of larval and early post-larval stages of *Arctica* are presented in a format designed to provide an adequate basis for comparison with corresponding stages of other bivalves. It is suggested that use of a similar comprehensive format for presentation of life history data for other bivalve species should provide a means of eliminating the vast majority of practical barriers to the identification of early stages of bivalve molluscs isolated from both plankton and benthic samples. (Authors' Abstract)

Lyles, C.H. 1969.

Historical Catch Statistics (Shellfish) CFS No. 5007. U.S. Dept. Interior. U.S. Fish and Wildlife Service, Bur. Commer. Fish. July. 116 pp.

Available landing statistics for commercial shellfish in the United States are tabulated in this report.

Mack, G. 1976.

B. Raw shucked yields and color comparisons. *In*: Experimental canning of ocean quahogs (*Arctica islandica*). Dep. Environ. Canada, Fish. Mar. Serv., Tech. Rep. No. 673. 7 pp.

A study was undertaken to determine the effectiveness of hydrogen peroxide as a dip for Ocean Clams (*Arctica islandica*) meats to prevent or retard blue or black discolouration in the canned product. Shucked and washed clam meats were dipped in 800 and 400 P.P.M. H_2O_2 solutions for 10 minutes. The clam meats were then dipped in cold water for an additional 10 minutes, drained and canned. Chemical analyses were carried out on the dips and also on the canned product to determine hydrogen peroxide residues, if any. An alternative treatment, 0.1% citric acid was added to untreated clams before canning. The effects of citric acid and hydrogen peroxide treatments were then compared to a control group.

The effects of storage conditions and precooking were also studied.

No hydrogen peroxide residue was detected in the final canned product. The addition of citric acid (0.1% of the total can contents) was more effective in preventing or retarding the formation of blue or black discolouration in canned Ocean Clams, than the use of hydrogen peroxide dips. In addition, the use of citric acid was found to be easier, cheaper and safer than the use of hydrogen peroxide.

The other treatments used in this study are discussed and summarized. (Author's Abstract)

MacKenzie, C.L., Jr. 1982.

Compatibility of invertebrate populations and commercial fishing for ocean quahogs. North American Journal of Fisheries Management 2: 270-275.

The objective of this study was to determine whether fishing for ocean quahogs (*Arctica islandica*) with hydraulic dredges on the continental shelf off the coast of northeastern United States alters the abundance or species composition of associated benthic macroinbertebrates. Invertebrate populations in three types of ocean quahog beds were sampled with a Smith-McIntyre grab (0.1 m^2) in October 1978, at the end of the reproductive season of most invertebrates. The beds differed in that one had been fished for about a year and then abandoned in May-June 1978, another had been fished for about 2 years and was actively fished during the sampling, and the third bed had never been fished and served as a control. Differences in the mean numbers of total invertebrates and species were not statistically significant and differences in the abundance-weighted species composition were not evident among the beds. Thus, hydraulic dredging for ocean quahogs did not appear to

alter the invertebrate populations in these beds off the coast of New Jersey. This finding is important because many of the invertebrates found here serve as food for crabs and fish. (Author's Abstract)

MacPhail, J.S. 1957.

U.S. mechanical devices for harvesting shellfish. Fish. Res. Bd. Canada. Orig. Manuscript St. Andrews Biological Station. No. 894.

(Abstract not yet available)

MacPhail, J.S. 1960.

Northumberland Strait ocean quahog fishery. Molluscan Shellfish Summaries No. 24. *In*: Annual Report and Investigators' Summaries 1959-60, St. Andrews, N.B., Biological Station, Fish. Res. Bd Canada.

This year, a fish processor was loaned with a dredge and discharge hose in return for providing records of fishing operations for ocean quahog. 27 days of fishing resulted in landing over 2,000 bushels.

MacPhail, J.S., and J.C. Medcof. 1959.

Explorations for Ocean Quahaugs in Northumberland Strait. Annual Report and Investigators' Summaries 1958-1959, St. Andrews, N.B., Biological Station, Fish. Res. Bd. Canada. Summary No. 23.

August, 1958. (From Hiltz, 1977)

Area Surveyed:
Cape Bear, P.E.I., Pictou Island; Merigomish Island, Livingstone Cove; Cape George; additional objective was demonstration of equipment for intrested local fishermen.

Survey Conducted by:
Fisheries Research Board; the Industrial Development Service.

Vessel Used:
M.V. "Paula Marie"

Dredges Used:
a. Long Island type hydraulic dredge
b. Rocker type dredge.

Quahaug Resource:
-- Marketable resource located east of Cape Bear Light (areas explored: attached Chart A).
-- Pictou Island, catches low.
-- Merigomish Island, no quahaugs.
-- Cape George, a few quahaugs.
-- Livingstone Cove, one bushel per 10-minute tow recroded.

Important Operating Principles Obtained from this Trial:
1. Dredge blades need not be set to dig below 4-5 inches, as quahaugs are not deep burrowers.

2. Dredge efficiency (digging rate) directly related to capacity of water jets.
3. Digging rate increased by large volumes of water at high pressure.

MacPhail, J.S., and J.C. Medcof. 1959.

Ocean quahaug explorations. Trade News, June 1959, Dep. Fish. Canada, p. 3-6.

Efforts of the Fisheries Research Board of Canada to develop gear and methods for exploiting the ocean quahaug resource in Northumberland Strait and surrounding areas are described.

Malatesta, A. 1955.

(*C. islandica* from the Quartenary of Sicily). Boll. Uff. geol. Ital. 77: 447-460.

(Abstract not yet available)

Mann, R. 1981.

Reproduction in *Arctica islandica* and its relationship to the oceanography of the Middle Atlantic Bight. Abstracts, 1980 Annual Meeting, June 9-12, 1980. *In*: Jour. Shellfish. Res. 1(1): 119.

A review is made of the present knowledge of the biology of *Arctica islandica* with special reference to the reproductive cycle. *Arctica islandica* extends throughout a range in the Middle Atlantic Bight which is noted for seasonal thermal stratification of the water column. It is hypothesized that the intense summer thermocline forms an effective barrier to larval dispersion during the summer months, and that the functional reproductive period of this species occurs during the late fall and winter months and not in the late summer. The implications of this hypothesis on the range of larval dispersion in *A. islandica* are discussed. A continuing program of research to test this hypothesis is described. (Author's Abstract)

Mann, R., R.A. Lutz, and M. Castagna. 1981.

The reproductive biology of *Arctica islandica*. Internat. Coun. Explor. Sea. ICES C.M./1981/K:26, Shellfish Comm. 12 pp.

On the Southern New England Shelf the adult *Arctica islandica* spawn from May through November, spawning begin most intense from August through November. Multiple annual spawnings at both the individual and population level are evident. *A. islandica* is dioecious and oviparous. Attempts to stimulate adult clams to spawn in the laboratory have generally been unsuccessful. Stripped ova have an outer membrane which must be removed to effect a high percentage of fertilization in laboratory cultures. The larvae have been reared to metamorphosis in 32-35 days at 13°C and 53 days at 9°C. Post larval forms rapidly develop the characteristic shape and colored periostracum of the adult form. (Abridged Authors' Summary)

Mann, R., and C.C. Wolf. 1983.

Swimming behavior of larvae of the ocean quahog *Arctica islandica* in response to pressure and temperature. Mar. Ecol. Prog. Ser. 13: 211-218.

Trochophore larvae of the ocean quahog *Arctica islandica* swim continuously. At a constant temperature of 12°C they are negatively geotactic, have no phototactic response and exhibit no change in swimming behaviour in the pressure range 1 to 3 bar. In a vertical thermal gradient from 9 to 25°C the trochophores swim throughout the experimental chamber and show no temperature preference. Veliger larvae of *A. islandica* alternate between periods of active upward swimming in vertically oriented helices, that is a negative geotaxis, and periods of passive sinking with the velum either trailing or retracted between closed valves. They do not swim in the horizontal plane and, in the length range 160 to 202 μm, show no phototactic response. When exposed to sequential increases and decreases in hydrostatic pressure at 12°C, larvae in the length range 160 to 196 μm consistently exhibited a net upward movement following an increase in pressure and a net downward movement following a decrease in pressure. The threshold pressure change to elicit response is <0.5 bar. Larvae of 170 μm length respond to increased pressure by decreasing the diameter of the helix and increasing the height gain per rotation. Larvae of 196 μm length respond to increased pressure by increasing height per rotation and vertical velocity. Larvae of 202 μm length exhibit no significant change in swimming behavior with incresed pressure. In a vertical thermal gradient early veligers swim in the range 7 to 23°C with preferential aggregation, depending upon size, in the range 12 to 17°C. Larvae of 204 μm length show no temperature preference in the range 6 to 20°C. The implication of the observed behavior on seasonal depth distribution of *A. islandica* larvae in the Middle Atlantic Bight is discussed. (Authors' Abstract)

Mann, R. 1983.

The seasonal cycle of gonadal development in *Arctica islandica* from the Southern New England Shelf. Fish. Bull., 80(2): pg. #'s

The seasonal cycle of gonadal development of the ocean quahog, *Arctica islandica*, on the Southern New England Shelf was investigated by collecting adult clams at regular intervals from September 1978 to May 1980 from a 36-50 m depth transect, preparing histological sections of the gonadal tissue, and examining these microscopically for stages of development. Hydrographic measurements made concurrently with the clam collections included temperature, conductivity, dissolved oxygen, and pH. Morphologically ripe specimens were present from March through October, but predominated from May through September. A prolonged spawning period from May through November is indicated, spawning being most intense from August through November. Multiple annual spawnings at both the individual and population level were evident. After an assessment of the hydrographic conditions in the area it was hypothesized that larval survival is probably greatest during the months of October and November, which is the time of the breakdown of the intense seasonal thermocline and before the onset of low winter seawater temperatures. (Author's Abstract)

Mann, R. 1984.

Biochemical energetics of marine larvae. *In*: EOS, Trans., Amer. Geophys. Union 65(45), November 6, 1984, p. 900.

The duration of planktonic development of marine larvae may vary from hours to weeks. During this period energy requirements are fulfilled from maternally derived reserves supplied via the egg (lecithotrophy), by feeding on microplankton and dissolved organic material (planktotrophy) or a combination of both. In either case lipids, predominately neutral lipids, and proteins serve as major respiratory substrates. Lipids, because of their low specific gravity and high caloric content per unit weight, are particularly appropriate as larval buoyancy aids and energy stores. Carbohydrate, a respiratory substrate of high specific gravity appropriate for a sessile existence in regions that periodically experience low oxygen tensions, plays only a minor role in larval energetics. Recent studies of larvae of fish, crustacea and molluscs suggest a pivotal role for lipid reserves in determining the ability of larvae to successfully metamorphose: larvae commencing metamorphosis with less than a threshold level of lipid fail to complete metamorphosis. A simple quantitative method utilizing lipid specific stains in combination with photometry or spectrofluorometry to assess larval energy reserves in individual organisms in the field is presented. The method is non-destructive and provides plankton biologists with a real time assay of larval viability that has previously been unavailable. (Author's Abstract)

Mars, P., and J. Picard. 1960.

Note sur le gisements sous-maren a faune celtique en Méditerranée. (Note on the under sea deposits of Celtic fauna in the Mediterranean). (*C. islandica* from Quarternary sediments in the Mediterranean.). Rapports et Procès-Vebaux des Réunions. Commission Internationale pour l'exploration scientifique de la Mer Méditerranée, Monaco, Vol. XV (3): 325-330. (In French)

An attempt to resolve the diverse problems raised by the temporary existence of faunal assemblages in the Quartenary Mediterranean recalling those of the present Celtic zone (in the sense of Woodwards).

General ecological factors conditing the Celtic fauna

The fauna is comprised of *Cyprina islandica*, *Mya truncata*, *Panomya arctica*, *Modiolus modiolus*, etc. It is not, as previously thought, an arctic stock, but merely a stock inhabiting cool waters of a salinity not exceeding 35 to 35.5^{0}/oo. Temperature is not the only factor to be considered, but salinity is also extremely important. The hypothesis is that the temporary existence of this fauna in the Mediterranean in the recent Quartenary corresponds to the spreading of melting glacial waters.

In summary, the factor which had the most notable variation in the Quartenary Mediterranean waas not temperature, but the salinity

Conditions for the formation of sub-sea deposits of the recent Quartenary

Removing dead shells of current inhabitants it appears that species in the various deposits are distribution in two groupings according to substrate requirements.

A fossil grouping, clearly muddy, corresponds to a decantation phae of terriginous deposits: *Turriletta tricarinata*, (*T. communis*), *Cyprina islandica*, *Mya truncata*, *Panomya arctica*, *Lutraria lutraria*, *Modiolus modiolus*, *Mytilus edulis* var. etc., constituting a faunistic unit indicating (troubled [sic] (active) waters, rich in mineral particles as well as orgnic matter.

A second grouping, typically sandy and gravelly with little mud, noticeably similar to present groups which have established themselves there where notable bottom currents may be found [along with the list of species enumerated (*Venus casina*, etc.) they postulate that certain forms of *C. islandica* may also be present.

Fossil forms are easily distinguished from moderal forms by size and shell thickness.

The remainder of the paper concerns itself with speculation of glacial and climate mechanics affecting the Mediterranean basin which created conditions suitable for colonization by species which are no longer present or only temporarily found in non-producing, small populations. (R.T.)

Maurer, D., P. Kinner, W. Leathem, and L. Watling. 1976.

Benthic faunal assemblages off the Dalmarva Peninsula. Est. Coast. Mar. Sci. 4: 163-177.

Based on 90 quantitative samples collected May and November 1973 the species composition, distribution and abundance of benthic invertebrates on the inner continental shelf off the Delmarva Peninsula (38°23'N and 47°15'W) were determined. A total of 149 species were identified. Thirty-five were found only in May and 65 only in November. In May the fauna consisted primarily of nearly equal numbers of plychaete and crustacean species with an increase in the number of polychaete species and decrease in crustacean species in November. In May the polychaetes *Goniadella gracilis* and *Lumbrineris acuta* were co-dominants (Biological Index Value) while in November the archiannelid *Polygordius* sp. was strongly dominant.

There was essentially no change in the number of deposit-feeding individuals from May to November. Even though the trophic structure remained unchanged, the species changed and the total number of individuals increased by 50% from May to November.

The Delmarva assemblage was briefly compared to benthic assemblages closer to the Delaware Bay estuary. Comparison revealed the importance of estuaries and ridge and swale microtopography in influencing the distribution of the shelf fauna.

It was concluded that the Delmarva assemblage belonged to a clean sand fauna which occurs throughout the inner continental shelf of the Middle Atlantic Bight. A number of species representing polychaetes, crustaceans, mollusks and echinoderms were proposed as characteristic sand fauna species. (Authors' Abstract) *Arctica islandica* was found in May 1973 in the study area.

Mclane, T. 1982.

Maturation of *Arctica islandica* in southwestern Nova Scotia. Vol. II. Contr. 08SC. FP-0-0973. Bio-Atlantech Ltd., 73 Merrimac Dr., Dartmouth, N.S., Canada. 11 pp., 9 Figs.

Reports collecting *Arctica islandica* from seven Nova Scotia areas and preparation of gonads for an examination of sexual development. Results do not show a complete reproductive cycle and conclusions are somewhat tenuous.

Meagher, L., and J.C. Medcof. 1972.

Shell rings and growth rate of ocean clams (*Arctica islandica*). Fish. Res. Bd. Canada. Orig. Manuscript St. Andrews Biological Station No. 1105. 13 pp.

Growth of *Arctica* 50 mm in shell length that were notched and recovered after one full year was slow (0.6 mm). Caged clams 20 mm long held for three months grew 0.03 to 0.05 mm per day and increased in length by 17%. Changes in periostracum color were noted and disturbance rings from experimental treatment.

Medcof, J.C., and J.S. MacPhail. 1955.

Survey of bar clam resources of the Maritime Provincesd. 1. Fish. Res. Bd. Canada. Bull. No. 102. 6 pp.

Mentions that the ocean quahaug (*Cyprina islandica*) is sometimes mistaken for the bar clam (*Spisula solidissima*).

Medcof, J.C. 1956.

Trial fishing, processing and storage of ocean quahaugs. Fish. Res. Bd. Canada., Orig. MS St. Andrews Biological Station, No. 1087. 6 pp. (Date filed 1965).

Preliminary trials carried out November 1956 (From Hiltz, 1977)

Area:
Cape Bear, P.E.I. and Pictou Island.
Survey Conducted by:
St. Andrews Biological Station, N.B. - Fisheries Research Board of Canada.
Vessel Used:
Murray Harbour I
Dredges Used:
Two small dredges without attachments:
a. Fall River Dredge (Terry Crawford modifications).
b. Local Dredge.
Quahaug Resource:
Indications of marketable quantitites if suitble hydraulic dredge used.

Medcof, J.C. 1957.

Search for ocean quahaugs in Port Medway Harbour, N.S. Fish. Res. Bd. Canada, Orig. MS St. Andrews Biol. Station, No. 1022. 7 pp.

Second Exploration: July 2-3, 1957 (From Hiltz, 1977)

Area:
Port Medway Harbour.
Survey Conducted by:
St. Andrews Biological Station, N.B. - Fisheris Research Board of Canada.
Vessel:
M.R. Mallotus
Dredge Used:
Fall-River Dredge (Terry Crawford modification). Three sets of teeth tested.
Quahaug Resource:
-- Dredge efficiency could not be determined; results indicated difference in quahaug abundance; lower harbour (sandy soil) indicated greater resource than Vogler's Cover (muddy) upper part.
-- Jet dredge recommended for use in determining resource in this area.
-- From samples taken, many year classes of quahaugs represented in this area; stable population; could withstand exploitation.

Medcof, J.C. 1957.

Stocktaking of molluscan shellfish resources and prospects of their fisheries. Fish. Res. Bd. Canada. St. Andrews Annual Rept., Series No. 22.

Black quahogs (*Arctica islandica*) are not familiar to many although regionally abundant; there are indications of vast beds in the southern Gulf of St. Lawrence in depths ranging from 8 to 20 fathoms.

Medcof, J.C. 1958.

Stock-taking of molluscan shellfish resources and prospects for improvement. Fish. Res. Bd. Canada, Prog. Rept. Atl. Coast Sta. No. 71, p. 21-25.

Arctica included as a clam for chowder. Notes that it is not fished but vast beds exist in the southern Gulf of St. Lawrence at 8 to 20 fathoms.

Medcof, J.C., and J.S. McPhail. 1958.

Mechanical harvesting of shellfish. Molluscan shellfish summary report No. 21. *In*: Annual Report and Investigators' Summaries 1957-58, St. Andrew's, Biological Station, Fisheries Research Board of Canada.

A Maryland-type escalator harvestor was tried experimentally for several projects. It had been upgraded from a 1956 version. Tests began in 1957 for hydraulic and toothed dredges for harvesting ocean quahogs. The industry looking for ways to exploit vast beds of this species. (J.B.)

Medcof, J.C., and R.A. Chandler. 1968.

Exploring for uses of ocean quahog, obstacles and opportunities. Fish. Res. Board Can., Tech. Rep. No. 101, 8 pp.

Ocean quahogs (*Arctica islandica*), which are abundant but unexploited in Canada, were prepared into marketable packs. The clams were from deepwater. Test lots were immediately steamed, shucked and canned, other lots were shucked and held in frozen storage 8 months before canning, and still other lots were relaid in the intertidal zone, held there for 2 months, refished and canned. After an inspection and grading of the lots, all were considered substandard and unmarketable because of unpleasant odor, poor color, and strong "iodine" flavor. Additional resource development, food preparation, food chemistry and marketing studies were recommended. (Abridged Authors' Abstract)

Medcof, J.C. 1969.

File 46-11-0. Orientation of Ocean Quahaug in their burrows Jan. 28.

Medcof, J.C. 1969.

File 46-11-0. Commercial clams of the Canadian Atlantic.

Medcof, J.C. 1969.

Trial fishing, processing and storage of ocean quahaugs. Fish. Res. Bd. Can., original manuscript of the Biological Station, St. Andrews, No. 1087. October. 3 pp.

Medcof, J.C. 1969.

Report on trip to Gloucester and Woods Hole, Mass.; Providence, R.I.; and Annapolis, Md., U.S.A. 22 Sept.-1 Oct. 1969. (File 46-11-0 St. Andrews; File 9-1 Halifax Lab).

Medcof, J.C., and D.F. Alexander. 1969.

Trial fishing with rocker dredge for ocean quahaugs and bar clams off Richibucto and Escuminac, N.B. July 1-4, 1969. Fish. Res. Bd. of Canada MRS (Biol.) No. 1068. *In*: Medcof, J.C., D.F. Alexander, and R.A. Chandler. 1969. Promising places to look for ocean quahogs and bar clams and trial fishing with a rocker dredge off Richibucto, N.B. and Clark's Harbor, N.S. Fish. Res. Bd. of Canada. MRS No. 1068: 31 pp.

Medcof, J.C., D. F. Alexander, and R.A. Chandler. 1969.

Promising places to look for ocean quahogs and bar clams and trial fishing with a rocker dredge off Richibucto, N.B. and Clark's Harbor, N.S. Fish. Res. Bd. Canada. MRS No. 1068: 31 pp.

(From Hiltz, 1977)

This report is composed of three separate documents as follows:
(i):
Medcof, J.C., and David F. Alexander. 1969. Trial fishing with rocker dredge for ocean quahogs and bar clams off Richibucto and Escuminac, N.B. July 1-4, 1969.
Quahaug Resource: (From Hiltz, 1977)

Richibucto Bed Tows:
Made in approximate areas outlined in 1961 Scallop Survey (Bourne & McIver, 1961. MRS #807) and during submarine exploration by Dr. John Caddy (Caddy, J. 1970. Fish. Res. Bd. of Canada 27:545). Dredge performance: not working properly.
Escuminac Bed Tows:
Conducted in areas where large quantities of empty bar clam shells had been reported. Toothed scallop drag and rocker dredge compared in paired tows. Dredge performance: not digging properly.
Richibucto Harbor Tows:
Rocker dredge performed in soft bottom but in areas where sand intermingled with mud, dredge would not perform.
Summary of tows made with rocker dredge and toothed scallop dredge in Richibucto and Escuminac areas: see attached Charts E and F.
Conclusions:
Although few living ocean quahaugs were found, this should not be taken as an indication that ocean quahaugs were not present; hard bottom contributed to poor dredge performance; if commercial exploration is ocnsidered, a hydraulic dredge should be used and successful fishery of ocean quahogs and bar clams are reasonable expectations.
(ii):
Chandler, R.A. 1969. Ocean quahaug explorations with rocker dredge off Cape Sable Island, N.S. May 20-23, 1969.
Study Date: 1961 (From Hiltz, 1977)

Survey Objective:
Scallop Survey - records were kept of dominant bottom invertebrate species where scallop beds were located; among those recorded was the *Arctica islandica* or ocean quahaug.
Areas Surveyed:
Region I: Northumberland Strait. The area bounded on the northwest by a line from Point Escuminac, N.B. to North Point, P.E.I. and on the southeast by a line from Cape George, N.S. to East Point, P.E.I.
Region II: Southeast Gulf of St. Lawrence. George's Bay and the west coast of Cape Breton Island.
Region III: North Coast of Prince Edward Island. Extends from East Point to North Point.
Region IV: Western Gulf of St. Lawrence. The area from Escuminac Point, N.B. to Shippegan Island.

Region V: Chaleur Bay. The beds in Chaleur Bay and east coast of Miscou Island.
Page 23, MRS (Biol.) No. 807 summarizes survey; records type of bottom. Charts B outline survey results.
Conclusions:
Indicated substantial stocks of ocean quahaugs in five aras and bar clams in three aras.
(iii):
Medcof, J.C., and R.A. Chandler. "Promising places to look for ocean quahaugs and bar clams," (memo with attachments).

Medcof, J.C., and R.A. Chandler. 1969.

"Promising places to look for ocean quahaugs and bar clams." (memo with attachments) *In*: Medcof, J.C., D.F. Alexander, and R.A. Chandler. 1969. Promising places to look for ocean quahaugs and bar clams and trial fishing with a rocker dredge off Richibucto, N.B. and Clark's Harbour, N.S. Fish. Res. Bd. of Canada. MRS No. 1068: 31 pp.

Medcof, J.C. 1971.

Ocean clamming--a new N.S. fishery. Progressive Enterprise, 92(36): 13-14.

The development of a fishery for ocean quahogs in Nova Scotia waters is described.

Medcof, J.C. 1971.

Report on summer student shoreline survey work at FRB Biological Station, St. Andrews, N.B. May-Sept 1971. (File 46-11-0 St. Andrews; 9-1 Halifax Lab).

Medcof, J.C., and J.F. Caddy. 1971.

Underwater observations on performance of clam dredges of three types. Int. Coun. Explor. Sea Gear and Behaviour Comm., C.M. 1971/B:10, 5 pp.

Reports observations by scuba divers and from submersibles of two types of hydraulic dredges operated to catch ocean clams (*Arctica islandica*).

Mendelsohn, J.M., P.S. Parker, E.D. McRae, Jr., F.S. King, and A.H. Joyce. 1970.

The ocean quahog--a bountiful clam. Food Product Development 4(7): 90, 92, 97 (November).

Reviews completed research and development work on *Arctica islandica*. An estimate of a sustained annual production of 150 million pounds of meats is given. Discusses technological problems limiting acceptance and use of the clam. Approaches to resolving most of the problems are included.

Mendelsohn, J.M., L.J. Ronsivalli, F.J. King, J.H. Carver, R.L. Learson, B.W. Spracklin, and E.M. Kenyon. 1969.

Opening oysters and other bivalves using microwave energy. Fishery Industrial Res., Bureau Commercial Fisheries. 4(7): February: 241-248.

Oysters and other bivalves (including *Arctica islandica*) are difficult to open by hand shucking operations. A commercial process using microwave energy can save 33% of the costs of hand-shucking, increases plant productivity, eases labor recruitment, lowers accident rates and frees the product of shell fragments (J.W.R.)

Mendelsohn, J.M. 1974.

Clams of commercial importance. *In*: A.H. Johnson and M.S. Petersen (editors), Encyclopedia of Food Technology, Vol. 2, p. 224-226. The AVI Publishing Co., Inc., Westport, CT.

A popular account of the various clams and *Arctica islandica* of commercial importance, including a generalized biology, harvesting techniques and processing methods.

Merrill, A.S. 1960.

Abundance and distribution of sea scallops off the middle Atlantic coast. Proc. Natl. Shellfish. Assoc. 51: 74-80.

In a survey of the abundance and distribution off the middle Atlantic coast, the most common large mollusks associated with sea scallops were *Buccinum undatum, Lunatia heros, Crucibulum striatum, Arctica islandica, Spisula solidissima, Volsella modiolus, Ensis directus, Venericardia borealis,* and *Astarte subequilatera*.

Merrill, A.S., and R.L. Edwards. 1960.

Spring water temperatures and fishing log, Block Island to Cape Hatteras, *Delaware* Cruise No. 60-7, 11-12 May 1960, Woods Hole Lab., MS Rep. No. 61-3.

The black quahog, *Arctica islandica*, is listed in catches designed to investigate the distribution and abundance of the sea scallop using a 30-inch Digby dredge. The list includes fishing and bathythermograph stations and pertinent data.

Merrill, A.S., and J.R. Webster. 1964.

Progress in surf clam biological research. *In*: The Bureau of Commercial Fisheries Biological Laboratory, Oxford, Maryland, Programs and Perspectives, Circular 200, p. 38-47.

Describes progress in biological research on the commercially important surf clam, *Spisula solidissima*, and includes information on the distribution of the mahogany or ocean quahog, *Arctica islandica*. The latter occurs mixed with surf clams in deep offshore waters of the middle Atlantic coast.

Merrill, A.S., J.L. Chamberlin, and J.W. Ropes. 1969.

Ocean Quahog Fishery. *In*: F.E. Firth (ed.), The Encyclopedia of Marine Research, Van Nostrand Reinhold Co., N.Y., p. 125-129.

The geological and recent history of *Arctica islandica* are summarized and an account is given of its present distribution, fishery, and biology.

Merrill, A.S., and J.W. Ropes. 1969.

The distribution and density of the ocean quahog, *Arctica islandica*. Annu. Rep. for 1969, 35th Annual Meeting. Am. Malacol. Union, Bull. p. 19 (Abstract).

Bottom samples taken with a sea scallop dredge, a Campbell grab, and a hydraulic surf clam dredge from Cape Hatteras, North Carolina to the Gulf of Maine provided quantitative and qualitative information on density and distribution of ocean quahogs. The data from samples of quahogs taken by each of the three types of collecting equipment were analysed separately and the results were generally similar. The best commercial ocean quahog potential was found in an area off Long Island, New York, and New Jersey at depths of 36 to 61 meters. North of Long Island ocean quahogs were generally locally abundant and in shallower waters. South of New Jersey they were found farther offshore to northern North Carolina and were not in commercially significant numbers. Shell lengths of the clams were analyzed relative to depth.

Merrill, A.S., and J.W. Ropes. 1969.

The general distribution of the surf clam and ocean quahog. Proc. Natl. Shellfish. Assoc. 59: 40-45.

The general distribution of surf clams, *Spisula solidissima* (Dillwyn), and ocean quahogs, *Arctica islandica* (Linnaeus), has been determined for the continental shelf of the Gulf of Maine and the Middle Atlantic Bight. Both species are concentrated in the latter area. Most surf clams inhabit the near-shore water to depths of 43 m, although greater depths have been recorded; most ocean quahogs are further offshore, at depths of 25 to 61 m. In the middle Atlantic region, the average depth of surf clams and ocean quahogs were 29 and 42 m respectively. Both species occurred in deeper water at the southern end of their range than at the northern end. (Authors' Abstract)

Merrill, A.S., and H.S. Tubiash. 1970.

Molluscan resources of the Atlantic and Gulf Coast of the United States. Proc. Symp. Mollusca, Part III, p. 925-948.

Of 15 species of mollusks harvested commercially along the east coast of the United States and the Gulf of Mexico, 5 bivalves form the major bulk and value of the fisheries. They are the American oyster, *Crassostrea virginica*; the sea scallop, *Placopecten magellanicus*; the northern hard clam, *Mercenaria mercenaria*; the soft clam, *Mya arenaria*; and the surf clam, *Spisula solidissima*. The distribution, biology, life history and fisheries are described. *Arctica islandica* was considered a species of minor significance at that time (J.W.R.)

Merrill, A.S., and J.W. Ropes. 1977.

Shellfish Beds. *In*: Clark, J. (ed.) Coastal Ecosystems Management. A Technical Manual for the Conservation of the Coastal Zone Resources. John Wiley & Sons, N.Y. 928 pp.

Mentions the potential use of *Arctica islandica* for food.

Moore, R.C. (ed.). 1969.

Treatise on Invertebrate Palentology. Geol. Soc. Amer., Inc., Part N, Vol. 1 and 2, Mollusca 6, Bivalvia p. N1-N489, N491-N952.

Information on the geological history, communities, biotic associations, environmental characteristics, outline of classification, systematic description, anatomical features, and uncertain bivalve genera assigned to the family Arcticidae is given for the *Arctica islandica*.

Morrison, C.M., and P.H. Odense. 1974.

Ultrastructure of some pelecypod adductor muscles. J. Altrastruct. Res. 49(2): 228-251.

The adductor muscles of the pelecypods *Placopecten magellanicus*, *Crassostrea virginica*, *Arctica islandica* and *Astarte undata* reveal a series of differences, from striated to smooth types. A transverse periodicity of about 5.0 nm was seen in thick filaments of all sectioned and homogenized preparations examined, and in paramyosin crystals from opaque muscle. Occasionally a periodicity of 15.0 nm also was observed. A diagonal periodicity was seen in thick filaments in sectioned and homogenized preparations of those muscles exhibiting catch. It appeared to be a surface feature composed of electron-dense patches arranged helically around the filament, occurring only in some filaments. As the diagonal periodicity did not seem to be associated with well-developed cross-linkages, another mechanism, such as electrostatic attraction between the thick filaments, may be responsible for catch. (Authors' Abstract)

Morse, E.S. 1919.

Observations on living lamellibranchs of New England. Proc. Boston Soc. Nat. Hist. 35: 139-196.

Describes size, shape, papillae and color of the syphons of *Cyprina islandica* and its foot and shell.

Morton, J.E. 1964.

Locomotion. *In*: K.M. Wilbur and C.M. Yonge, ed. Physiology of Mollusca, Vol. 1, Academic Press, N.Y. p. 383-423.

Ocean quahogs, *Arctica islandica*, are given as a species that can leap.

Murawski, S.A., and F.M. Serchuk. 1979.

Shell length-meat weight relationships of ocean quahogs, *Arctica islandica*, from the middle Atlantic shelf. Proceedings of the National Shellfisheries Association, Vol. 69-1979: 40-46.

Shell length-drained meat weight relationships were calculated from 2,564 ocean quahogs, *Arctica islandica*, taken from the Middle Atlantic shelf during January-February, 1978. Significant differences between regression equations were evident among three sub-areas (Southern New England-Long Island, New Jersey, Delmarva). No consistent trends were noted when depth was the major criterion of separation. An increase in relative meat weight for similar sized quahogs along a north to south cline may be indicative of the more stable thermal regime in southern areas, or related to density dependent factors. The overall shell length (L, mm) - meat weight (W, g) regression equation for all Middle Atlantic specimens is ($r = 0.9635$): $\log_e W = -9.589618 + 2.888016 \log_e L$. Allometric growth between shell length and meat weight was confirmed for most areas. (Authors' Abstract)

Murawski, S.A., and F.M. Serchuk. 1980.

Dynamics of ocean quahog *Arctica islandica* populations off the Middle Atlantic Coast of the United States. Proc. Natl. Shellfish. Assoc. 70: 127 (Abst.).

Abundance and size composition estiamtes of Middle Atlantic ocean quahog, *Arctica islandica*, populations were derived from seven federal (BCF-NMFS) research survey cruises conducted from Cape Cod to Cape Hatteras during 1965-1977. Sampling was performed with an hydraulic shellfish dredge utilzing a transect grid-type survey design, post-stratified to area/depth strata. Standardized tows of four minutes duration using a 121.92 cm (48 in) wide dredge sampled approximately 83 m^2 of bottom per station.

Minimum population size in numbers and biomass (meat weight) was calculated using mean quahog densities (1965-1977) expanded by strata areas. With the surveyed regions, a standing crop of approximately 56.6×10^9 ocean quahogs was estimated, having a biomass of 1.5×10^6 metric tons (mt). The larget proportion of the resource (46%) was located off Long Island, with 44% off New

Jersey and 10% off Delmarva Peninsula. Estimates of equilibrium yields for the Middle Atlantic quahog resource (Long Island through Delmarva) ranged from 3,02 to 45,332 mt, assuming rates of instantaneous natural mortality (M) between 0.01 and 0.10, and mortality of unharvested quahogs due to gear encounters between 40-60% of the amount caught. If $M \leq 0.05$, (implying that > 0.7% of the population survives to age 100), total annual equilibrium yield for the area Long Island-Delmarva is less than 23,000 mt.

Commercial offshore landings in 1977 and 1978 were 7,295 and 9,163 mt, respectively with the bulk of the FCZ landings from off New Jersey and the Delmarva Peninsula. While the accumulated Middle Atlantic ocean quahog population biomass can support substantial increases in annual harvests, present data suggest that the current landings may be near the equilibrium capacity of the resource and the current distribution of fishing effort is disporportionate to the spatial distribution of stock biomass.

Murawski, S.A., J.W. Ropes, and F.M. Serchuk. 1980.

Growth studies of the ocean quahog, *Arctica islandica*. Intern. Counc. Explor. Sea ICES/C.M.1980/K:38. Shellfish Comm. 24 pp.

SEE: Murawski, S.A., J.W. Ropes, and F.M. Serchuk. 1982.

Murawski, S.A., J.W. Ropes, and F.M. Serchuk. 1981.

Population biology of the ocean quahog in the Middle Atlantic Bight. J. Shellfish. Res. 1: 120 (Abst.).

The ocean quahog, *Arctica islandica*, has become increasingly important to the clam industry of the United States. Landings of shucked meat incrased thirty-fold between 1975 and 1979; from 570 metric tons to 15,610 metric tons. Data on the distribution, relative abundance, and size compositions of Middle Atlantic stocks have been gathered during a series of dredge surveys since 1965. Additional information on age and growth is available from recent field and laboratory studies. A review of important biological features, and a current assessment of Middle Atlantic populations are presented.

Murawski, S.A., J.W. Ropes, and F.M. Serchuk. 1982.

Growth of the ocean quahog, *Arctica islandica*, in the Middle Atlantic Bight. Fish. Bull. 80(1):

In situ growth rate of the ocean quahog, *Arctica islandica*, was investigated at a site 53 m deep off Long Island, New York, during 1970-80. Specimens notched during summer 1978 and recaptured 1 and 2 calendar years later yielded information on shell growth and the periodicity of supposed annual marks. Growth of specimens recaptured after 1 year at liberty (n = 67, 59-104 mm shell length) was described by $SL_{t+1} = 2.0811 + 0.9802\ SL_t$, where SL is shell length in millimeters at age t. Average shell length of marked specimens recaptured during summer 1980 increased 1.17 mm (n = 200), approximately twice that of ocean quahogs recaptured in 1979 (0.556 mm). Band formation on the external surface of small ocean quahogs (less than about 60 mm)

was apparently an annual event since small specimens recaptured in 1979 formed one such mark during the interval between release and recapture. Small specimens sampled during summer exhibited relatively wide marginal growth from the last external mark to the shell edge, while winter samples had formed new annuli at the shell margin, thus, external bands were formed during early autumn-early winter. Internal banding in shell cross sections of small ocean quahogs correlated in number and position with external features. An equation representing back-calculated growth, based on external banding patterns of small unmarked specimens (19-60 mm) captured during summer 1978, was: SL = 75.68-81.31 (0.9056), where *t* is age in years. Length-frequency samples were available for the vicinity of the marking study from routine dredge surveys of clam resources during 1970-80. Growth rates inferred from progressions of length-frequency modes in 1970 and 1980 samples were similar to those computed from mark-recapture and age-length equations. Ocean quahogs are apparently among the slowest growing and longest lived of the continental shelf pelecypods; annual increases in shell length were 6.3% at age 10, 0.5% at age 50, and 0.2% at an estimated age of 100 years. (Authors' Abstract)

Muus, K. 1973.

Settling, growth and mortality of young bivalves in the Øresund. Ophelia 12: 79-116.

The quantitative aspects of settling of 11 bivalve species, one of which was *Arctica islandica*, were registered in the Øresund, based on bottom samples from two localities. Spatfall of *A. islandica* occurred first in February and lasted until August at an 18 m depth location, although larvae were in the plankton all months of the year. Metamorphosed larvae were generally low in number and disappeared rapidly.

Sizes are given at metamorphosis, at first appearance in the samples, and after about six months of growth. At 27 m, a successful spatfall in February and somewhat faster growth than at the 18 m depth was followed by an early September spatfall and even faster growth. (Abridged Abstract)

Nair, N.B., and A.D. Ansell. 1968.

Characteristics of penetration of the substratum by some bivalve molluscs. Proc. Malacol. Soc. Long. 38: 179-197.

The characteristics of penetration of the substratum of *Cyprina islandica* and other bivalves are reported.

Neville, W.C. (coordinator). 1945.

The ocean quahog fishery of Rhode Island. A survey conducted by the United States Department of the Interior, Fish and Wildlife Service, in cooperation with the Division of Fish and Game of the Department of Agriculture and Conservation of the State of Rhode Island. R.I. Dep. Agric. Conserv., Div. Fish Game, 31 pp.

The supply of ocean quahogs in the offshore waters of Rhode Island represents a basis for a potentially large industry of value to the state in providing employment and as a source of high quality food. Development will depend on the biological ability of the species to support such an envisaged industry; the adherence by the industry to the United States Public Health Service Sanitation Code for shellfish in order that a quality produce can be maintained throughout production, processing and distribution channels; and by the initiative of the industry to develop a product in accordance with trends in consumers' purchases and cooking practices.

The foregoing sections of this report have described various features of the problem of development, including biological, technological and economic aspects. Some recommendations have been made on the results of some parts of study. Other sections of the study have not progressed sufficiently to permit even tentative conclusions on other phases of the problem of development. (Part of Conclusions)

Newell, N.D. 1965.

Classification of the Bivalvia. Am. Mus. Novit., No. 2206, p. 1-25.

Discusses problems of classification in the Bivalvia and includes the family Arcticidae to which *Arctica islandica* belongs.

Nicol. D. 1951.

Malacology--Recent species of the veneroid pelecypod *Arctica*. J. Wash. Acad. Sci. 41: 102-106.

The synonymy, geographical distribution, and ecology of *Arctica islandica* are reviewed. The possibility of *Arctica islandica* assuming commercial importance is mentioned.

Normandeau Associates, Inc. 1977.

Seabrook Benthic Report, Tech. Rept. VII-6. Bedford, N.H., p. 396-404.

The reproductive cycle and spawning of *Arctica* from a Seabrook, N.H. study site was determined from collections in 1975 and 1976 of gonads prepared histologically for microscopic examination. The majority of the clams spawned in July and August 1975, and at temperatures above 10°C, but in June 1976 spawning began at lower temperatures. A mean of 8°C was recorded during June 1976. Although gametogenesis followed a pattern identical to other studies in the literature, spawning in 1976 was at lower than reported temperatures.

O'Brien, J.J. 1971.

Ocean quahog survey by Delaware II. National Marine Fisheries Service. Fishery Market News Report B-166. Aug. 26.

Investigations to determine the distribution and abundance of ocean quahogs (*Arctica islandica*) were extended geographically to include areas between Cape Cod and the Isles of Shoals (New Hampshire) in 1971. Additional coverage was accomplished between Nantucket Shoals and New Jersey.

Primary emphasis was given to coverage in ocean quahog depth range. The 1971 survey was conducted to find new geographical coverage, production fishing and population estimation.

O'Malley, M.L. 1977.

Bacteriology. Operation hotspot - cruise 76-II August 1976. *In*: Lear, D.W., M.L. O'Malley, and S.K. Smith (eds.), Effects of ocean dumping activity Mid-Atlantic 1976--interim report. U.S. Environ. Protect. Agency, Reg. III, Philadelphia, PA. EPA 903/9-77-029. p. 158-159.

Methods of catching and analyzing sediment and shellfish samples for bacteriology are described. *Arctica* was one of the molluscs sampled.

Owen, G. 1953.

The shell of lamellibranchia. Quart. J. Micros. Sci. 94: 57-70.

Arctica islandica is included in a study of the effect of shell form on the hinge. It is likened to *Glossus* because of a similar mantle isthmus "that is continuously displaced posteriorly owing to the effect of the tangential component on the mantle edge."

Palmer, R.E. 1979.

A histological and histochemical study of digestion in the bivalve *Arctica islandica* L. Biol. Bull. (Woods Hole) 156: 115-129.

1. The histology and enzyme histochemistry of the stomach and digestive gland of *Arctica islandica* were examined. Several enzymological and morphological features contribute to a well-developed system of extracellular digestion in this species.

2. Extracellular exopeptidases and alkaline phosphatases are largely derived from primary and secondary ducts. The epithelium of these ducts also secretes esterases and acid phosphatases. In all cases, secretory activity of the ducts overshadows that of the stomach wall. Other digestive enzymes, including acid endopeptidases, are supplied by fragmenting digestive cells. Starvation has little apparent effect on most enzyme activity, but does depress secretion of alkaline phosphatases and intracellular production of acid phosphatases. These enzymes can be induced under appropriate feeding conditions.

3. The primary ducts in *A. islandica* are organized into many ciliated folds, rather than seprate rejection and acceptance tracts characteristic of aniomyarian bivalves. This structural arrangement insures that enzymes present in digestive cell fragments are utilized in the gastric cavity, rather than being rejected by the intestinal groove.

4. Mature and immature basophilic cells, intermediate cells, and mature and immature digestive cells are present in the digestive tubules. The two types of digestive cells are distinguishable on the basis of cellular inclusions, ability to phagocytize particulate matter, metachromatic staining, and nuclear structure.

5. Cytological and histochemical evidence suggests that, in the digestive tubules of *A. islandica*, there is only one basic cell type, which passes through a number of distinct phases in its life history. (Author's Conclusions)

Palmer, H.D., and D.W. Lear. 1973.

Environmental survey of an interim ocean dumpsite Middle Atlantic Bight. Cruise report - 1-5 May 1973. U.S. Environ. Protect. Agency, Reg. III, Philadelphia, PA. EPA 903/9-001-A September 1973. 134 pp.

An oceanographic survey cruise was made to a proposed interim sludge dumping site on the continental shelf in the Middle Atlantic Bight in spring 1973. Observations were made of circulation patterns, sediment composition, bathymetry, water quality, heavy metals in sediments and biota, bacteriology, phytoplankton communities, zooplankton communities, vertebrates, and benthic invertebrates.

The site was found to be a normal mid-temperature shelf environment, with no significant stresses. There was some evidence that material from a neighboring acid waste dumpsite may affect the site. Evidence of heavy metals enhancement of iron and copper in bottom fauna at some stations warrants further investigations. (Authors' Abstract)

Arctica was a dominant infaunal suspension feeder at a former sludge disposal site and an acid waste site.

Parker, P.S. 1966.

Ocean clam survey off U.S. middle Atlantic coast--1963. Commer. Fish. Rev. 28(3): 1-9.

A cooperative clam survey was conducted during the summer of 1963 by the Eastern Sea Clam Packers Committee of the Oyster Institute of North America and the U.S. Bureau of Commercial Fisheries. The purpose was to locate and access clam resources in the areas adjacent to those commercially fished. The surveyed areas are off the coast of New Jersey and Delaware on the seaward side of present fishing grounds. Additional concentrations of surf clams (*Spisula solidissima*) sufficient to sustain the commercial fishery at its present rate of production were not found. Many good catches of black quahogs (*Arctica islandica*) were made. The scope of the project has now been expanded, and the Bureau is continuing the survey of potential clam-producing areas in the Mid-Atlantic Bight. (Author's Abstract)

Parker, P.S. 1967.

A clam measuring board. Comm. Fish. Rev. 29(4): 65-66.

A description and plans for a device to measure clams is reported.

Parker, P.S. 1967.

Sleeve for clam jetting hose connection. Comm. Fish. Rev. 29(4): 67.

A steel sleeve used for connecting clam jetting hose is described and pictured.

Parker, P.S. 1967.

Clam survey Ocean City, Maryland, to Cape Charles, Virginia. Commer. Fish. Rev. 29(5): 56-64.

During the summer of 1964 and the fall and winter of 1965, BCF made a clam survey off the coasts of Maryland and Virginia (Survey Area III). The purpose was to gather information on abundance, distribution, and size of surf clam (*Spisula solidissima*) and other species found with a potential for commercial use. Samples were taken at 1-mile intervals with a hydraulic jet dredge; 894 stations were made at 55 survey sites. Considerable variaton in abundance, distribution, and size of surf clams occurred; these variations are related to bottom type and water depth. Limited beds of ocean quahogs (*Arctica islandica*) were found in some sections. (Author's Abstract)

Parker, P.S., and L.A. Fahlen. 1968.

Clam survey off Virginia (Cape Charles to False Cape). Commer. Fish. Rev. 39(1): 25-34.

The third in a continuing series of surf clam (*Spisula solidissima*) surveys being made by the Bureau of Commercial Fisheries was completed off the coast of Virginia between May 1965 and May 1966. Its abundance and distribution and factors affecting its populations were determined from samples taken with a 48-inch hydraulic dredge. During the survey, 1,367 stations were occupied. Small populations of ocean quahogs (*Arctica islandica*) were widely scattered.

Parker, P.S., and E.D. McRae, Jr. 1970.

The ocean quahog, *Arctica islandica*, resource of the northwestern Atlantic. Fish. Ind. Res. 6(4): 185-195.

The ocean quahog is a species of marine clam. Some of the anatomical differences between it and the hard clam, *Mercenaria mercenaria*, are discussed. The range and population density of the ocean quahog in Continental Shelf areas off the Atlantic seaboard vary considerably with changes in water depths and bottom sediments.

Much of the basic information for this article was gathered during the survey of the surf clam, *Spisula solidissima*, by the Bureau of Commercial Fisheries. The gear, method used, procedure, and results of the survey pertinent to ocean quahogs are presented.
The ocean quahog resource is generally unused. It is waiting for anyone willing to reap the harvest. (Authors' Abstract)

Parker, P.S. 1971.

History and development of surf clam harvesting gear. NOAA Tech. Rept., NMFS Circ. 364. 15 pp.

The development of harvesting gear for surf clams, *Spisula solidissima*, along the eastern coast of the United States is reviewed from early times up to the present.
Early clamming was done by hand using rakes or tongs, while today the industry depends upon large, efficient dredges operating from stable vessels. Little gear development took place prior to World War II; however, since that time, the industry has made rapid strides in the development of harvesting gear. Today this trend is still very much in evidence, with gear constantly being modified for adaptation to newer vessel types.
Most gear development work has been the result of the surf clam industry itself. However, the Federal Government, in cooperation with industry, has developed several pieces of equipment for adaptation to clamming gear. (Author's Abstract)
Hydraulic clam dredges, similar to those described in this report, have been modified for harvesting *Arctica*.

Paulus, M. 1950.

Note sur la presence of *Cyprina islandica* Linné, an large de Baleares. Vie Milieu 1: 302-304. (Note on the presence of a large *Cyprina islandica* Linne from off the Balearic Isles.)

Notes measurements of two specimens of *Cyprina islandica* from off the Baleric Isles that were considered large for the area. Discusses the clam's penetration into the Mediterranean during the geologic past. (Translation available at the NMFS, Oxford Laboratory.)

Payne, J.R., J.L. Lambach, R.E. Jordan, G.D. McNabb, Jr., R.R. Sims, A. Abasumava, J.G. Sutton, D. Generro, S. Gagner, and R.F. Shokes. 1982.

Georges Bank monitoring program, analysis of hydrocarbons in bottom sediments and analysis of hydrocarbons and trace metals in benthic fauna. Final Report July 1981-May 1982 to U.S. Dept. Int., MMS, Wash. D.C., by Science Application, Inc., La Jolla, CA 92039. 189 pp.

This program was conducted for the MMS to document background hydrocarbon and trace metal levels in selected sediments and benthic fauna, and to monitor potential short- and long-term changes resulting from exploratory drilling activities in the Georges Bank Lease Sale 42 region. Aromatic hydrocarbons,

as measured by UV/Fluorescence, were present in low (100 ng/g dry weight) concentrations in sediments immediately around the drill rig, Rowan Midland, before drilling was initiated. Approximately two months after drilling began, an apparent increase in sediment aromatic hydrocarbons occurred immediately around the rig; concentrations approaching 400 ng/g dry weight were observed 5-6 months after the onset of drilling, and remained fairly constant for up to 11 months after the drilling was discontinued. Attempts to confirm the presence of drilling fluid components in sediment extracts by FID-GC and GC/MS analyses were inconclusive due to the higher detection limits of these techniques. Several individual polynuclear aromatic hydrocarbons were identified at 1-10 ng/g dry weight concentrations, but direct correlations with aliphatic and aromatic components in the drilling fluids were not obtained.

Results of UV/Fluorescence analyses at stations further than 2 km from the rig indicated no significant changes in aromatic hydrocarbon concentration in the sediments. Evidence of petrogenic hydrocarbons was found in several natural depositional regimes around the periphery of Georges Bank; however, the concentrations and chemical composition of these materials did not appreciably change after drilling began.

There was no evidence of drilling fluid-related hydrocarbon accumulation in the epifaunal tissues analyzed. Trace metal concentrations in two species (*Arctica islandica* and *Paralichthys oblongus*) were uniformly low for all elements, including Ba. (Authors' Abstract)

Pelosio, G. 1960.

Afioramenti fossiliferi del Calabriano nel Preappennino parmense. (Cyprina islandica, Quaternary, Parma, N. Italy). G. Geol. (2a)28: 123-184 (English summary).

The Author describes a new outcrop of Calabriano with *Cyprina islandica* in the surroundings of Parma and illustrates its fauna of Molluscs by comparing it with the one of other similar layers in the Central-Northern Italy. (Author's Abstract)

Perkins, E.J. 1974.

The biology of estuaries and coastal waters. Academic Press, London and New York, 1974, p. 293 and 298.

Cyprina islandica is included in a list of some 23 species common in grounds featuring fauna of mud associations at 90-110 m and at 140 m. Likewise, *Cyprina islandica* is part of the boreal offshore muddy sand association in the offshore region, and with modification may be found in sheltered conditions and in estuaries.

Peter Silveri Assoc., Inc. 1982.

Unlocking the secrets inside a clam shell. Lapidary Journal 36(8): 1390-1393.

Popular article explaining the procedures for preparing surf clam and ocean quahog shells for age determination. (J.W.R.)

Porter, H.J., and A.F. Chestnut. 1960.

The offshore clam fishery of North Carolina. Proc. Natl. Shellfish. Assoc. 51: 67-73.

Mentions the use of a type of hydraulic dredge for harvesting various bivalves, including *Arctica*.

Porter, H.J. 1974.

The North Carolina Marine and Estuarine Mollusca - an Atlas of Occurrence. Univ. N.C., Inst. Mar. Sci. 351 pp.

Lists references for *Arctica islandica* but indicates that the Institute of Marine Sciences has no collected specimens.

Prakash, A., J.C. Medcof, and A.D. Tennant. 1971.

Paralytic Shellfish poisoning in Eastern Canada. Fish. Res. Bd. Canada. Bulletin 177.

Ocean clams (*Arctica islandica*) sampled from the Gulf of St. Lawrence and Bay of Fundy were found to be toxic from *Gonyaulax tamerensis*, but the clam has not been implicated in poisonings and was not rated as a PSP hazard.

Rees, C.B. 1950.

The identification and classification of lamellibranch larvae. Hull Bull. Mar. Ecol. 3(19): 73-104.

A single field collected larvae is identified as *Cyprina islandica* in this report. It is compared with other larvae having similar characteristics.

Reid, R.G.B. 1965.

The digestive system in the bivalvia. Summa Thesis High Degree, Fac. Sci. Eng., Univ. Glag. 1963-64. p. 137-139. (See Abstract Below)

Reid, R.G.B. 1965-66.

The structure and function of the stomach in bivalve molluscs. J. Zool. Lond. 147: 156-184.

The structure and function of the stomachs of nine bivalves (including *Arctica islandica*) are examined. These animals belong to the Gastrotetartika, Gastrotriteia, and Gastropempta, the three orders of the Polysyringia, a new sub-class of the Bivalvia suggested by Purchon (1960a). It is found that in all three orders there are common ciliary tracts and grooves. For example, tracts are always found in association with the duct openings, and a distinction between the right duct tract and the posterior sorting area is drawn. Another tract which is a constant feature of these stomachs, but which has not been noted before, is the autero-dorsal tract. A generalized polysyringian stomach is constructed. All the stomachs examined function similarly, there being set up in the lumina circulating currents of the gastric fluid. In general, large particles and masses of particles are recirculated until they are broken down, and small heavy particles are rejected by the sorting areas, of which three main types are described. Light particles in suspension in the stomach fluid are carried by the circulating current to the vicinity of the opening of the ducts of the digestive diverticula.

The form of the primitive polysyringian stomach and the evolution of sorting areas are postulated. Possible steps in the evolution of the gastropemptan stomach through the gastrotetartikan form are suggested. The function of the appendix is that of a temporary store for large, heavy particles which escape the pallial sorting mechanism. It is noted that this organ occurs in all three orders of the Polysyringia. (Author's Abstract)

Reynolds, B., and G. Pesch. 1973.

Part III. Metal concentrations in the ocean quahog, *Arctica islandica*. *In*: Lear, D.W. (ed.) 1973. Supplemental report. Environmental survey of two interim dumpsites Middle Atlantic Bight. Operation "Fetch." Cruise Report 5-10 November 1973. U.S. Environ. Protection Agency, Office of Res. and Devel., Reg. III., Philadelphia, PA. p. 13-21.

Tissues of the clam, *Arctica islandica*, were analyzed for accumulated concentrations of 12 metals at 14 stations distributed about an industrial waste dumpsite and a sewage waste dumpsite. Conclusions drawn from a statistical treatment of the results show (1) that metals thus disposed of do accumulate in the tissue of benthic organisms and in quantities roughly proportional to the amounts dumped; (2) that certain metals, particularly V and Cd, are dumped in such quantities in one of the two sites such that they may be used as tracers for that dumpsite; and (3) that, due to hydrographic conditions, the effects of these dumped materials is in no way limited to the area bounded by the dumpsites proper but are spread over a large area, as yet

undetermined, particularly in the direction of the prevailing currents. A much larger sample grid is needed to establish the extent of this area. (Authors' Abstract)

Reshöft, K. 1961.

Untersuchungen zur zellulären osmotischen und thermischen Resistenz verschiedener Lamellibranchier der deutschen Küstengewässere. (Investigations on the cellular osmotic and thermal resistance of some bivalves from German coastal waters). Kiel. Meeresforsch. 17: 65-84. (Translation by Language Services Branch, NOAA, NMFS, U.S. Dept. Comm. available at NE Fish. Cent., Woods Hole, MA)

The cellular thermal and osmotic resistance limits of isolated gill tissue of the eight following different bivalves from the German coastal waters were determined: *Spisula solidissima, Modiolus modiolus, Mya arenaria, Mytilus edulis, Cyprina islandica, Astarte borealis, Congeria cochleata, Dressena polymorpha.*

The experimental results prove that there are existing relationships between the cellular osmotic and thermal resistance limits of the examined bivalves and their horizontal and vertical distribution. --The most resistant species was *Congeria cochleata* immigrated from South West Africa into the Kiel Canal. The most sensitive species was *Spisula solida* from high salinity bottom waters of the North Sea. These results are referring both the thermal and the osmotic resistance limits. --The thermal and osmotic resistance limits determined for the mentioned species are very probably species specific by genetic adaptation. Plotting graphicaly the logarithm of survival times to lethal temperatures result in a characteristic straight line for each species. --The results of long period adaptation experiments provide with a high degrees of probability that *Mytilus edulis* from the North Sea and the Western Baltic can not be considred as different physiological races in a relation to their thermal and osmotic resistance limits. (Author's Abstract)

Reynolds, B.H. 1979.

Trace metals monitoring at two ocean disposal sites. U.S. Environ. Protec. Ag., Narragansett, R.I. EPA-6001-3-79-037. 64 pp.

The areal distributions of the concentration of cadmium, copper, nickel, and vanadium in sea scallop and ocean quahog tissue were examined in the vicinity of two ocean disposal sites located off the U.S. mid-Atlantic coast on four cruises conducted in 1974 and 1975. Incidental collections of the surf clam were also made on the last cruise. Patterns of metals distribution show that: (1) these metals may be used as identification tags for the individual types of wastes disposed at the two sites; (2) the distribution patterns of the metals content in shellfish may be explained to a large extent by the regional current patterns; and (3) the known toxicity of the wastes plus the demonstrated biological availability of the metals contained therein, coupled with the existence of an abundant literature documenting their toxicity in general, indicate that the wastes pose a significant threat to marine biota in the vicinity of these disposal sites. (Author's Abstract)

Ritchie, T.P. 1977.

A comprehensive review of the commercial clam industries in the United States. U.S. Dept. Commer., NOAA, NMFS. 106 pp.

Reviews the commercial clam industry in the United States during 1966-1975. The ocean quahog industry is included.

Robichaud, R. 1972.

Recherches pour L'ocean Quahog (*Arctica islandica*). Ministère des pêches et de l'Environment du nouveau-Brunswick, Services Expérimental des Pêches, Caraquet, N.B. Aout. 1972.

New Brunswich (From Hiltz, 1977)

Survey Date:
1972
Area:
New Brunswick. The work initiated in New Brunswick in 1970, carried out in 1971 and 1972 on the species *Arctica islandica* (ocean quahaugs) is summarized. Report outlines areas surveyed and equipment used (this report is prepared and published in French).

Ropes, J.W., and A.S. Merrill. 1967.

Malacobdella grossa in *Pitar morrhuana* and *Mercenaria campechiensis*. Nautilus 81: 37-40.

In a study of the occurrence of the commensal nemertean, *Malacobdella grossa*, in two bivalve species dredged from the western North Atlantic coast, mention was made of not finding it in *Arctica islandica*, a host species for the worm in European waters.

Ropes, J.W. 1971.

Surf clams and ocean quahogs. Annu. Reps. for 1970, 36th Annu. Meeting, Amer. Malacol. Union, Inc. p. 22-24.

Results are summarized from samples taken with a hydraulic dredge in the middle Atlantic continental shelf during 1965. An abundance rating and depth in meters is given in four geographical areas for *Spisula solidissima* and *Arctica islandica*. Invertebrates taken in the samples and size composition of the clams are briefly mentioned. (J.W.R.)

Ropes, J.W., and A.S. Merrill. 1971.

Data on samples for surf clams and ocean quahogs. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Data Rep. 57: 43 pp., on 1 microfiche.

Data on the catch of surf clams and ocean quahogs by several research vessels operating on the continental shelf of the Gulf of Maine to Cape Hatteras, N.C. are given. (Authors' Abstract)

Ropes, J.W. 1971.

Percentage of solids and length-weight relationship fo the ocean quahog. Proc. Natl. Shellfish. Assoc. 61: 88-90.

Percentage solids of ocean quahogs, *Arctica islandica*, were determined for samples taken from offshore Long Island, New York. Solids averaged 18.5% for clams between 30 and 129 mm in shell length. Dry meat weights increased most rapidly between clam lengths of 92-113 mm. Calculated yields of bushel quantities are given for two areas off Long Island and New Jersey where clams are plentiful. (Author's Abstract)

Ropes, J.W., and A.S. Merrill. 1976.

Historical cruise data on surf clams and ocean quahogs. NOAA DR ERL MESA-17. 106 pp.

The occurrence of two bivalve mollusks were recorded during bottom sampling cruises from 1965 to 1974. Samples were taken on the continental shelf from Block Island, R.I. to Cape Hatteras, NOC. Associated hydrographic and related data are presented in ADP prepared tables. Preliminary analysis indicate greater numbers of surf clams off the Delmarva Peninsula and Virginia Coast, which is opposite to results of earlier surveys. (Authors' Abstract)

Ropes, J.W. 1976.

NMFS studies new offshore clam resource: the ocean quahog. Commer. Fish. News, Dept. Nat. Res. Md., 9(6): 1-4.

Describes the history of the fishery, biology of the clam, general distribution and distribution in the Middle Atlantic Bight.

Ropes, J.W., and S. Chang. 1977.

Appendix I. Impact on offshore sea clam populations (surf clam and ocean quahog) associated with anoxic bottom water in the Middle Atlantic Bight during summer, 1976. *In*: Oxygen depletion and associated environmental disturbances in the Middle Atlantic Bight in 1976. A report on a series of interagency workshops held in November and December 1976. U.S. Dept. Commer., NOAA, NMFS, NEFC, Sandy Hook, N.J. Tech. Ser. Rept. No. 3. 471 pp.

The types of stress and mortality of surf clams (*Spisula solidissima*) and ocean quahogs (*Arctica islandica*) associated with a large cell of cold bottom water, deficient in oxygen but high in hydrogen sulfide, that developed off the central New Jersey coast is documented from early reports, fishermen interviews, otter trawl assessment surveys and dredge assessment surveys. Dredge assessment survey results from off Long Island are included and measurements of temperature and oxygen taken during dredge surveys. The results show that surf clams were most seriously affected.

Ropes, J.W. 1979.

Biology and distribution of surf clams (*Spisula solidissima*) and ocean quahogs (*Arctica islandica*) off the Northeast coast of the United States. *In*: Proceedings of Northeast Clam Industries: Management for the Future. Exten. Sea Grant Prog., Univ. Mass. and Mass. Inst. Tech. SP-112: 47-66.

Describes the histories of the fisheries, biology and distribution, with emphasis on the Middle Atlantic Bight.

Ropes, J.W. 1980.

Biological and fisheries data on surf clam, *Spisula solidissima* (Dillwyn). U.S. Dept. Commerce, NOAA, NMFS, Tech. Ser. Rep. No. 24, 88 pp.

The taxonomic identity, distribution, bionomics and life history, population, exploitation, protection and management of the surf clam, *Spisula solidissima*, is reviewed with numerous references. *Arctica* is mentioned in relationship to determinants of distribution and regulatory measures.

Ropes, J.W. 1982.

The Atlantic Coast Surf Clam Fishery, 1965-1974. Mar. Fish. Rev. 44(8): 1-14.

This report includes historical highlights of the Atlantic coast surf clam, *Spisula solidissima*, fishery, and summarizes fishing operations during 1965-1974, a period of increased exploitation and growth in the Middle Atlantic Bight. Landings increased almost every year during the 10-year period, often setting new catch records, and accounted for more than half (about 60 percent) of the domestic clam meat landings (by weight) in the United States; landings averaged 44.7 million pounds annually during the first 5 years and increased to 72.3 million pounds in the last 5 years. This latter value included the peak 96.1 million-pound yield attained in 1974.

During the 10-year period, the most significant events were increased effort, in the form of additional larger vessels with greater fishing capabilities; a drastic decline in surf clam stocks off Point Pleasant, N.J., one of the traditional and principal ports for landings; and transfer of vessels to more southern ports and expansion of fishing operations on newly discovered beds off the Delmarva Peninsula and Virginia. These latter stocks sustained the very high annual yield in the 1970-74 period. Major pre- and post-study period events through 1977 are discussed. (Author's Abstract) The increase in utilization of ocean quahogs in 1976 and 1977 is mentioned

Ropes, J.W. 1984.

Methods for aging oceanic bivalves. Underwater Naturalist 15(1): 12-15.

New methods used at the Woods Hole Labratory since the mid-1970's for aging surf clams, *Spisula solidssima*, and ocean quahog, *Arctica islandica*, are described. The acetate peel preparation method has been used to reveal annual periodicity of annuli in ocean quahogs of the method and old age of many ocean quahogs prevents routine collection of age composition data of the stocks.

Ropes, J.W. 1984.

Procedures for preparing acetate peels and evidence validating the annual periodicity of growth lines formed in the shells of ocean quahogs, *Arctica islandica*. Mar. Fish. Rev. 46(2): 27-35.

Techniques are described for producing acetate peels of radially sectioned ocean quahog, *Arctica islandica*, shells to observe age and growth phenomena. Specimens marked and recovered 1 and 2 years later validated the hypothesis that growth lines are formed annually. Growth functions have been developed for quahogs from off Long Island, N.Y., and Georges Bank. The growth of the species is characterized as being slow. Some geographic and individual specimen variability in growth was observed. Sexual maturity was attained at 5-6 years of age, but varied with size and sex. Ages approaching and exceeding 100 years are not uncommon. One specimen was about 225 years old, an age greater than known longevity estimates of other bivalve species. Author's Abstract)

Ropes, J.W., D.S. Jones, S.A. Murawski, F.M. Serchuk, and A. Jearld, Jr. 1983.

Documentation of annual growth lines in the ocean quahog, *Arctica islandica* Linné. J. Shellfish. Res. 3(1): 100. (Abstract)

About 42,000 ocean quahogs (*Arctica islandica*) were marked for release at a deep (53-m) oceanic site off Long Island, NY, in 1978. Shells of live specimens recovered 1 and 2 years later have been radially sectined, polished, and etched for preparation of acetate peels and examination by optical microscopy or microprojection; selected specimens were similarly prepared for examination by scanning electron microscopy. Specific growth-line and growth-increment microstructures are described and photo-illustrated. An annual periodicity of microstructure is documented. The observations form a basis for resource assessment ageing studies of the commercially important species.

Ropes, J.W., A.S. Merrill, S.A. Murawski, S. Chang, and C.L. MacKenzie, Jr. 1979.

Chap. 11. Impact on clams and scallops, Part 1. Field survey assessments. *In*: Swanson, R.L. and C.J. Sindermann (eds.). Oxygen depletion and associated mass mortalities in the New York Bight. NOAA Prof. Paper 11. ERL-MESA Spec. Publ. p. 263-275.

An assessment was made of the stress and mortalities caused in surf clams, *Spisula solidissima*, ocean quahogs, *Arctica islandica*, and sea scallops, *Placopecten magellanicus*, by a large mass of bottom water which was deficient in oxygen and containing above normal quantities of hydrogen sulfide off the New Jersey coast in 1976.

For surf clams, a 6,750-km^2 area of mortality was delimited off New Jersey. The area extended from immediately north of Manasquan Inlet to immediately south of Atlantic City, and seaward to about 37 m. An almost complete kill (92%) took place in the mortality area, but was least intense in the 3- to 15-km-wide beach zone. An estimated 61.5 percent of the total surf clam biomass was lost off New Jersey. Surf clam landings were substantially lower (31%) in New Jersey during 1976 than during 1975.

The principal ocean quahog resource occurs deeper than 37 m and thus only the shoreward margin of the population was affected. The mortality area was 9,105 km^2, and 25.4 percent of the quahog biomass within it was lost. Of the entire New Jersey ocean quahog resource, 6.3 percent of the biomass was lost. New Jersey vessels began fishing ocean quahogs in 1976 and landed 71.7 percent of the U.S. total.

The principal sea scallop resource also occurs deeper than 37 m, and only the shoreward margin of the population was affected. From 8.8 to 12.9 percent of the entire New Jersey scallop resource was killed. Scallop landings increased four-fold in 1976.

Ropes, J.W., and S.A. Murawski. 1980.

Size and age at sexual maturity of ocean quahogs, *Arctica islandica* Linné, from a deep oceanic site. Intern. Coun. Explor. Sea C.M. 1980/K:26, Shellfish Comm. 7 pp.

Gonadal tissue and shells of small ocean quahogs, *Arctica islandica*, were collected during summer of 1978 from off Long Island, New York, to determine sexual maturity and age. The quahogs ranged from 19 to 60 mm ($\bar{x}$ = 39.2 mm) in shell length. Undifferentiated and differentiated gonadal development was found, but many in the latter condition were in an intermediate state and were separated into two groups based on tubule development and germinal cell production. Attainment of sexual maturity was variable with respect to size and age. The sex ratio was imbalanced in favor of males and was most unequal in quahogs in intermediate stages of gonadal development, probably because females initiated maturation at somewhat larger sizes and older ages than males. (Authors' Abstract)

Ropes, J.W., F.M. Serchuk, and S.A. Murawski. 1981.

Studies of ocean quahogs off Shinnecock Inlet, Long Island. Coastal Oceangr. Climatol. News 3(3): 31-32.

Observations of gonadal condition, sexual maturity, and age in 19-60 mm ocean quahogs collected in 1978 are summarized and related to observations of sex and size of specimens 57-103 mm collected in 1980. The data indicated a great disparity in favor of females with increasing size and age. (J.W.R.)

Ropes, J.W., and S.A. Murawski. 1981.

Size and age at sexual maturity of ocean quahogs *Arctica islandica* Linné, from a deep oceanic site. J. Shellfish. Res. 1: 122. (Abst.).

Gonadal tissues and the corresponding shells of ocean quahogs *Arctica islandica* were collected during late July to early August 1978, from off Long Island, New York, for an examination of sexual development and growth line formation. The collection dates were before the known time of spawning for the species and when gonadal development was expected to be in a ripe stage. Most of the clams were of small size ($\bar{x}$ = 39.2 mm; standard deviation (SD) ± 8.13), ranging from 18.7 to 60.4 mm in shell length. A 5-year-old (41.0 mm) and three 6-year-old (36.4 to 41.0 mm) clams were the youngest containing well developed gonads and numerous sex cells, but a 10-year-old (47.9 mm) clam only had moderately developed gonads containing few sex cells. Gametogenesis indicative of the female sex was in older (5-year-old) clams than in males (3-year-old), suggesting a later attainment of sexual maturity of female clams. Gonadal tubule development, gametogenesis, and attainment of sexual maturity were variable with respect to size and age.

Ropes, J.W., D.S. Jones, S.A. Murawski, F.M. Serchuk, and A. Jearld, Jr. 1984.

Documentation of annual growth lines in ocean quahogs *Arctica islandica* Linné. Fish. Bull. 82: 1-19.

About 42,000 ocean quahogs, *Arctica islandica* Linne, were marked and released at a deep (53 m) oceanic site off Long Island, New York in 1978. Shells of live specimens recovered 1 and 2 years later were radially sectioned, polished, and etched for preparation of acetate peels and examination by optical microscopy or microprojection; selected specimens were similarly prepared for examination by scanning electron microscopy. Specific growth line and growth increment microstructures are described and photographed. An annual periodicity of microstructure is documented, providing a basis for accurate age analyses of this commercially important species. (Authors' Abstract)

Ropes, J.W., and D. Pyoas. 1982.

Preliminary age and growth observations of ocean quahogs, *Arctica islandica* Linné, from Georges Bank. ICES C.M. 1982/K:15, Shellfish Committee. 6 pp.

Examination of annual growth lines revealed ocean quahogs from Georges Bank to be much younger than specimens of equal shell length from off Long Island, New York, or off Sable Island, Canada; specimens from the Sable Island area were the oldest. Comparisons between sample data for 1980 from Georges Bank and similar data from the Long Island, New York, area indicate significant differences in mean shell length at comparable ages. (Authors' Abstract)

Ropes, J.W., S.A. Murawski, and F.M. Serchuk. 1984.

Size, age, sexual maturity, and sex ratio in ocean quahogs, *Arctica islandica* Linné, off Long Island, New York. Fish. Bull. 82: 253-267

Ocean quahogs, *Arctica islandica*, were collected off Long Island, New York, in 1978 for a determination of sexuality and gonadal condition. A microscopic examination of histologically prepared tissues of 133 clams, 19-60 mm in shell length, revealed that 36 were in an undifferentiated condition and could not be sexed. Sexual differentiation was evident in 97 clams; of the latter, 69 were in two types of intermediate development; those with sparse (20) and moderate (49) tubule development. Only 28 clams were fully mature. Age and growth were assessed from acetate peels of shell cross sectins. Determinatins of sex of these, and of specimens 57-103 mm in shell length collected from the same area in 1980, indicated that the smallest and youngest ocean quahogs were predominantly male, but the largest and oldest were predominantly female. (Authors' Abstract)

Rowell, T.W., and D.R. Chaisson. 1983.

Distribution and abundance of the ocean quahog (*Arctica islandica*) and Stimpson's surf clam (*Spisula polynyma*) resources on the Scotian Shelf. Can. Ind. Rep. Fish. Aquat. Sci. 142: V + 75 pp.

During 1980 to 1982, an assessment of underutilized clam resources using hydraulic dredges was conducted along the south shore of Nova Scotia between St. Mary's Bay and St. Margaret's Bay and on the offshore banks of the Scotian Shelf. Distribution and minimum biomass were determined for the principal target species, the ocean quahog (*Arctica islandica*) and the Stimpson's surf clam (*Spisula polynyma*). Maximum sustainable yield (MSY) for populations of the ocean quahaug in the inshore area is estimated at 322 t to 1,767 t[1]. No significant concentrations of Stimpson's surf clam were found in the inshore areas. The offshore areas of Sable Island and Western Banks were found to have the highest concentrations of ocean quahogs and Banquereau Bank. The greatest clam densities on Western and Sable Island Banks are estimated to have a MSY for the ocean quahaug of 2,803 t to 12,601 t[1] while those on Banquereau Bank are estimated to have a MSY for the surf clam of 23,960 t to 87,892 t[1]. (Authors' Abstract)

Footnote: [1]Range of MSY value based on 90% confidence limits of the minimum biomass estimates.

Rumohr, H., and W.E. Arntz. 1982.

The "Benthosgarten" - a new approach for the study of soft bottom communities. MeeresForschung 29: 225-238.

The paper discusses technical and methodological aspects of a large-scale *in situ* experiment on macrozoobenthic colonization, succession and secondary production that was carried out at the bottom of Kiel Bay (Western Baltic) during 1975-1979. In particular, reference is made to problems of basic requirements, experimental set-up, materials and sampling techniques that may complicate this kind of study. (Authors' Abstract) *Cyprina islandica* was one of the macrobenthic species investigated.

Russell, H.D. 1965.

A new clam industry in New England. Nautilus 69: 53-56.

Describes processing of *Arctica islandica* and fishing methods for a new deep ocean clam industry.

Sager, G., and R. Sammler. 1983.

Mathematical investigations into the longevity of the ocean quahog, *Arctica islandica* (Mollusca: Bivalvia). Int. Revue ges. Hydrobiol. 68(1): 113-120.

Annual internal growth banding of *Arctica islandica* has shown that the species has a surprising longevity of up to 149 years as stated by Thompson, Jones and Dreibelbis (1980). The have compiled 100 values of valve height against age as reproduced in Figure 1. Visually gained growth curves have been added for single specimens that leave some doubt as to the existence of an inflexion point. In this paper a cross-sectional evaluation of growth behaviour is carried out with nine functions using nonlinear regressions. Five growth functions yield almost equally good results with a final valve height just below 100 mm. An inflexion point is either present in early youth or lacking altogether, depending on the growth function used. (Authors' Abstract)

Saleuddin, A.S.M. 1964.

Observations on the habit and functional anatomy of *Cyprina islandica* (L.). Proc. Malacol. Soc. Lond. 36: 149-162.

Some observations have been made on the habitat and functional anatomy of *Cyprina islandica*. It burrows vertically into sand or sandy mud and because of its short siphons cannot burrow deep.

The siphons which are fringed with tentacles are formed by the fusion of the inner folds of the mantle lobes. A histological and histochemical study of the mantle epithelium and associated glands reveals that there is only one type of gland secreting mucopolysaccharide-proteins on the inner surface of the mantle and two on the outer.

The structure of the gill is described. The gill is plicate and the ascending lamella of the inner demibranch has ciliary connection with the visceral mass all along its length.

A study of the anatomy and function of the stomach has been made and it conforms with Purchons' type V. In the digestive tubule there are cells with long vibratile cilia and absorbing cells. (Author's Summary)

Saks, V.I. 1948.

Chetvertichnyi period v Sovetskoi Arktike. -Trudy Arktich. nauchno-issled. in-ta, t. 201. (Quaternary Period in Soviet Arctica. -Transactions of the Arctic Scientific Research Institute, volume 201).

(Abstract not yet available)

Saks, V.I. 1949.

Chetvertichnaya istoriya Shpitsbergena. -Probl. Arktiki, No. 3. (Quaternary history of Spitsbergen. -Problems of Arctica, No. 3).

(Abstract not yet available)

Sannia, A., and B.L. James. 1977.

The Digenea in marine molluscs from Eyjafjordur, North Iceland. Ophelia, 16(1): 97-109.

Fourteen species of marine molluscs, collected from the west coast of Eyjafjordur, North Iceland, are examined for parasitic Digenea. The distribution and where necessary the morphology of seven parasite species is described, including three new to science, namely, *Metacercaria margaritae-groenlandicus* I, *Cercaria littorinae-saxitilis* VI and *Metacercaria nucellae-lapillus*. The others, involving two new host records, have not previously been recorded from Iceland. (Authors' Abstract) *Arctica* was a species examined for Digenea.

Schlesch, H. 1959.

A monstrosity of *Cyprina islandica* (L.). J. Conch., Lond. 24: 318.

A *Cyprina islandica* with a normal right valve but nearly flat left valve is reported.

Schlieper, C. 1966.

Genetic and nongenetic cellular resistance adaptation in marine invertebrates. Helgol. Wiss. Meeresunters 14: 482-502.

Cyprina islandica is included in a study of the physiological capacity and ability of marine invertebrates to adapt to the biotic and abiotic qualities of their environments. The cellular pressure resistance of *C. islandica* is compared with litoral bottom organisms, some of which have greater resistance and greater vertical distribution.

Schlieper, C., H. Flügel, and H. Theede. 1967.

Experimental investigations of the cellular resistance ranges of marine temperate and tropical bivalves. Physiol. Zool. 40: 345-360.

Cyprina islandica is cited as a more cold stenotherm temperate bivalve that is also less pressure sensitive than *Mytilus edulis*. The pressure resistance of *C. islandica*, similar to the behavior of *Modiolus auriculatus* of the Red Sea, ceases at 350 atm. The related species *Modiolus modiolus* from 15-50 m in the Kategat were distinctly more pressure resistant. This suggests that euryoecous and eurythermal species have developed a greater stability of protein and protein complexes which provide them with higher pressure resistance abilities.

Schlieper, C. 1968.

High pressure effects on marine invertebrates and fishes. Mar. Biol. 2: 5-12.

In a review of his own and others' work, he includes *Cyprina islandica* in a figure comparing experimental pressure limits (LD50-atm) of marine invertebrates and fishes from shallow waters of the western Baltic Sea. The clam withstood a hydrostatic pressure of 730 atm for 1 h at 10°C and 15 $^{o}/oo$ S. Also includes the influence of increased hydrostatic pressure on the cellular survival-rate.

Schram, T.A. 1962.

Undersökelse avbunninvertebratplanktonet i Öresund 1959-60. Thesis (in Norwegian). University of Oslo, Norway. 96 pp.

(Abstract not yet available)

Sen Gupta, A.K. 1972.

Recent advances in the chemistry and biochemistry of methyl-trenched fatty acids. From the Unilever Forshungsgesellscha mbH. Hamburg. 74 Jahrang. Nr. 12.

(Abstract not yet available)

Serchuk, F.M., and S.A. Murawski. 1980.

Evaluation and status of ocean quahog, *Arctica islandica*, (Linnaeus) populations off the MIddle Atlantic coast of the united States. NMFS, NEFC, Woods Hole Laboratory, Lab. Ref. Doc. No. 80-32, 4 pp.

Report updates evaluation of the status of ocean quahog populations off the Middle Atlantic coast of the United States. Minimum biomass estimates and derived equilibrium yields (i.e., maximum sustainable yields) were computed. Based on current harvest levels, it was concluded that the resource was not apparently being harmed.

Serchuk, F.M., S.A. Murawski, and J.W. Ropes. 1982.

Ocean quahog, *Arctica islandica*. *In*: Grosslein, M.D. and T.R. Azarovitz (eds.), Fish Distribution. MESA New York Bight Atlas Monograph 15, New York Sea Grant Inst., Albany, N.Y., pp. 144-146.

Distribution, population size, population size, fisheries, and biological information on ocean quahogs are reported. (J.W.R.)

Sharp, J.H. 1976.

Anoxia on the Middle Atlantic Shelf during the summer of 1976. Report on a workshop held in Washington, D.C., October 15 and 16, 1976. Internat. Decade of Ocean Explor./Natl. Sci. Found. 122 pp.

Fifty university, state, and federal scientists attended an October 15-16 workshop held in Washington, D.C., sponsored by the National Science Foundation's Office for the International Decade of Ocean Exploration (IDOE). They agreed that the anoxic (low oxygen) condition that existed during the summer and fall of 1976 was the combined result of meteorological conditions, shelf water circulation, and the degradation of organic matter, including an extensive algal bloom. The anoxic region is located about 4 miles off the New Jersey coast and is, at its greatest extent, about 100 miles long and 40 miles wide. It has had a severe impact on the finfish and shellfish populations in the area.

Scientific presentations focused on the data available from this region and the probable causes of the phenomenon. Specifically, an extensive algal bloom, dominated by the organism *Ceratium tripos*, developed in the early spring and extended into the fall of 1976. This could have contributed significantly to the organic matter on the shelf. However, its precise contribution to the anoxic condition remains uncertain. Probable contributing

factors were a relative dearth of storm activity, anomalous surface wind conditions, and unusually warm sea surface temperatures over much of the Middle Atlantic Bight. It appears that the oxygen content of the water beneath the permanent thermocline in this area is in a state of very critical natural balance.

The scientists agreed that the anoxic phenomenon was so large and complex that it would be necessary to enlist the efforts of all the scientific disciplines represented at the workshop to understand its causes and consequences. These disciplines included physical, chemical, and biological oceanography, meteorology, fisheries biology, and resource management. (Author's Abstract)

Skuladottir, U. 1967.

Krabbadyr og skeldyr (Crustaceans and mollusks). From: Radstefna Islenzkra Verkfraedinga (Proceedings of Conference of Icelandic Professional Engineers), 52: 13-23. (Translated by the Translation Bureau Foreign Languages Division, Department of the Secretary of State of Canada, Fisheries Research Board of Canada Biological Station, St. Andrews, N.B. No. 1206).

Cyprina islandica and *Mytilus edulis* are mollusks considered practical to catch for human consumption in Icelandic waters. Seasonal meat weights in selected shell length groups of the clam are given. Maximum meat weight was reached in mid-July. Thereafter it declined rapidly due to spawning. An age of 18 years was given for the oldest, 9 cm long clams; most were 10-14 years old and 7-8.7 cm long. Chemical analyses of the percentage of protein, fat, salt, water, and ash are given. Protein and fat were most variable. Mytilotoxin from toxic algae was discussed. (Translation of work by Translation Bur., Canada, is available at the NMFS, Oxford Laboratory.)

Smith, R.I. 1964.

Keys to marine invertebrates of the Woods Hole region. Systematics-Ecology Prog. Mar. Biol. Lab., Contr. No. 11. 208 pp.

Arctica islandica is included in a key to bivalved molluscs and annotated list.

Smith, E.A. 1912.

On the generic name applied to the *Venus islandica*. Linn. Proc. Mal. Soc. London 10(pt. 2): 105-106.

A synonmy of *Cyprina islandica* is given. The generic name *Cyprina* is supposed to be the correct one for the *Venus islandica* of Linnaeus. (See also Boss, K.J. 1969)

Smolowitz, R.J., and V.E. Nulk. 1982

The design of an electrophydraulic dredge for clam surveys. Mar. Fish. Rev. 44(4): 1-18.

A clam dredge system, using an electrically driven submersible pump, was designed for surf clam. *Spisula solidissimia*, and ocean quahog, *Arctica islandica*, surveys along the northeast coast of the United States in water depths to 100 m. the 3,200 kg, 5.2 m long dredge has a 1.52 m cutting knife and pumps 7,570 l per minute through the cutting jet manifold. The pump power requirement is 100 amps of 460 V AC 3-phase current provided via a special cable by the ship's 150 k W generators. This paper describes the design of the dredge and the operating experiences to date. (Authors' Abstract)

Sorby, H.C. 1879.

Address on the structure and origins of limestones. Quart. J. Geol. Soc. London. 35: 56-95.

Examined the shell structure of *Cyprina islandica* and found "fibers perpindicular to the plane of growth [that] are so short as to appear like granules, though the optic axes are still definitely oriented in the normal manner."

Stafford, J. 1902.

The clam fishery of Passamaquoddy Bay. Contr. Canad. Biol. 1901(3): 19-40.

This is a monograph on the biology of *Mya arenaria*, the soft shell clam. A few pages are included on its fishery in Canadian eastern provinces. Other bivalve molluscs are mentioned briefly. The family Cyprinidae belonging to the order Siphoniata containing the sea clam or Black Quahog is mentioned. It is differentiated from the Myidae by having no mantle sinus, a short and non-retractile siphon. (J.B.)

Standley, M.L., and P.S. Parker. 1967

Developments of a submersible pumping system for a hydraulic surf clam dredge. Comm. Fish. Rev. 29(6): 50-54.

An electrically driven submersible pump was tested as a means of supplying water to a surf clam dredge. A 65-horsepower submersible pump ws mounted on a 48-inch clam jetting dredge. The pump supplied 2,000 gallons per minute directly to the jet manifold of the dredge. Comparison tows were made with the submersible system and the standard vessel-mounted pumping system to determine their relative efficiencies. The submersible pump operated satisfactorily and gave results comparable to the vessel-mounted system. Advantages of the new system are ease of handling and greater efficiency in power transmission.

Steimle, F.W., Jr., and R.B. Stone. 1973.

Abundance and distribution of inshore benthic fauna off southwestern Long Island, N.Y. NOAA Tech. Rep. SSRF-673, 50 pp.

Specimens of *Arctica islandica* were reported in Peterson grab samples from off the Long Island, N.Y., coast.

Steimle, F. 1976.

A summary of the fish kill-anoxia phenomenon off New Jersey and its impact on resource supplies. *In*: Sharp, J.H., Anoxia on the Middle Atlantic Shelf during the summer of 1976. Rept. on a workshop held in Washington, D.C., October 15 and 16, 1976. 122 pp.

The impact of anoxic conditions on fishery resources that developed off New Jersey in the summer of 1976 is summarized. Surf clams and ocean quahogs were specifically mentioned as species suffering significant mortalities.

Steimle, F.W., and C.J. Sindermann. 1978.

Review of oxygen depletion and associated mass mortalities of shellfish in the Middle Atlantic Bight in 1976. Mar. Fish. Rev. 40(12): 17-26.

In summer and autumn of 1976, mass mortalities of shellfish occurred in a 165-km long corridor of severe oxygen depletion paralleling the New Jersey coast from 5 to 85 km from shore. Mortalities of surf clams, *Spisula solidissima*, the most severely affected species, were estimated in excess of 140,000 t. Alteration of normal migration patterns of lobsters and several species of finfish was also noted. A series of anomalous meteorological and hydrological events (particularly early warming of surface waters resulting in early thermocline development, and a massive shelf-wide phytoplankton bloom) superimposed on an already stressed coastal area, was considered to be responsible. The occurrence is particularly significant because the continental shelf of the Middle Atlantic Bight, from Cape Cod to Cape Hatteras on the east coast of the United States, contains the largest known stocks of ocean shellfish of any comparable coastal area of North America. (Authors' Abstract)

Mortalities of ocean quahogs, *Arctica islandica* were also reported, although they were much less than for surf clams.

Steimle, F.W, R. Terranova, and S. Murawski. 1981.

Size and calorimetry in *Arctica islandica*: preliminary results. (Unpublished manuscript)

A preliminary analysis of the relationship between shell length and caloric content of the meat in *Arctica islandica* is provided. The results indicated that there was an inverse relationship with caloric content decreasing with an increse in shell length. (J.B.)

Steimle, F.W., P.D. Boehm, V.S. Zdanowicz, and R.A. Bruno. (In Press).

Organic and trace metal levels in the ocean quahog (*Arctica islandica* Linne) from the northwestern Atlantic. Fish. Bull. 84(1):

Chemical contamination of biological resources is an important problem for resource managers. This study reports on body burden levels of several contaminants of concern: polychlorinated biphenyls, polynuclear aromatic hydrocarbons of both petroleum and combustion sources, total petroleum hydrocarbons and seven trace metals (Ag, Cd, Cr, Cu, Ni, Pb and Zn) in a resource species, the ocean quahog, collected between Virginia and Nova Scotia. Organic and trace metal contaminants were detected, at low levels, in all samples examined, with highest levels being generally found in samples from the inner New York Bight and Rhode Island Sound. The highest PCB and PAH values were 27 and 55 ppb, respectively; Ag, Cd and Cr values were generally less than 5 g/g dry wt; Cu, Ni and Pb generally less than 15 g/g dry wt with a few exceptions; and Zn ranged from 50 to 153 g/g wt. (Authors' Abstract)

Step, E. 1960.

Shell Life - An Introduction to the British Mollusca. Frederick Warne & Co., Ltd., London and New York. 443 pp.

(Abstract not yet available)

Swanson, R.L. 1976.

Evaluation of proposed sewage sludge dumpsite areas in the New York Bight. U.S. Dep. Commer. NOAA Tech. Memo. ERL MESA-11. 212 pp.

Significant features of the New York Bight's midshelf environment and alternative sewage sludge dumpsite areas are summarized. Applicable conclusions about the effects of dumping sewage sludge at any interim dumpsite in this environment are drawn and specific recommendations relative to dumping operations and monitoring activities are presented. Potential commercial shellfish resources, including the ocean quahog, distributed in and near the proposed dump areas, did not favor selecting either site.

Taylor, J.D., W.J. Kennedy, and A. Hall. 1969.

The shell structure and mineralogy of the Bivalvia. Bull. British Museum (Natl. Hist.); Zool. Suppl. 3, 125 pp.

The shell structure of *Arctica islandica* is given in considerble detail in a section on homogeneous shell structure.

Taylor, A.C., and A.R. Brand. 1975.

A comparative study of the respiratory responses of the bivalves *Arctica islandica* (L.) and *Mytilus edulis* L. to declining oxygen tension. Proc. R. Soc. Long. B. Biol. Sci. 190(1101): 443-456.

The bivalves *A. islandica* and *M. edulis* generally maintain repiratory independence during hypoxia, but the mechanisms by which this is achieved are very different. In declining O_2 tension, *Arctica* increases the rate of ventilation down to a low PO_2 of about 7 kPa, while O_2 utilization is gradually reduced. In contrast, *Mytilus* shows only a slight initial incrase in ventilation rate, which then falls steadily as the PO_2 of the medium declines, while the O_2 utilization increases sharply. *Mytilus* which have lost the ability to maintain respiratory independence show little change in O_2 utilization. The increase in ventilation rate of the subtidal *Arctica* is brought about principally by increasing the duration of the pumping periods; a mechanism not available to *Mytilus* which, like other intertidal species studied, normally pumps more or less continuously whenever it is immersed. The cardiac responses to hypoxia are very similar in *Arctica* and *Mytilus*; heart rate and amplitude incrase down to a PO_2 of about 2-4 kPa, below which both decrease rapidly. In *Arctica* the ventilation/perfusion ratio remains approximately constant over the range of O_2 tension that respiratory independence is maintained. In *Mytilus* this ratio gradually declines as the ambient PO_2 is reduced. The different respiratory responses of these 2 spp. to hypoxia may be due to the different patterns of pumping behavior related to their different habitats, and to the relative energy costs of pumping blood and water. (Authors' Abstract)

Taylor, A.C., and A.R. Brand. 1975.

Effects of hypoxia and body size on the oxygen consuption of the bivalve *Arctica islandica* (L.). J. Exp. Mar. Biol. Ecol. 19(2): 187-196.

The relationship between O_2 consumption and body weight was examined in *A. islandica*. Large *Arctica* exhibit a high degree of respiratory independence under hypoxic conditions; like other species studied, repspiratory independence increases markedly with increasing body size. Respiratory independence can be modified by temperature and physiological condition. The division of species per se into O_2 regulators and O_2 conformers is not merited as these terms describe only the extremes of a variable capacity to maintain respiratory independence during hypoxia. (Authors' Abstract)

Taylor, A.C. 1976.

Burrowing behaviour and anaerobiosis in the bivalve *Arctica islandica* (L.). J. Mar. Biol. Ass. U.K. 56, 95-109.

In laboratory tanks as well as in the sea *Arctica islandica* shows a pattern of intermittent burrowing activity. Periods spent at the surface of the deposit alternate with periods buried several centimetres beneath the surface of the sand, during which the animals respire anaerobically. There is no obvious rhythmicity to this behaviour; the duration of periods spent beneath

the surface is very variable even in the same animal, but normally lasts between 1 and 7 days.

On the return to aerobic conditions both the heart rate and oxygen consumption are increased but decline gradually during the following 20-25 hr. This increased oxygen uptake is caused primarily by an increase in oxygen utilization but there is little change in ventilation rate. Both the initial rate of oxygen consumption and the duration of the recovery period show a correlation with the duration of the period of anaeobiosis. The concentration of alanine in the blood of *Arctica* is high immediately after the return to aerobic conditions but declines during the recovery period. The similarity in the time taken for the concentration of alanine in the blood and the oxygen consumption of *Arctica* to return to normal levels suggests that at least part of this increased oxygen demand is associated with the metabolism of end-products of anaerobiosis.

Tebble, N. 1966.

British bivalve seashells. British Museum (Natl. Hist.) London, 212 pp.

Describes *Arctica islandica*, notes occurrence all around the British Isles, and gives general worldwide distribution.

Theede, H. 1965.

Vergleichende experimentelle Untersuchungen über die zelluläre Gefrierresistenz mariner Muscheln. (Comparative experimental investigations on the freezing resistance of marine bivalves. Kieler Merresforsch 21: 153-166.

The cellular freezing resistance of 12 bivalve species (including *Arctica islandica*) from the North Sea and the Baltic Sea were experimentally measured by means of surviving tissue pieces. The resistance is a species specific and partly environmentally induced value which is correlated to the occurrence (especially depth) and the geographical distribution of the species. *A. islandica* from the Baltic Sea was less resistant than *Mytilus edulis* and more resistant than *Astarte borealis* or *Abra alba*. (Translation of work by Nat. Sci. Found. is available at the NMFS, Oxford Laboratory.)

Theede, H., A. Ponat, K. Hiroki, and C. Schlieper. 1969.

Studies on the resistance of marine bottom invertebrates to oxygen-deficiency and hydrogen sulphide. Mar. Biol. (Berlin) 2(4): 325-337.

Oxygen-deficient and H_2S-containing marine areas are characterized by a decline in the number of species. In laboratory experiments with bottom invertebrates from various biotopes of the North Sea and the Baltic, comparative measurements of the resistance to oxygen-deficiency alone, and to the simultaneous presence of H_2S were carried out. The resistance values obtained show relations to the substratum on which the species naturally occur. The resistance to H_2S is greater in those macrofauna species which show higher survival rates under oxygen-deficiency. Further experiments with

isolated tissues demonstrated that the species specific differences in resistance occurring in whole animals are already based on the cell metabolism. In general, oxygen-deficiency and simultaneous presence of H_2S were endured better in cold than in warmth, and at somewhat reduced pH-values (around 7). the dependence of this resistance on the salinity was only minimal in euryhaline species. (Authors' Abstract)

Cyprina islandica was among the marine bottom invertebrates tested.

Theede, H. 1973.

Comparative studies on the influence of oxygen deficiency and hydrogen sulfide on marine bottom invertebrates. Netherlands J. Sea Res. 7: 244-252.

Comparative measurements of the resistance of marine bottom invertebrates of macrofauna (polychaetes, lamellibranchs, gastropods, crustaceans, echinoderms) to oxygen deficiency and to H_2S reveal correlations to the respiratory conditions of the biotopes, where the species naturally occur. High resistance to H_2S parallels that to oxygen deficiency alone. This is valid on the organismic as well as on the tissue level. The resistance to H_2S is strongly modified by some environmental factors; it is significantly higher at low temperatures and at reduced effect within a relatively broad range. In bivalves resistance to oxygen deficiency and to H_2S is connected with a pronounced ability to reduce mechanical and metabolic activity by responses of the whole animals and by cellular reactions. Measurements of the dependency of oxygen consumption on oxygen tension in whole animals demonstrate different types of reaction dependent on the species and the state of activity. Temporary increases of oxygen consumption at "normal" oxygen tensions after subjection to seawater deprived of oxygen indicate adaptations to oxygen deficiency. (Author's Abstract)

Cyprina islandica was among the marine bottom invertebrates tested.

Templeman, W. 1966.

Marine resources of Newfoundland. Fish. Res. Bd. Canada Bull. 154: 127.

The ocean quahog is given very brief mention in a section on "other molluscs." It occurs at least in St. George's Bay and on the southeast shoal of the Grand Bank.

The author states: "It is difficult to market in quantity at the present time and its abundance is not yet evaluated." (J.B.)

Theroux, R.B., and R.L. Wigley. 1983.

Distribution and abundance of East Coast bivalve mollusks based on specimens in the National Marine Fisheres Service Woods Hole Collection. NOAA Technical Report NMFS SSRF-768.

This report presents the distribution and numerical abundance of over 108,000 specimens of bivalve mollusks (81% of which were alive when captured) collected and maintained by the Benthic Dynamics Investigation at the NMFS Northeast Fisheries Center at Woods Hole, Mass. Distribution and ecology of

Arctica islandica is described as reviewed in the literature and as found in NMFS Specimen Reference collection. The ocean quahog occurs in 3.6% of the samples and represents 1.9% of the specimens in the collectin. The samples range from Nova Scotia to Cape Hatteras, N.C. All samples were confined to offshore regions, with the exception of Cape Cod Bay. Samples range in depth from 10 to 400 m with a mean depth of 79 m. 57% of samples and specimens are in the 50-99 m depth range grouping; abundance of both samples and specimens diminishes with increasing and decreasing depth range beyond this range. 56% occurred in sand, 12% in clay, and 9% in silty sand.

Thiele, J. 1934.

Handbuch der systematischen Weichtierkunde. Bd. 2, Teil 3, p. 781-1022.

Lists *Cyprina islandica* as a species in the north Atlantic.

Thompson, I., and D.S. Jones. 1977.

The ocean quahog, *Arctica islandica*, "tree" of the North Atlantic shelf. *In*: Abstr. Ann. Meeting Geol. Soc. Amer. (1977) p. 1199.

Notes that *Arctica* records neritic ocean conditions by varying the width of annual bands in the hinge plate.

Thompson, I., D.S. Jones, and D. Dreibelbis. 1980.

Annual internal growth banding and life history of the ocean quahog *Arctica islandica* (Mollusca:Bivalvia). Marine Biology 57: 25-34.

Internal growth bands visible in cross-sections of the valves and hinge plates of *Arctica islandica* Linné are deposited annually, possibly in response to the reproductive cycle. Growth rate and longevity, inferred from the bands, are surprising: *A. islandica* grows very slowly and lives to an advanced age. Individuals with more than 90 bands are not uncommon; the maximum number of bands discovered so far is 149. On the basis of average size for Middle Atlantic Bight specimens, modal age is estimated to range from 65 to 105 years. (Authors' Abstract)

Thompson, I., D.S. Jones, and J.W. Ropes. 1980.

Advanced age for sexual maturity in the ocean quahog, *Arctica islandica* (Mollusca:Bivalvia). Marine Biology 57, 35-39.

A study of gonadal state in 39 small specimens of *Arctica islandica* Linne collected in April 1976 from the Middle Atlantic shelf of North America suggests that sexual maturity is reached at a later age than has been reported for other shelf bivalves. Eight of the specimens had gonads in the undifferentiated state. On the basis of annual internal growth banding in the shells of these immature specimens, age ranged between 4 and 14 years. Average age was 9.38 years (standard deviation, s = 3.54). Shell length ranged from 24 to 47 mm (average 38.85 mm, s = 9.25). Differentiated gonads

were found in specimens as young as 6 years. Age of maturity shows a wide range and may be dependent upon growth rate and locality. (Authors' Abstract)

Thorson, G. 1936.

The larval development, growth and matabolism of Arctic marine bottom invertebrtes. Medd. Grønl., Bd. 100, Nr. 6, 155 pp.

Notes occurrence of *Cyprina islandica* in the fauna of the Barents Sea, the White Sea, and sea around Kanin Peninsula, but that the pelagic larvae are unknown from Northest Greenland. Fossil shellbeds from Spitsbergen contain the clam.

Thorson, G. 1946.

Reproduction and larval development of Danish marine bottom invertebrates, with special reference to the planktonic larvae in the sound (Øresund). Medd. Dan. Fish. Harunder, (Ser. Plankton). 523 pp.

An extensive study of reproduction and larval development of Danish marine bottom invertebrates. *Arctica* is included in a synopsis of Lamellibranchia (see Jorgensen, 1946).

Thorson, G. 1965.

The distribution of benthic marine mollusca along the N.E. Atlantic shelf from Gibraltar to Murmansk. Proc. First Eur. Malacol. Congr. (1962), p. 5-25.

Cyprina islandica is given as one among 24 Lamellibranchia listed from western Europe. The article reviews distribution, percentage representation, feeding habits, and larval development and includes an extensive list of references.

Trueman, E.R. 1953.

Observations on certain mechanical properties of the ligament of *Pecten*. J. Exp. Biol. 30: 453-467.

The opening moment of the ligament of *Cyprina islandica* relative to total shell volume is given as 550q mm per ml.

Trueman, E.R. 1964.

Adaptive morphology in paleoecological interpretation. *In*: Imbrie, J. and N.D. Newell (eds.), Approaches to Paleoecology. Wiley Inc., pp. 45-74.

See abstract for Trueman, E.R. 1953.

Tryon, G.W., Jr. 1884.

Structural and systematic conchology. An introduction to the study of the Mollusca. Acad. Nat. Sci., Philadelphia, PA. Vol. III, 453 pp. and plates.

Arctica islandica is described as *Cyprina islandica*. Information on distribution, shell morphology and anatomy are reported. (J.B.)

Turekian, K.K., J.K. Cochran, Y. Nozaki, I. Thompson, and D.S. Jones. 1982.

Determination of shell deposition rates of *Arctica islandica* from the New York Bight using natural ^{228}Ra and ^{228}Th and bomb-produced ^{14}C. Limnol. Oceanogr., 27(4): 737-741.

Shell deposition rates of specimens of *Arctica islandica* (Mollusca: Bivalvia) from the New York Bight were determined using natural ^{228}Ra and ^{228}Th and bomb ^{14}C. The specimens from deep (>55 m) offshore waters show annual growth banding. A shell obtained from the inner bight at <30-m depth seems to be younger than indicated by band counting. (Authors' Abstract)

Turner, H.J., Jr. 1949.

The mahogany quahaug resources of Massachusetts. *In*: Report on investigations of improving the shellfish resources of Massachusetts. Commonw. Mass., Dep. Conserv., Div. Mar. Fish., p. 12-16.

The history of development of the ocean quahog, *Arctica islandica*, fishery is discussed and a survey conducted in 1949 is described. Prospects for enlarging the fishery to offset declines in soft clam and sea clam resources are considered. Biological notes of commercial importance of the clam are included.

Turner, H.J., Jr. 1949.

The conservation problems associated with possible development of a sea clam fishery in Massachusetts. Ref. No. 49-17 WHOI Rep. Mar. Fish. Sct., Mass. Dep. Conserv., p. 3-22.

Notes that beds of mahogany quahogs, *Cyprina (Arctica) islandica* occur in and adjacent to Massachusetts waters in sufficient quantities to support an extensive fishery, if a suitable market can be developed. Information on the life history of the clam is included.

Turner, H.J., Jr. 1953.

A review of the biology of some commercial molluscs of the east coast of North America. *In*: Sixth Report on Investigations of the Shellfisheries of Massachusetts. Commonwealth of Mass., Dep. Nat. Res., Div. Mar. Fish., p. 39-74.

Brief reviews are given of the biology of several molluscs, including *Arctica islandica*. Its habitat, influence of temperature on zonation, thermal death point, and occurrence in underwater photographs are noted.

Tyler, A.V. 1973.

Caloric value of some North Atlantic Invertebrates, Mar. Biol. 19: 258-261.

Nineteen marine species were anlyzed for caloric value; 7 of these were analyzed for seasonal trends. Variation in caloric value for the polychaetes *Nephtys incisa* and *Lumbrineris fragilis* was not related to season. *Pandalus montagui* (decapod shrimp), *Septocheirus pinguis* (gammarid amphipod), *Astarte undata*, *Arctica islandica* (pelecypods) had summer maxima. *Meganyctiphanes norvegica* (krill) had more complex seasonal changes involving winter and summer maxima. (Author's Abstract)

U.S. Department of Commerce

Fishery statistics of the United States 1945-1977. U.S. Dept. Commerce, NOA, NMFS. Statistical Digests Nos. 18-70.

Ocean quahog landings and their value are reported from 1945 to the most current published year, 1977. Landings in 1945 were only reported for Rhode Island. In 1954, Massachusetts first reported landings. In 1975, the State of New Jersey was added to the ocean quahog fishery. In 1976, a 2,500 MT landing was followed by significant increases to an annual mean of 15,800 MT for 1979 to 1983.

U.S. Department of Commerce

Rhode Island landings, 1945-1985. U.S. Dept. Commerce, NOAA, NMFS. Current Fisheries Statistics (various numbers).

Monthly ocean quahog landings and their value and reported for Rhode Island.

U.S. Department of Commerce

Massachusetts landings, 1954-1985. U.S. Dept. Commerce, NOAA, NMFS. Current Fisheries Statistics (various numbers).

Monthly ocean quahog landings and their value are reported for Massachusetts.

U.S. Department of Commerce

New Jersey landings, 1975-1985. U.S. Dept. Commerce, NOA, NMFS. Current Fisheries Statistics (various numbers)

Monthly ocean quahog landings and their value are reported for New Jersey.

U.S. Department of Commerce, Natl. Oceanic and Atmospheric Administration, National Marine Fisheries Service, North Atlantic Fisheries Research Center, Woods Hole, Mass. 1971.

Research Vessel Cruise Report R/V Rorqual. Ocean Quahog Survey. Aug. 16 - 30, 1971. 5 pp.

Describes and presents results of a clam survey in lower Ipswich Bay during 1971. *Arctica islandica* and *Spisula plynyma* were taken in the catches. (J.W.R.)

U.S. Department of Commerce. 1977.

Report to Congress. The molluscan shellfish industries and water quality: problems and opportunities. NOAA, NMFS, Office of Fish. Devel. 46 pp.

Identifies Federal and State involvement in regulating shellfish waters, growing, harvesting, transporting, processing, and marketing of oysters, clams, and mussels.

U.S. Department of Commerce. 1977.

Final Environmental Impact Statement/Fisheries Management Plan for Surf Clam and Ocean Quahog Fisheries. NOAA, NMFS. 115 pp. and appendices.

The Fishery Conservation and Mangement Act of 1976 (P.L. 94-265) enacted and signed into law on April 13, 1976, established a Fishery Conservation Zone and provided for exclusive U.S. regulation of this zone under the concept of optimum yield. This management plan for surf clam and ocean quahog was prepared by the Mid-Atlantic Fishery Management Council in consultation with the New England and South Atlantic Fishery Management Councils in accordance with P.L. 94-265,

The short-term objectives of the plan are to stabilize surf clam populations and to prevent overfishing of the ocean quahog resource in a manner which will minimize short-term economic dislocations and promote economic efficiency. Management of surf clam and ocean quahog resources located in state waters are excluded from this plan. The states are encouraged, however, to adopt conservation measures which are compatible with those implemented by the Secretary of Commerce in the Fishery Conservation Zone.

Implementation of this plan by the Secretary of Commerce constitutes a major Federal action significantly affecting the quality of the human environment. (J.W.R.)

U.S. Department of Commerce. 1979.

Amendment No. 2 for the Surf Clam and Ocean Quahog Fishery Management Plan and Final Supplemental Environmental Impact Statement. NOAA, NMFS. 114 pp. with appendices.

The original managment plan for the surf clam and ocean quahog fisheries of the northwestern Atlantic Ocean was approved by the Secretary of Commerce in November, 1977, for the period through September, 1979. Amendment #1 to the FMP extended it through December 31, 1979, and revised reporting requirements to bring them in compliance with the amended FCMA. This Amendment #2 would extend the FMP through the end of calendar year 1981. (J.B.)

U.S. Department of Commerce. 1981.

Amendment No. 3 to the fishery management plan for the surf clam and ocean quahog fisheries and supplemental environmental impact statement. 64 pp. and appendices.

Amendment No. 3 extends the plan indefinitely and revises it. It also incorporates a moratorium on entry of vessels into the Mid-Atlantic surf clam fishery.

An objective relating to the ocean quahog fishery is:

3. Prevent the harvest of ocean quahogs from exceeding maximum sustainable yield and direct the fishery toward achieving optimum yield.

Annual quota for ocean quahog harvest is between 4.0 and 6.0 million bushels or 40-60 million pounds of meat. (J.B.)

U.S. Department of Commerce. 1982.

Surf clam and ocean quahog plan amendment No. 4.

Developed in response to the Regional Director's announcement that NMFS will withdraw the moratorium on entry of vessels into the Mid-Atlantic surf clam fishery unless the council takes some action. The revised plan removes the mortaorium on entry of new vessels into the ocean quahog/surf clam fishery, but leaves the current management regime in place.

The annual quota for ocean quahogs remains between 4.0 and 6.0 million bushels - or 40-60 million pounds of meat. (J.B.)

U.S. Department of Commerce. 1984.

Amendment No. 5 to the surf clam and ocean quahog fishery management plan. 71 pp. and appendices.

Revises surf clam minimum size limits from 5.5 inches to 5.25 inches in order to decrease the percentage of discards at sea from 60% to under 30%. There is no change in the ocean quahog management plan. (J.B.)

U.S. Department of Commerce. 1985.

Amendment No. 6 to the surf clam and ocean quahog fishery management plan. 96 pp and appendices.

Amendment No. 6 divides the New England area into the Nantucket Shoals and Georges Bank area for management and assessment purposes.
The objectives and quotas for the ocean quahog fishery remain unchanged. (J.B.)

U.S. Department of the Interior. 1976.

Final environmental impact statement. Proposed 1977 outer continental shelf oil and gas lease sale offshore the North Atlantic States. OCS Sale No. 42, Bur. Land Manag., Vols. 1 of 5, p. 327-343.

Arctica islandica is listed as a dominant species of the fine and silty-sand faunal assemblage (data from a study by Wigley, 1968). (J.W.R.)

U.S. Department of the Interior. 1978.

Final environmental impact statement. Proposed 1979 outer continental shelf oil and gas lease sale offshore the Mid-Atlantic States. OCS Sale No. 49, Bur. Land Manag. Vol. 1 of 3, p. 171-183.

Arctica islandica is listed as an important form in terms of number (density) and/or biomass (data from a study by Wigley and Theroux, 1976).

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries. 1965.

Cruise Report, MV Delaware Cruise 65-2, Feb. 19 - Mar. 18, 1965. Clam Survey. 4 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries. 1965.

Cruise Report, MV Delaware Cruise 65-4, May 3 - June 3, 1965. Clam Survey. 3 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries. 1965.

Cruise Report, MV Delaware Cruise 65-10, Sept. 10 - Nov. 24, 1965. Clam Survey. 4 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base, Gloucester, Mass. 1966.

Cruise Report, MV Delaware Cruise 66-3, April 29 - May 13, 1966. Clam Survey. 3 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base, Gloucester, Mass. 1966.

Cruise Report, M.V. Delaware Cruise 66-6, August 5 - Sept. 2, 1966. Clam Survey. 3 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, Exploratory Fishing and Gear Resarch Base, Gloucester, Mass. 1967.

Cruise Report, MV Delaware Cruise 67-5, June 6 - 30, 1967. Clam Survey. 2 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base, Gloucester, Mass. 1970.

Cruise Report, Delaware II Cruise 70-1, Jan. 26 - Feb. 5, 1970; Feb. 11 - 18, 1970. Ocean Quahog Survey. 7 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base, Gloucester, Mass. 1970.

Cruise Report, Delaware II Cruise 70-5, July 17 - 23, 1970; July 30 - Aug. 7, 1970. Ocean Quahog Survey. 6 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base, Gloucester, Mass. 1971.

Cruise Report, Delaware II Cruise 71-1, June 1 - July 23, 1971. Ocean Quahog Survey. 6 pp.

U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base, Gloucester, Mass. 1971.

Charter Cruise Report, Fishing Trawler Jo-Ann. Ocean Quahog Survey, April 18 - May 6, 1971. 4 pp.

Verber, J.L. 1967

Safe shellfish from the sea. Am. Soc. Limnol. Oceanogr., Spec. Symp. 2, p. 433-441. *In*: Gross, M.G. (ed.), Middle continental shelf and the New York Bight, Spec. Symp., Vol. 2. Amer. Soc. Limnol. Oceanogr., Inc.

The National Shellfish Sanitation Program was initiated in 1925 after a widespread typhoid fever outbreak caused by raw oysters. Specific recommendations made in 1925 established guidelines for classifying offshore waters for clam harvesting and stated that shellfish being harvested must not be exposed to fecal contamination. In 1974, sea clams accounted for 59% of all shellfish (oysters, clams, and mussels) harvested from United States waters. The Food and Drug Administration is responsible for classifying the offshore water beyond 5.5 km for harvesting shellfish. In recent years, the sea has been used increasingly for sewage sludge and industrial waste disposal. Depletion of the resources in the original major sea clam harvest area off New Jersey and increased demand (43 million kg were harvested in 1974) have caused the industry to expand its area of operation to the southeast in search of more productive shellfish beds. There too, heavy population and industrial growth have increased the amounts of chemical wastes, sewage sludge, and other waste materials being disposed of at sea. Warning notices to harvesters, closing areas of the New York Bight to shellfishing, have been posted since 1970. High bacterial levels are found in both the sewage sludge and dredge spoil sites. (Author's Abstract)

Arctica listed as having from 0.007 to 0.012 mg/kg in their tissues, levels lower than FDA limits for consumption.

Verrill, A.E. 1873.

Report on the invertebrate animals of Vineyard Sound and adjacent waters, with accounts of the physical characters of the region. *In*: U.S. Comm. Fish and Fisheries, pt. 1, Rep. Comm. 1871-1872, p. 295-778.

Notes the excavations of the cirratulid worm *Dodacacera* in the shell of *Cyprina islandica*, the abundance of the clam in soft mud, and occurrence of the clam as food in cod stomachs. The "eastern end of Long Island to the Arctic Ocean; on the northern European coasts southward to England" is given as the distribution of the clam. Occurrences at specific depths along the North American coast and observations on the fossil record are given.

Verrill, A.E. 1874.

Brief contributions to Zoology from the Museum of Yale College. No. XXVIII. Results of recent dredging expeditions on the coast of New England. No. 6. Am. J. Sci. Arts, 7 (April): 405-414.

Notes the occurrence of *Cyprina islandica* at a depth of 72 fathoms and *C. islandicum* at 117 fathoms.

Verrill, A.E. 1874.

Explorations of Casco Bay by the United States Fish Commission in 1873. Proc. Am. Assoc. Adv. Sci., Portland Meeting, August 1873, p. 340-395.

Notes the occurrence of *Cyprina islandica* at a depth of 72 fathoms and *C. islandicum* at 117 fathoms.

Verrill, A.E. 1880.

Part III. Catalogue of Mollusca recently added to the fauna of southern New England. Proc. U.S. Natl. Mus. 3: 405-409.

Lists the occurrence of *Cyprina islandica* from the outer banks south of Cape Cod.

Verrill, A.E. 1885.

Results of the explorations made by the steamer "Albatross" off the northrn coast of the United States. *In*: U.S. Comm. Fish and Fisheries, Part XI. Report of the Commissioner for 1883. Appendix D. Natural History and Biological Research.

Lists the depth range living specimens of *Cyprina islandica* as 0 to 128 fathoms; dead shells only as 130 to 349 fathoms.

Vokes, H.E. 1967.

Genera of the Bivalvia: A systematic and bibliographic catalogue. Bull. Am. Paleontol. 51(232), 394 pp.

Arctica is included in this catalogue.

*von Oertzen, J.A. 1972.

Cycles and rates of reproduction of six Baltic Sea bivalves of different zoogeographical origin. Mar. Biol. 14: 143-149.

All bivalves investigated (*Astarte borealis, A. elliptica, Macoma calcarea, Cyprina islandica, M. baltica, Cardium lamarcki*) are dioecious. The mean egg-diameters were determined by a series of measurements of 6 bivalves and compared with data from other authors. *M. calcarea* does not have a direct non-pelagic larval development as previously assumed, but probably produces pelagic planktotrophic larvae. The arctic species exhibit no modification of their mode of development in the boreal area. The boreal forms spawn over a relatively short period in spring and usmmer. The arctic forms revealed, over long periods, ripe eggs and sperms. Apparently they begin to spawn in winter or early spring. This extension and shift of the spawning season represents adaptation of the Arctic species to the specific conditions of the Baltic Sea. The number of eggs laid by the most important bivalves were determined

and correlated with the larval ecology and length of generation time. (Author's Abstract)

* von Oertzen, J.A., and S. Schulz. 1973.

Beitrag zur geographischen Vertretitung und okologischen Existenz von Bivalviern der Ostsee. (Contribution to the geographical distribution and the ecological existence of bivalves in the Baltic.) Beitrag zur Meereskunde 32: 75-88. (Translation for the Natl. Sci. Found. and U.S. Dept. Comm., NOAA, NMFS by Agence Tunisienne de Public-Relations. TT 75-55058).

Summary: On the basis of extensive sample material, the geographical distribution of *Astarte borealis* (Chemnitz), *Astarte elliptica* (Brown), *Macoma calcarea* (Chemnitz) and *Cyprina islandica* (Linne) was established on distribution charts, and discussed as a factor of the main abistic parameters. In addition to micro-geographical investigations, a description is given of the easternmost limits of distribution of the above-mentioned benthic species (*Macoma calcarea coenosis*), and comparison is made with the shallow-water species (*M. baltica coenosis*): *Macoma baltica* (Linne), *Cardium lamarcki* (Reeve), *Mya arenaria* (Linne) and other species.

* von Oertzen, J. 1973.

Abiotic potency and physiological resistance of shallow and deepwater bivalves. Oikos Suppl. 15: 261-266.

The physiological resistance of four shallow water bivalves and three deep water bivalves taken from the Bay of Mecklenburg against temperature, salinity, oxygen deficiency and hydrogen sulphide was determined.

The physiological resistance and the abiotic specific potency (temperature and salinity) of the species from the deep water and the shallow water were compared by means of an ecogram-figure. The species from deep water have, with the exception of their resistance against oxygen deficiency, a lower specific potency and a lower physical resistance than the species obtained in shallow water. (Author's Abstract)

Cyprinda islandica was a deep water bivalve that showed a high resistance to low oxygen levels, but a low physiological resistance to other environmental stressors such as temperature.

Welsh, J. 1956.

Neurohomones in invertebrates. I. Cardio-regulators of *Cyprina* and *Buccinum*. J. Mar. Biol. Assoc. U.K. 35: 193-201.

Among the larger molluscs available in the Plymouth region, *Cyprina islandica* and *Buccinum undatum* have hearts which, when isolated, are suitable for the bioassay of acetylcholine and 5-hydroxytryptamine.

Mytolon, a vertebrate neuro-muscular blocking agent, is a highly effective antagonist of acetylcholine in the hearts of *Cyprina* and *Buccinum*. Lysergic acid diethylamide (LSD), a synthetic ergot alkaloid derivative, is an effective antagonist of 5-hydroxytryptamine in these hearts. (Part of Author's Summary)

Wendt, A.A. 1969.

Process for treating clams - Patent No. 3,471,300 Official Gazette, U.S. Patent Office, 867(1): 204. Oct. 7, 1969.

Fish Processing: Clams: Patent.
A process for converting normally inedible clams is described which comprises heating the clam meat such as that derived from mahogany clams with steam prior to sterilization to volatilize the matter contained therein which causes the undesirable odor and taste associated with the clam meat.

Wenzloff, D.R., R.A. Greig, A.S. Merrill, and J.W. Ropes. 1979.

A survey of heavy metals in the surf clam, *Spisula solidissima*, and the ocean quahog, *Arctica islandica*, of the Mid-Atlantic coast of the United States. Fish. Bull. 77(1): 281-285.

In a 1974 survey off the Mid-Atlantic coast, greater concentrations of silver, arsenic, cadmium, copper, and zinc were found in ocean quahogs than surf clams. Concentrations of several metals decreased southward. Based on existing guidelines, it was concluded that the concentrations found should be of little concern to consumers.

Whiteaves, J.F. 1901.

Catalogue of the marine invertebrata of eastern Canada. Geol. Survey Canada, no. 722, 271 pp.

Lists the occurrence of *Cyprina islandica* (L.) in the marine environment of eastern Canada. Also, notes that an observation by Verrill of invertebrate species "perforating recent and sound shells of *Cyprina islandica*."

Wiborg, K.F., and B. Böhle. 1968.

Occurrences of edible shellfish (bivalves) in Norwegian coastal waters (with a section on marine gastropods). Fiskets Gang (Fisheries Migration), 54(9): 149-161.

Briefly describes the shell, periostracum, and size of the ocean or mahogany quahog, *Arctica islandica*, and notes its habitat, use for bait, and potential use for human consumption. Locations of occurrence and abundant catches along the Norwegian coast are given. (Translation of work by Translation Bur., Canada is available at the NMFS, Oxford Laboratory.)

Wigley, R.L., and K.O. Emery. 1968.

Submarine photos of commercial shellfish off Northeastern United States. Commer. Fish. Rev. 30(3): 43-49.

Several thousand photographs of the sea bottom off the northeastern coast of the United States were taken as part of a joint study by the Woods Hole Oceanographic Institution, the U.S. Bureau of Commercial Fisheries, and the U.S. Geological Survey. Nearly every photograph reveals the presence of animals living in or on the bottom. Of special interest are the commercially valuable mollusks--the sea scallop (*Placopecten magellanicus* Gmelin), surf clam (*Spisula solidissima* Dillwyn), and ocean quahog (*Arctica islandica* Linnaeus). Occurrence records from the photographs correspond closely with the distribution patterns for each species based on other sources. Living sea scallops were clearly apparent in the bottom photographs; of surf clams and ocean quahogs (usually buried with only the siphons exposed) only the shells of dead specimens were detected. All three species are restricted to the continental shelf, and their geographic distributions overlap considerably.
The photographs may provide clues to more efficient methods of harvesting these species. (Abridged Authors' Abstract)

Wigley, R.L., and R.B. Theroux. 1970.

Sea-bottom photographs and macrobenthos collections from the continental shelf off Massachusetts. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. No. 613, 12 pp.

Epibenthic invertebrates were sampled with a scallop dredge and photographed at four locations on the continental shelf off Massachusetts in 1965. *Arctica islandica* was encountered in large numbers on Georges Bank. (Abridged Authors' Abstract)

Wigley, R.L., and F.C. Stinton. 1973.

Distribution of macroscopic remains of recent animals from marine sediments off Massachusetts. Fish. Bull. 71: 1-40.

Macroscopic animal remains are common constituents of bottom sediments on the continental shelf and upper continental slope south of Cape Cod, Mass. The largest quantities are in sandy deposits in the vicinity of Nantucket Shoals, where they form nearly 30% by volume of the total substrate. The smallest quantities are along the outer continental shelf and upper slope, where animal remains generally make up less than 1% of the substrate. Representatives of all three major realms of aquatic animals contribute to the prefossil skeleton assemblages; benthic forms are the principal components, nektonic forms are common, and planktonic forms are rare. The quantitatively dominant taxonomic groups present in the sediment are: echinoderms, mollusks, and teleosts. Typical specimens of all groups represented in the sample are illustrated. Charts and graphs show the geographic and bathymetric distributions of the common species. (Authors' Abstract)

Arctica islandica was one of the pelecypods found in greatest density.

Wigley, R.L., and R.B. Theroux. 1976.

Macrobenthic invertebrate fauna of the Middle Atlantic Bight region. Part I. Collectin data and environmental measurements.

Data presented in this report pertain to macrobenthic invertebrate samples from the Middle Atlantic Bight region analyzed by the National Marine Fisheries Service, Northeast Fisheries Center (formerly the Bureau of Commercial Fisheries, Biological Laboratory), Woods Hole, Massachusetts. This series of samples was collected by the cooperative effort of the National Marine Fisheries Service, the Woods Hole Oceanographic Institution, and the U.S. Geological Survey. These samples constitute part of a broad biological and geological study of the U.S. continental margin extending from Nova Scotia to Florida. Some results of the quantitative analyses of these samples are given in a companion report entitled "Macrobenthic Invertebrate Fauna of the Middle Atlantic Bight Region: Part II. Faunal Composition and Quantitative Distribution."

Subarea designations refer to the geographic divisions illustrated in Figure 1. Subarea 1, Southern New England; Subarea 2, New York Bight; and Subarea 3, Chespeake Bight.

Distribution of the stations is illustrated in Figure 2. (Authors' Introduction)

Arctica islandica is included in the list of invertebrate species taken in the quantitative samples in the Middle Atlantic Bight.

Wigley, R.L., R.B. Theroux, and H.E. Murray. 1976.

Macrobenthic invertebrate fauna of the Middle Atlantic Bight region: Part 1. Collection data and environmental measurements. Northest Fisheries Center, Woods Hole, Mass.

(Abstract not yet available)

Wigley, R.L., and R.B. Theroux. 1981.

Atlantic continental shelf and slope of the United States--macrobenthic invertebrate fauna of the Middle Atlantic Bight region--faunal composition and quantitative distribution. U.S. Dept. Interior, Geol. Sur. Prof. Paper 529-N, 198 pp.

In the early 1960's, a quantitative survey of the macrobenthic invertebrate fauna was conducted in the Middle Atlantic Bight region. Purposes of this survey were to obtain a preliminary measure of the macrobenthic standing crop, particularly of biomass, and secondarily, to determine the principal taxonomic components of the fauna and the general features of their distribution. Sampling was conducted at 563 locations; water depths ranged from 4 to 3,080 m. An analysis of faunal composition and of quantitative distributions from the survey is presented in this report. Quantities are expressed in terms of density and biomass.

Dominant taxonomic components in numbers of individuals were (in percentage of total fauna): Arthropoda (46), Mollusca (25), Annelida (21), Echinodermata (4), and Coelenterata (1). Dominant in biomass were (in percentage of total fauna): Mollusca (71), Echinodermata (12), Annelida (7), Arthropoda (5), and Ascidiacea (2). The quantity of fauna, both density and biomass, decreased substantially from shallow to deep water. Another major trend was the marked decrease in quantity from north to south within the Middle Atlantic Bight. Bottom sediment composition strongly influenced both the kind and the quantity of macrobenthic animals. Coarse-grained sediments generally supported the largest quantities of animals, including many sessile forms. Fine-grained sediments usually contained a depauperate fauna; attached organisms were uncommon. No obvious correlations were detected between the amount of organic carbon in bottom sediments and the quantity of benthic animals present. Marked seasonal changes in bottom water temperature were associated with an abundant fauna composed of diverse forms, whereas uniform temperatures throughout the year were associated with a sparse fauna composed of a moderate variety of species. Taxonomic groups that were dominant in a significant number of samples, in terms of number of individuals, were: Bivalvia, Annelida, Echinoidea, Ophiuroidea, Crustacea, and the bathyal assemblage. Groups dominant in terms of biomass were: Bivalvia, Annelida, Echinoidea, Ophiuroidea, Holothuroidea, and the bathyl assemblage. (Authors' Abstract) *Arctica islandica* was a selected species studied because of their common occurrence and distinctive distribution.

Winter, J.E. 1969.

Uber den Einfluss der Nahrungskonzentration und anderer Faktoren auf Filtrierleistung und Nahrungsausnutzung der Muscheln *Arctica islandica* und *Modiolus modiolus*. (On the influence of food concentration and other factors on filtration rate and food utilization in the mussels *Arctica islandica* and *Modiolus modiolus*). Mar. Biol. Berlin 4: 87-135.

Filtration rates and the extent of phagocytosed food particles were determined in the offshore lamellibranchs *Arctica islandica* and *Modiolus modiolus* in relation to particle concentration, body size and temperature. Pure cultures of the algae *Chlamylomonas* sp. and *Dunaliella* sp. were used as food. A new method for determining filtration rates was developed by

modifying the classical indirect method. Specimens of *A. islandica* with a body length of 33 to 83 mm filter between 0.7 to 71/h (30-280 mg dry weight of algae/24 h) and phagocytose 21 to 122 mg dry weight of algae during a period of 24 h. The extent of food utilization declines from 75 to 43% with increasing body size. Temperature coefficients for the filtration rate are in *Arctica islandica* Q_{10} (4°-14°C) = 2.05 and Q_{10} (10°-20°C) = 1.23, and temperature coefficients for the amount of phagocytosed algae amount to Q_{10} (4°-14°C) = 2.15 and Q_{10} (10°-20°C) = 1.55. A temperature decrease of 12° to 4° reduced filtration rate and amount of phagocytosed algae by 50%. Filtration rates decreased at increased algal cell concentrations. With increasing temperatures, the amount of suspended matter, allowing higher rates of filtration and food utilization, shifts toward higher particle concentrations; but at each temperature a threshold exists, above which increase in particle density is not followed by increase in the amount of particles ingested. Species inhabiting waters with high seston contents seem to be adapted to higher food concentrations, and are unable to compensate for low concentrations by higher filtration activities. Adaptation to higher food concentrations makes it possible to ingest large amounts of particles even at low filtration rates. Suspension feeding bivalves are subdivided into four groups on the basis of their different food filtration behaviour. (Abridged Author's Abstract)

Winter, J. 1970.

Filter feeding and food utilization in *Arctica islandica* L. and *Modiolus modiolus* L. at different food concentrations. *In*: J.H. Steele (ed). Marine Food Chains. Oliver and Boyd, Edinburgh. p. 196-206.

Filtration rates and the extent of phagocytosed food particles were determined in the offshore lamellibranchs *Arctica islandica* and *Modiolus modiolus*, in relation to body size, temperature, and offered particle concentration. Pure cultures of *Chlamydomonas* and *Dunaliella* were used as food. (Abridged Author's Abstract)

Wise, J.P. 1971.

Clams: Resources are healthy. Comm. Fish. Rev., June. 33(6): 19-20.

Includes graphs and tables showing that the clam fishery is healthy. Mentions article about ocean quahog becoming more important.

Wise, J.P. 1974.

The United States Marine Fishery Resource. MARMAP Contr. No. 1 (Marine resources monitoring, assessment, and prediction program). U.S. Dept. Comm., NOAA, NMFS, 379 pp.

Arctica islandica is included as a commercial clam of lesser importance.

Yancey, R.M. 1965.

Supplemental cruise report - U.S.B.C.F. Biological Laboratory, Oxford, Md. Charter Vessel *Undaunted* - May 13-June 25, 1965. 3 pp. (mimeo)

Catch-per-tow statistics are given on an exploratory cruise for *Arctica islandica* covering the area from Montauk Point, Long Island, to Cape Charles, Va., with stations at depths of 94 to 195 feet.

Yonge, C.M. 1962.

On the primative significance of the byssus in the Bivalvia and its effects on evolution. J. Mar. Biol. Assoc. U.K., 42: 113-125.

Adults of the superfamily Cyprinacea, which includes *Arctica islandica*, are listed as bivalves that do not have a byssus.

Yonge, C.M. 1982.

Ligamental structure in Mactracea and Myacea (Mollusca: Bivalvia). J. Mar. Biol. Assoc. U.K. 62: 171-186.

The opening moment of the values of *Arctica islandica* (500 gmm/ml) is mentioned relative to *Mya arenaria* (174) and other Myacea. (J.W.R.)

Younker, D., and G. MacPhee. 1970.

Offshore bar clams and ocean quahaug explorations, final report. Prepared for Dept. of Fish., P.E.I. and Ind. Dev. Branch, Dept. of Fish. and Forestry, Ottawa.

Prince Edward Island (from Hiltz, 1977)

Survey Date:
May 14 - September 14, 1970
Area Surveyed:
Coast of Prince Edward Island and Magdalen Islands
Vessel used:
M.V. Morning Star III
Conducted by:
Prince Edward Island Department of Fisheries, Charlottetown, P.E.I. and Industrial Development Branch, Department of Fisheries and Forestry, Ottawa.
Report covers:
The areas surveyed, type of dredge and gear used, summary of catches and shell measurements of clams taken from areas surveyed.
Quahaug resource:
Areas yielding most quahaugs were: (1) Cape Bear, P.E.I.; (2) Basin Head, P.E.I.; (3) Point Sapin, N.B.

Younker, D., and B. Cudmore. 1971.

Offshore ocean clam exploration - final report. Prepared for Prince Edward Island Dept. of Fisheries, Charlottetown, P.E.I. and Industrial Development Branch, Fisheries Service, Dept. of Environment, Ottawa.

Prince Edward Island (From Hiltz, 1977)

Survey date:
July 20 - September 11, 1971
Area:
Off Cape Bear, P.E.I.
Survey objective:
To determine extent of ocean quahaug resource off Prince Edward Island.
Vessel used:
M.V. Cape Sharp
Conducted by:
Prince Edward Island, Department of Fisheries, Charlottetown, P.E.I. and Industrial Development Branch, Fisheries Service, Department of Environment.
Quahaug resource:
Number of areas surveyed - 179. This survey, generally, reaffirmed the 1970 tests, i.e., there is a large unexploited stock of ocean clams off Cape Bear. Signs of ocean clams indicated at Basin Head and Graham Pond. *Important*: the resources off Prince Edward Island are in 14-20 fathoms, on exposed coast.

Zatsepin, V.I. 1939.

Pitanie pikshi v raione Murmanskogo poberezh'ya v sbyazi s donnoi faunoi. -Trudy Polyarn. nauchno-issled. in-ta morsk. rybn. khoz-va i okeanogr., vyp. 3. (Feeding of haddock in the region of the Murmansk seacoast in relation to benthic fauna. -Transactions of the Polar Scientific Research Institute of Maritime Fisheries and Oceanography, No. 3.)

(Abstract not yet available)

Zatsepin, V.I. 1946.

Severo-boreal'nye soobshchestva *"Modiolus modiolus - Pecten islandicus"* i *"Mactra elliptica"* Murmanskogo pribrezh'ya - Vestnik MGU, No. 2. (North boreal communities of *Modiolus modiolus, Pecten islandicus* and *Mactra elliptica* off the Murmansk seacoast. Bulletin of the Moscow State University, No. 2.)

(Abstract not yet available)

Zatsepin, V.I., and Z.A. Filatova. 1961.

Dvustvorchatyi mollyusk *Cyprina islandica* (L.), ego geograficheskoe resprostranenie i rol' v soobshchestrakh donnoi fauny. (The bivalve mollusk *Cyprina islandica* (L.), its geographic distribution and role in communities of benthic fauna.) Trudy Inst. Okeanol. Akad. Nauk SSSR. 46: 201-216.

Cyprina, a characteristically north-boreal form, lives in well-warmed and slimy sands of northern seas and of the Atlantic Ocean. In regions where it predominantes it forms a characteristic benthic community. In different regions the composition of "*Cyprina islandica*" communities vary in different areas, its role varies, and so do the proportions of the boral and arctic species. A list of species of the forms which are found in the *Cyprina* communities on the coast of Murmansk is provided. A White Sea form, found in ooze-filled trenches, is designated as a subspecies, *C. islandica marisalbae*. (A copy of the translated work is available at the NMFS, Woods Hole Laboratory.

Zenkevich, L.A. 1930.

Kolichestvennyi uchet donnoi fauny Prikaninskogo raiona. -Trudy Morskogo nauchnogo in-ta; t. IV, vyp. 3. (Quantitative registration of benthic fauna in the region of Kanin Peninsula. -Transactions of the Maritime Scientific Institute, volume 4, No. 3.)

(Abstract not yet available)

Ziegelmeier, E. 1957.

Die Muscheln (Bivalvia) der deutschen Meeresgebiete (Systematik und Betimmung der heimischen Arten nach ihren Schalenmerkmalen). (The Mollusks (Bivalvia) of the German Sea region (systematics and definition of the indigenous species according to their shell features). Helgol. wiss. Meeresunters 6: 1-51.

The molluscan fauna of the German sea is systematically described by means of shell features. *Arctica islandica*, a clay-sand species, is included and its general distribution given.

Zoellner, D.R. 1977.

Water quality and molluscan shellfish: an overview of the problems and the nature of appropriate Federal laws. U.S. Dept. Comm., NOAA, NMFS. 106 pp. and 115 pp. appendices.

Reviews the effect of water quality on molluscan shellfish and the impact of Federal laws concerning water quality. *Arctica* specifically mentioned.