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The Annapolis Basin Scallop Fishery: A Historical Perspective and 1993 Stock Assessment

E. L. Kenchington and M. J. Lundy

Benthic Fisheries and Aquaculture Division
Biological Sciences Branch
Department of Fisheries and Oceans
P.O. Box 550
Halifax, Nova Scotia B3J 2S7

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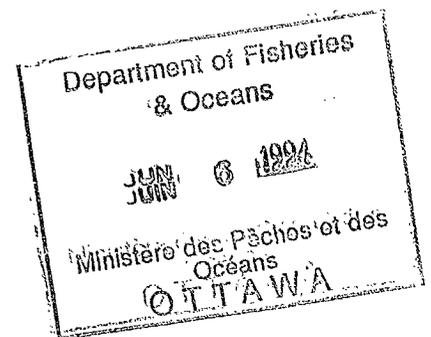
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THE ANNAPOLIS BASIN SCALLOP FISHERY:
A HISTORICAL PERSPECTIVE AND 1993 STOCK ASSESSMENT

by

E. L. Kenchington and M. J. Lundy

Molluscan Fisheries and Aquaculture Section
Benthic Fisheries and Aquaculture Division
Department of Fisheries and Oceans
Halifax Research Laboratory
P.O. Box 550, Halifax
Nova Scotia B3J 2S7



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ABSTRACT

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An outline of scallop fishing in the Annapolis Basin, Nova Scotia is described from the earliest documentation in 1609 to the present. Results of a June 1993 biomass survey are reported along with data on the spatial distribution, age class structure, growth rate, meat yield and condition of this stock.

RÉSUMÉ

Kenchington, E. et M.J. Lundy. 1994. The Annapolis Basin scallop fishery: A historical perspective and 1993 stock assessment. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2230: 27 p.

On effectue ici un survol de la pêche du pétoncle dans le bassin de l'Annapolis (Nouveau-Écosse) depuis les premiers comptes rendus sur cette pêche, remontant à 1609, jusqu'à l'heure actuelle. On présente aussi les résultats d'un relevé de biomasse réalisé en juin 1993 ainsi que des données sur la distribution spatiale, sur la structure des classes d'âge, sur le taux de croissance, sur le rendement en chairs et sur l'état du stock de cette région.

INTRODUCTION

The Annapolis Basin of Nova Scotia (Fig. 1) has been proposed as a potential site for Atlantic salmon farming. However, there are a number of traditional fisheries, such as scallop, lobster, groundfish and clam which maintain that salmon aquaculture will impact on their resources. These concerns spawned a multi-disciplinary research project by the Department of Fisheries and Oceans to provide information on the marine environment and the traditional fisheries of the Basin. This report provides a historical perspective of the scallop fishery in this area and information on the scallop beds which support this fishery. These data may be used to assess future impacts on the scallop stock should salmon farming proceed.

HISTORICAL PERSPECTIVE ON THE FISHERY

Documented harvesting of scallops in the Annapolis Basin first appears in the earliest colonial days. They were easy to fish from shallow water at low tide or to gather from beaches after storms. The first written record of scallop harvesting in this area is described by Lescarbot (1609) while he was at Port Royal on the Annapolis Basin in 1605: "There are also there, scallops (palourdes), twice as large as oysters in size; also cockles, which have never failed us." It is not known whether the French learned of the scallop beds from the natives or from by-catches of other fisheries. There is no archaeological evidence of scallop shells in the pre-contact native middens (refuse piles) at Smith Cove, east of Digby (Dr. S. Davies, St. Mary's University, Halifax, pers. comm.), and faunal analysis of middens in Passamaquoddy Bay, N.B. indicates that the shellfish diets of the natives were whelks, soft-shell clams, blue mussels and horse mussels. The conspicuous absence of scallops in the Bay of Fundy middens may reflect a knowledge of shellfish toxins amongst the native groups. Analysis of the shells of the soft-shell clams indicates that harvesting only occurred in the winter months during which time toxin levels are low (Dr. D. Black, University of New Brunswick, Fredericton, pers. comm.). However, middens in Mahone Bay, N.S. (Eisenhower Mound) show scallops to be a dominant component of the shellfish diets of natives there (Smith and Wintemberg 1929). These scallops would not have had the high toxin levels found in the Bay of Fundy. Bourne (1964) quoting J. Erskine in a personal communication states that "Scallop shells have been found in Indian middens. Some are worn which shows they were used as implements but many are not, and it is reasonable to believe that they were used as food by the Indians long before the early European

Table 1. Summary of Scallop Fishery Regulations Affecting the Annapolis Basin 1918-Present.

Effective Date	Nature of Regulation	Reference*
April 13, 1918	- license required	(1)
	- closed season June 1 to September 15	
	- minimum size 4 inches	
December 18, 1920	- closed season extended June 1 to October 15	(1)
	- waste portions not to be thrown overboard on scallop grounds	
	- soaking in freshwater prohibited	
April 29, 1922	- special season changed to November 15 to December 30 for Lunenburg County and Dec. 1 to Jan. 31 for Digby Basin	(1)
	- regulations not applicable beyond territorial waters	
March 13, 1926	- minimum ring size in rakes of 4 inches	(1)
October 29, 1927	- season starts September 15 for this year only	(1)
March 22, 1930	- season in Digby Basin closed until February 1935 and thereafter restricted to February	(1)
April 25, 1936	- closed season changed to June 1 to September 30 for inside and outside territorial waters	(1)
September 25, 1937	- closed season changed to May 1 to October 14	(1)
October 29, 1938	- total combined gear width restricted to 18 ft.	(1)
May 6, 1939	- for 1939 only, season extended to May 10	(1)
April 26, 1941	- for 1941 only, season extended to May 17	(1)
September 13, 1941	- closed season changed to May 1 to September 30	(1)
May 28, 1947	- closed season restricted to Bay of Fundy proper but gear restrictions apply	(1)
May 12, 1948	- closed season restricted to outer half of Bay of Fundy	(1)
	- gear width restrictions limited to outer Bay of Fundy, Digby Basin, and Lunenburg County	
February 14, 1951	- closed season restricted to inshore Digby area	(1)
May 13, 1953	- minimum scallop size dropped	(1)
December 31, 1954	- special season for Digby Basin dropped	(1)
September 13, 1961	- closed season changed to May 1 to Aug. 31 for inshore Digby	(1)
1966	- abolition of closed season	(2)
May 22, 1963	- minimum ring size dropped	(1)
March 11, 1970	- SCUBA diving for scallops permitted with license	(1)
1971	- closure of inshore fishery	(2)
1972	- experimental open season	(2)
1973	- re-established closed season at 6 miles from shore	(2)
June 11, 1975	- special closed season for Digby Gut and Annapolis May 1 to November 30	(1)
April 14, 1976	- minimum ring size re-introduced, 3-1/4 inches	(1)
June 28, 1978	- bag limit of 100 scallops for SCUBA diving	(1)
January 14, 1981	- scallop license fees taken out, except for SCUBA diving which were increased	(1)
November 26, 1987	- meat count of 72 meats per 500 g May 1 to September 31	(3)
	- meat count of 55 meats per 500 g October 1 to April 30	
	- closure zone at 8 miles from shore May 1 to Sept. 30	
	- use of offshore and "Green sweep" drags prohibited	
	- ring size of 82 mm	

*(1) Sinclair et al. 1985 (2) Caddy 1979 (3) Canada Gazette Part II, Vol. 121 no. 125

explorations.", however this is a generalized statement and does not apply to the Bay of Fundy. It is interesting to note that the natives did not partake of the shellfish course at the "Historic Feast" at Port Royal (Lescarbot 1609).

Although there wasn't to be a commercial fishery in the Annapolis Basin for another 300 years, it can be assumed that scallops were gathered for local consumption and trade throughout this period, and in the 1800's in Perley's (1851) "Report on Fisheries in the Bay of Fundy" it is noted that "there are extensive beds of scallops". Rowing boats using single drags of varied designs and hauled by hand were used to harvest them, but eventually teams of drags were introduced to the Bay.

The commercial fishery, as we know it today, began in 1920. The pioneers of the scallop fishery were Digby fishermen J. W. Hayden, Roland Wormell and Arch Amero. The following excerpt is taken from the files of Carl Medcof (St. Andrew's Biological Station, Department of Fisheries and Oceans): "There is some controversy as to which of these gentlemen actually made the first trials. According to Mr. Hayden, he was accompanied by Mr. Wormell but Mr. Wormell states that he made several drags alone but, in any case, they worked together the first season which probably began in late August or September, 1920. Mr. Hayden's brother purchased a clam cannery and found, among the various items of equipment, a scallop drag similar to those used on the south shore of the province. This gentleman offered the dory to anyone interested in exploring for scallops. Messrs. Hayden and Wormell, both knew from their fishing experience that it was a common occurrence to find scallops fastened to the snoods or hooks of a line-trawl set in the vicinity of Bear Island in the Annapolis Basin. With this knowledge, they set out in an open motor boat powered with a one-cylinder gas engine. The drag was about three feet in width and contained a mesh bag of knitted twine to collect and hold the scallops. There was a right V-shaped iron bar fastened to both sides by which it was towed. They fastened a rope to the drag and after 10 to 15 minutes running with the tide, they hauled it up by hand to find 72 scallops. Not knowing what to do with the scallops, they took them ashore and placed them in a partly-sunken dory fastened to the pilings of an old wharf near the roquet. The next day, their luck was better and they gathered over 600 scallops. These were also placed in the dory. It was then decided that an effort should be made to locate a buyer and determine a method of handling and shipping. Guy Tory was a fishery inspector at Digby. He and Capt. Neilson, a shipper and fish buyer, advised them to negotiate with a fish brokerage in Boston who in turn told them to shuck the scallops, pack the meats in half barrels and ship by the quickest transportation to Boston. Thus, the fishery had commenced, they towed their small drag up or down the

Basin with the tide, hauled the drag by hand, steamed back against the tide and repeated the process.

By the end of that year, it was evident that the scallop beds in the Basin were not extensive and again the fact that scallops were often caught on trawls outside the mouth of the Gut caused these gentlemen to dream of a vast and important fishery near at hand. Therefore, in the winter of 1921, Messrs. Hayden and Wormell purchased a 36' sloop, 14' in the beam and powered by two one-cylinder gas engines totalling 11 horsepower. Mr. Hayden ordered a steel cable, blocks and obtained a 6 hp stationary engine equipped with one drum and a nigger head for hauling their drag and hoisting it on deck...The hoisting engine was placed on the port side immediately in front of the wheelhouse. The cable ran from the drum through a block on this same side to a point opposite the mast, thence across the boat and through a second block that was fastened to the end of a short boom placed at right angles to the boat's length and protruding slightly over the starboard rail and a rope was rigged through a pulley on the aft or hoisting boom."

At this time restrictive regulations (licenses, seasons, size limits, and gear limits) began to appear to prevent the depletion of the resource (Table 1). Initially the whole animal was brought back to the wharf and shucked. The meat, or adductor muscle, was separated and the remaining flesh (viscera, mantle and gills) was used for baiting trawls while the shells were ground up for the production of poultry grit. This is not the practice today as it is illegal to shuck scallops at the wharf, and only the "meat" is landed.

By 1926, 90 vessels were in operation. Fishing in the Annapolis Basin, due to its sheltered nature, was very intensive in the early years, to such an extent that in 1930 the Basin was closed completely to scalloping for a period of 5 years in order to allow the stocks to recover. There is very little documented information of fishing practices in the Annapolis Basin over the last 60 years. An oral history was obtained after consultation with several long-time scallop fishermen from Digby. Their recollections suggest that fishing activity in the Basin during this period was sporadic from year to year:

Malcolm Gregory (retired; fished 1940-87) "In the 40's we would try the Basin in early January and some years would fish in there for a couple of weeks usually catching 100 to 200 pounds per day. It got a lot better in the early 1960's when we were getting 400 to 450 pounds per day. Of course there weren't the number of boats that we got today but there were 6 or 7 of us that would fish in there from January to March."

Reg Hazelton (owner/operator F.V. Lakeside No. 2, began fishing in 1948) "There wasn't any fishing in the Basin in the 50's. Everybody would try a tow now and again but all we would get was a few old shells with not much of a meat in them. No, we didn't really fish in there much until the 60's and six or so boats would usually get around 200 to 300 pounds per day. In 1966 when the closed season was dropped there was one boat that fished there for one and a

half years steady for 100 to 150 pounds per day. After this there wasn't much activity, just the odd boat now and again for a few days fishing. 1987 was really when any real good fishing started in the Basin. Then a few boats (six) would fish there for six weeks steady for 400 to 600 pounds per day. There were a few boats in the last five years that would fish in there every night and would get 1000 pounds per night when the weather was fit."

Laurie Graham (owner/operator F.V. Doraine B) "last six years we fished in the Basin for a week or two in early January. Catches were up and down over the years but normally 400 pounds per day. In 1992 it was up to 1200 per day and in 1993, 800 per day."

As reported by various fishermen the main scallop beds in the Basin have been off Victoria Beach at the inner part of the Gut and extending into the Basin generally in depths greater than 60 feet. In 1972 fishing logbooks (giving the location and weight of the catch by vessel) became required as a part of licensing regulations (Table 1), and in 1973 a limited entry licensing policy was established. Today, as a result of the appeal process, 99 licenses are issued on an annual basis. Fishing logbooks are often unreliable and so it is difficult to assess the quantity and location of scallop landings from the Basin. The catches based on this incomplete log coverage are given in Table 2. Note that log compliance ranges from 14-96% of active scallop vessels. Since 1990 there has been an improvement in the quantity and quality of log reports and in 1992 it is estimated that 20 to 25 metric tons of meats were removed from the Basin (prorated catch: M. Lundy, Dept. Fisheries and Oceans, unpubl. data). This amount is relatively small when

Table 2. Scallop landings in the Annapolis Basin as reported by fishing logbooks (1981-1993*).

Year	Catch (Kg)	% vessels submitting logs
1981	2003	95
1982	825	95
1983	2773	96
1984	5069	93
1985	2786	96
1986	3120	85
1987	-	55
1988	34	18
1989	582	15
1990	373	14
1991	3367	28
1992	14487	45
*1993	8267	63

*preliminary data

compared to the overall Bay of Fundy scallop landings (Kenchington and Lundy 1992), however, the importance of this fishery lies in the timing of the harvesting. During January and February, 1992, landings from the Basin represented 38% of the total scallop landings for those months. The landed value of the logged catch in 1992 was approximately \$191,200 and preliminary landings in 1993 are valued at approximately \$154,600.

Currently scallop harvesting can only occur in the Annapolis Basin from December 1 to April 30 (Table 1). However, due to a conflict with the lobster fishery a restraining order is in effect which closes the Basin to scallop fishing during December when lobster traps are in place. The purpose of this regulation was initially to preserve the scallop stocks close to port for bad weather fishing in the winter months. However recent research (Kenchington et al. 1994) has shown that meat yield is at its highest in the post-spawning period from September to January and declines slowly thereafter to a low in the summer months. Thus this closure also ensures that a portion of the stock is harvested at near maximum yield per individual.

The Department of Fisheries and Oceans has conducted annual biomass surveys of the scallop beds off Digby since 1978. Prior to 1993 only occasional scallop survey tows were made within the Annapolis Basin. In 1990 two tows were made in the Basin and few scallops were found, however many single shells were dredged up indicating that many captains maintain the practice of shucking shellstocked¹ scallops within the Basin.

In 1993, as part of a "Baseline Studies Program for Annapolis Basin" initiated by the Aquaculture Co-Ordination Office, a survey of the scallop beds in the Annapolis Basin was conducted for the first time. The purpose of this survey was 1) to determine the abundance and distribution of scallops within Annapolis Basin 2) to determine age-class structure, growth rate, mortality rates and condition of the scallop population and 3) to design a monitoring programme to assess the effects of finfish culture on the scallop fishery. This later point refers to a proposed experimental fish farming operation in the Annapolis Basin.

¹ When scallops became abundant offshore (Georges Bank, German Bank) in the late 70's and early 80's the crew of the vessels were unable to shuck all the catch and a practice of shellstocking began. The vessels would load their holds with whole scallops and return to Annapolis Basin, anchor and shuck the catch. In 1986-87 a very large year class appeared 4-8 miles off Digby Gut however the scallops were too small for shucking. Many of the vessels began to save these small scallops in garbage pails from the last few tows of their trip and release them in the Basin on the way to the wharf which may be the source of high catches in recent years.

1993 ANNAPOLIS BASIN STOCK ASSESSMENT

MATERIALS AND METHODS

Survey

62 stations were surveyed (Fig. 1) using the Department of Fisheries and Oceans research vessel *J. L. Hart* in June 1993. The stations were randomly selected within each of the three depth contours (3.3-13.5, 13.6-38.6, and > 38.6 m) depicted on the hydrographic chart (#4386). The number of stations per depth stratum was determined by calculating the surface area of each stratum and using the relative areas to weight the number of stations per stratum. This avoided positioning a large number of stations in the deeper strata which occupy a relatively small area of the total.

At each station an 8 minute tow of the bottom was made with the tide. The distance towed was determined by the continuous recording every two seconds of LORAN C bearings on a Macintosh computer. All tows were standardized to a 800 m length by 5.5 m gear-width (4400 sq. m) to allow for tow by tow comparison. Bottom temperature was recorded at the end of each tow using a Vemco digital temperature recorder. All scallops live and dead (empty paired shells) were sorted for each bucket and measured in 5 mm height groups. Shell height is the straight line distance from the hinge (umbo) to the farthest ventral margin of the shell. Bottom type was recorded according to three classes: rock or gravel, mud, and sand. Data was analyzed to give a stratified mean number at age per tow and was contoured to show the spatial distribution of the scallop aggregations. Numbers at age per tow with location (latitude/longitude) describe a three dimensional surface. This surface is formed by defining Delaunay triangles from an algorithm found in Watson (1982). The vertices of these triangles, which are the actual data points, connect to neighbouring points. Smoothing of the surface is performed through the creation of interpolation points by subdividing the sides of the triangles into four equal segments of equal length giving sixteen subtriangles. Contour levels are established and the abundance of scallops is represented by darkening shades of gray. In this case, a Delaunay triangle, which had one or more sides whose length exceeded one minute, was not contoured. A complete description of this method can be found in Black (MS 1988).

Condition: RNA/DNA Ratios

At four stations (randomly selected prior to collection) three scallops from each of four size classes were randomly selected for future RNA/DNA analysis. The adductor muscle was removed and placed in liquid nitrogen prior to transport to the Halifax laboratory for storage at -85 °C. The ratio of RNA/DNA has been used as a condition

index in scallops (cf. Kenchington 1994) and data on temporal and spatial variability in this index is available for the Digby stock. The index is based on the assumption that the amount of DNA per cell in an organism is constant whereas the amount of RNA varies with the rate of protein synthesis. The ratio of these two in a tissue sample is therefore a measure of the amount of protein synthesis taking place per cell. This ratio was determined using fluorescence techniques. The fluorescent dye ethidium bromide (EtBr) will bind to nucleic acids. One half the sample is measured after adding EtBr to get the total amount of nucleic acid (RNA + DNA) and the other half first has the RNA removed by digesting it with the enzyme RNase (DNA only). From these two measurements the amount of RNA and DNA are calculated and the ratio of the two determined (for more information see: Kenchington 1994).

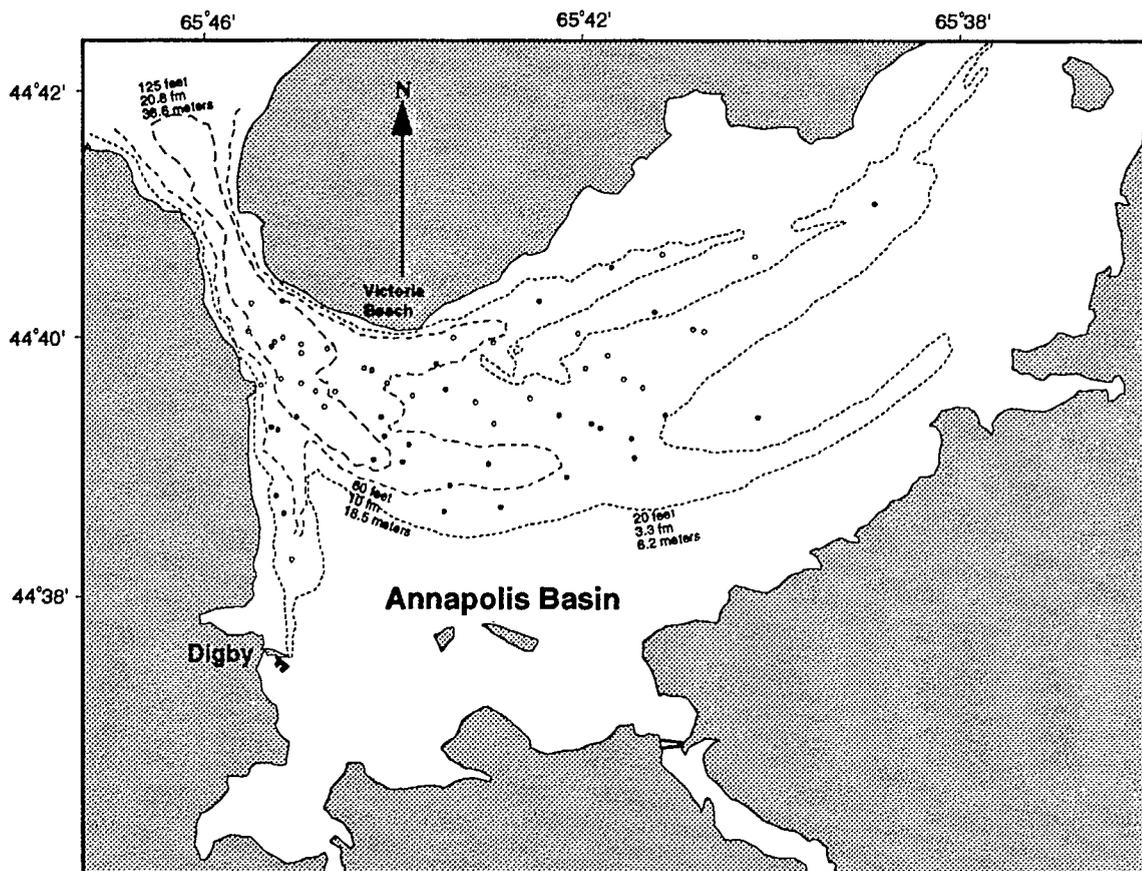


Figure 1. Location of tows completed in the June 1993 survey of the Annapolis Basin.

Commercial and Survey Gear

The gear of the commercial fishery normally comprises seven individual buckets, each 0.76 m wide, with a bag of 75 mm wire rings, attached to a single tow bar (Figure 2). In the last ten years individual fishermen have modified this design slightly to accommodate different bottom types and personal preference. Some of these modifications include using 9 buckets, each 0.6 m wide, with steel teeth welded to the frame ("Miracle gear") and various type of bales (bottom of drag) from wood to welded "offshore" 76 mm steel rings. For the assessment survey tows two gear types were used due to varying bottom types (rock and mud). Five 0.6 m wide, toothed buckets were used for tows #1-#48 on the muddier bottom, and four 0.76 m wide, regular Digby buckets for tows #49-#62 on the hard bottom. For both gear types buckets 1 and 3 were lined with a 38 mm polypropylene stretch mesh to be able to assess the abundance of the smaller pre-recruits (i.e. ages 1-4).

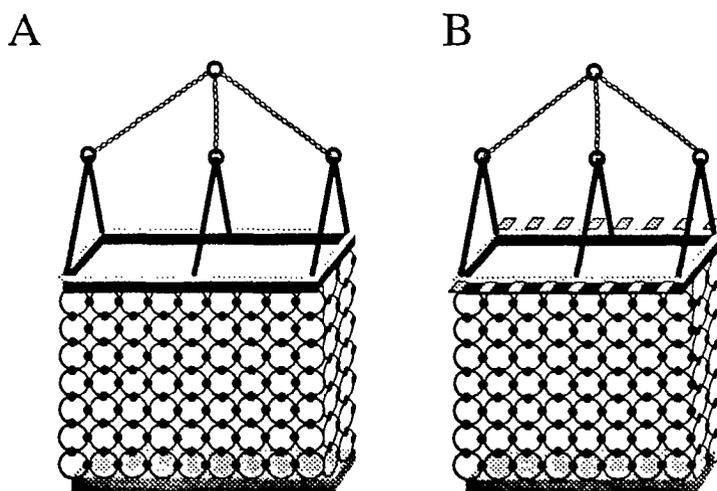


Figure 2. Typical buckets used in the Annapolis Basin scallop fishery. A) Wire ring bag of common design. B) "Miracle Gear" or toothed gear. Note the smaller size of the bucket and the steel teeth welded to the frame.

Shell Growth and Meat Yield

Scallop shells are covered with a series of fine concentric lines caused by the addition of new shell along the ventral margin of the shell. These lines become more closely spaced during periods of slow growth, usually during the winter (February-April), and give the appearance of rings much the same as is seen in tree rings (Figure 3). This yearly mark allows the determination of shell height at age and thereby the shell growth increment from year to year. As the majority of scallops spawn in late summer (August

or September), the first annual ring would be seen in the following spring when the animal is only six months old. This first ring is too difficult to detect on most shells and so the first prominent ring is usually put down in the second winter. These animals are referred to as 2 years old (i.e. having lived through 2 winters) although their chronological age is actually 16 to 18 months. This is now the standard scallop ageing technique for Bay of Fundy scallops (Caddy et al. 1970). Although it should be noted that some scientists age the first prominent ring as 1 year old (Jamieson and Lundy 1979). In our data set we measured the shell height for each age ring on the scallop, thus a ten year old shell would give ten heights at age. This means that we have a number of data points from the same animal and that the data are not independent. The bias of this method is that if for example the older scallops are also the slower growing ones, the data set will have more slow growth data points than would be expected from the actual population growth curve. Von Bertalanffy growth parameters (cf. Cushing 1975) were calculated by shell height at age analysis of 149 shells, and the curves were compared to those calculated for the Digby stock (Robert et al. 1985).

Least squares regressions were calculated using shell height as the dependent variable and adductor muscle wet weight as the independent variable. This equation will provide the baseline yield relationship for the stock by which any future changes in yield can be measured. It is specific to the pre-spawning period.

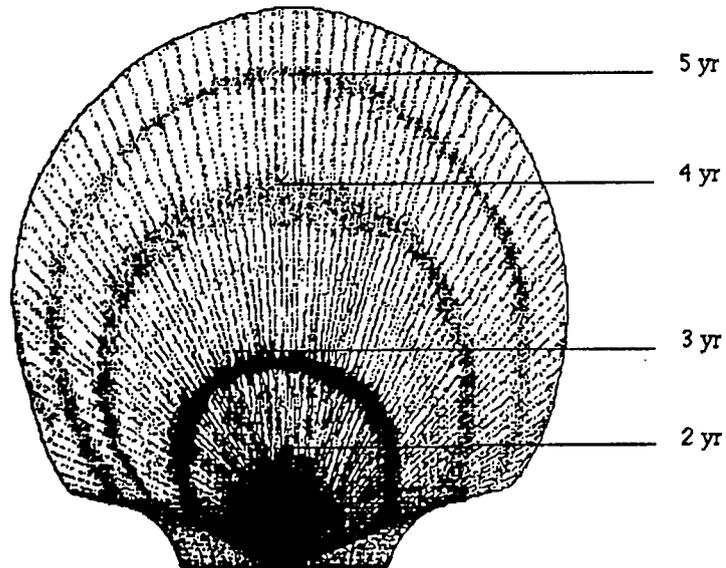


Figure 3. Top shell of *Placopecten magellanicus* illustrating yearly growth marks. This scallop would be aged at 5 although it is actually older than this as evidenced by the growth beyond the last ring. This scallop would have been harvested in the summer.

Movement

Concerns were raised by local fishermen over the possible movement of scallops from the Basin. Folk-lore surrounding mass migrations of scallops is common to many scallop fisheries (Orensanz et al. 1991). Studies on movement in the sea scallop (*Placopecten magellanicus*) show that although it is a capable swimmer, and there is individual movement within a bed, the beds themselves do not shift markedly (Posgay 1963).

In an attempt to determine broad scale movement of the scallops, possibly in or out of the Basin, a tagging study was initiated. 1300 scallops were tagged and released at various locations in the Annapolis Basin. A 5/64 inch hole was drilled into the ear of the upper shell and a "spaghetti" tag was attached with stainless steel wire. The tag number, shell height (mm) and the location of release were recorded. An equal number of animals greater than 100 mm and less than 90 mm shell height were released at each site. The two size classes were distinguished as scallops less than 90 mm are known to be more active swimmers (Dadswell and Weihs 1990). Tagged scallops were lowered to the bottom in a tethered wire basket during slack tide to alleviate possible tidal drift and released. A reward is offered to the fishermen for returning the tagged upper valve with data on date, location and depth of capture. Past tagging studies have seen approximately a 4 % return.

RESULTS AND DISCUSSION

Survey

The number of scallops found in each age class per tow is given in Appendix 1. These data are presented as the average number of scallops at age per depth stratum (Table 3). Most of the scallops were found in the 13.6-38.6 m (60-125 ft) depth stratum. The mean numbers of scallops per tow broken into 5 mm size increments by depth stratum are illustrated in Figure 4. There is a multimodal distribution indicating several year classes. The dominant size classes 65-70 mm shell height which corresponds to an age of 4 years (Figure 4, Table 2). There are also a healthy number of smaller, pre-recruit scallops 25-40 mm in shell height, and of older animals. The oldest recorded scallops in the survey were 11 years and these were found in the shallowest depth stratum. This is in contrast to the scallop beds outside Digby in the Bay of Fundy proper, where there has been no significant recruitment in the last three years (Kenchington and Lundy 1992). The frequency distribution of the population (Figure 4) suggests that the population is self-sustaining and that regular recruitment has occurred at least over the past decade.

The spatial distribution of the scallops is shown in Figure 5. Distribution by age class (1-4, 5-7, 8+ years) is shown in Figures 6 to 8.

Table 3. Average number of scallops at age caught in a seven-gang Digby drag projected from an end plus a center unlined bucket for recruits (age >4 years) and from an end plus a center lined bucket for pre-recruits (age ≤4 years).

	Age (years)									Total	No. of Stations
	2	3	4	5	6	7	8	9	10+		
Depth stratum:											
3.3 - 13.5 meters											
	2	8	8	3	7	5	3	2	2	40	40
13.6 - 38.6 meters											
	3	15	40	16	20	14	5	2	0	115	13
> 38.6 meters											
	1	1	7	5	7	10	8	2	0	41	9

Most of the scallops are concentrated south and southeast of Victoria Beach in the areas reported by the fishermen to be the most lucrative grounds. The same general spatial distribution is shared by the three age groupings (Figures 6-8), that is, there does not appear to be a separate area favouring juvenile scallops. Some tows did not catch any scallops, particularly those toward the more easterly reaches of the Basin. The bottom type in the area favoured by the scallops is predominantly rock and gravel (Figure 9). There was very little sand bottom in the survey area. The mud bottom dominates the shallower water.

Bottom temperature ranged from 5.5-9°C. This is in contrast to bottom temperatures on the scallop beds off Digby where June temperatures in 1993 ranged from 4.8-6.5°C. The temperature was recorded at different tidal phases, however, there appears to be a warm water temperature strata in the deeper water surrounding the major scallop concentrations (Appendix 1). Examination of the raw data shows that temperature did not vary by more than 1°C with tidal phase in any one stratum.

A number of small lobster (< 60 mm carapace length), and flounder (< 90 mm)

were observed in the by-catch in areas deeper than 13.5 m. Other invertebrates noted were crabs, sea cucumbers, sea urchins, whelks, starfish, shrimp, clams and mussels.

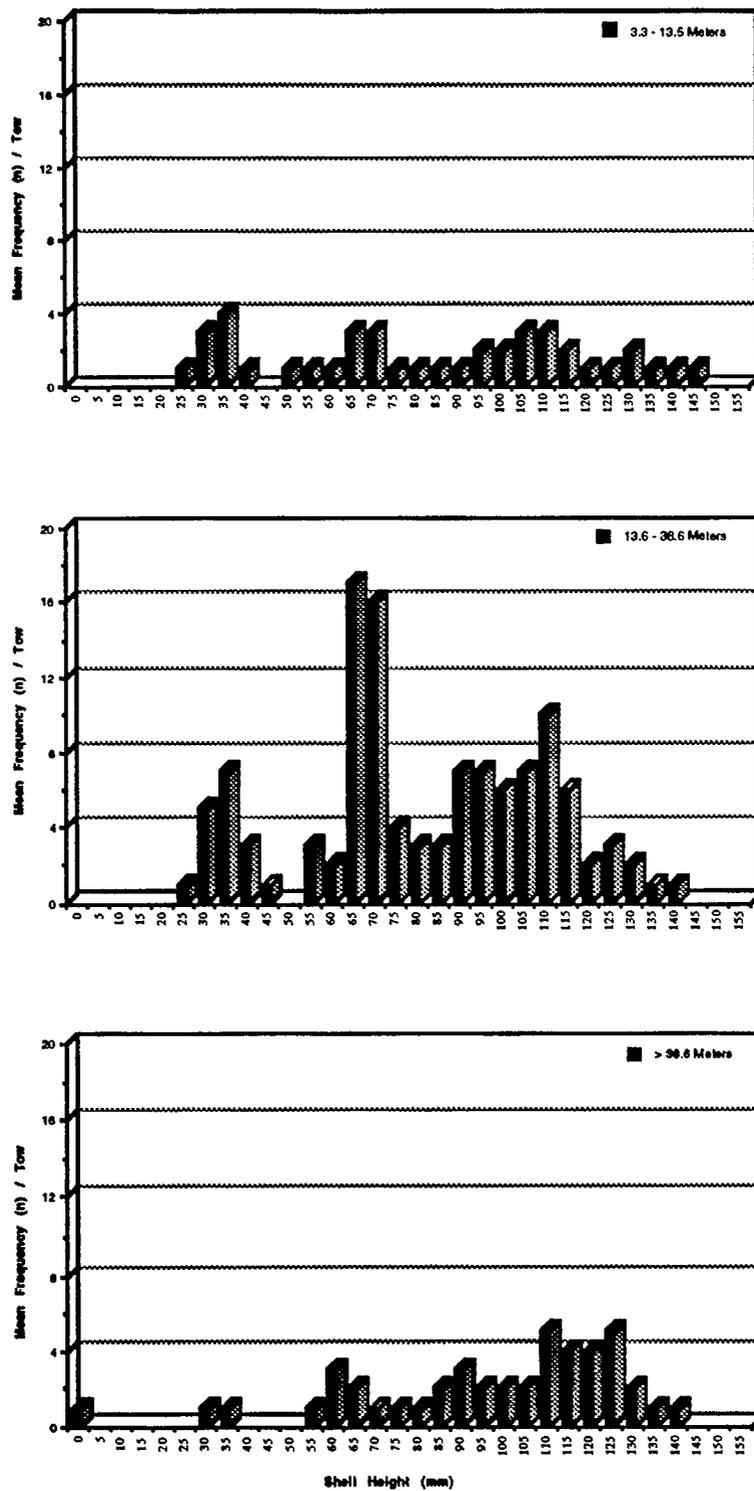


Figure 4. Mean number of scallops per tow divided into 5 mm shell height increments per depth stratum.

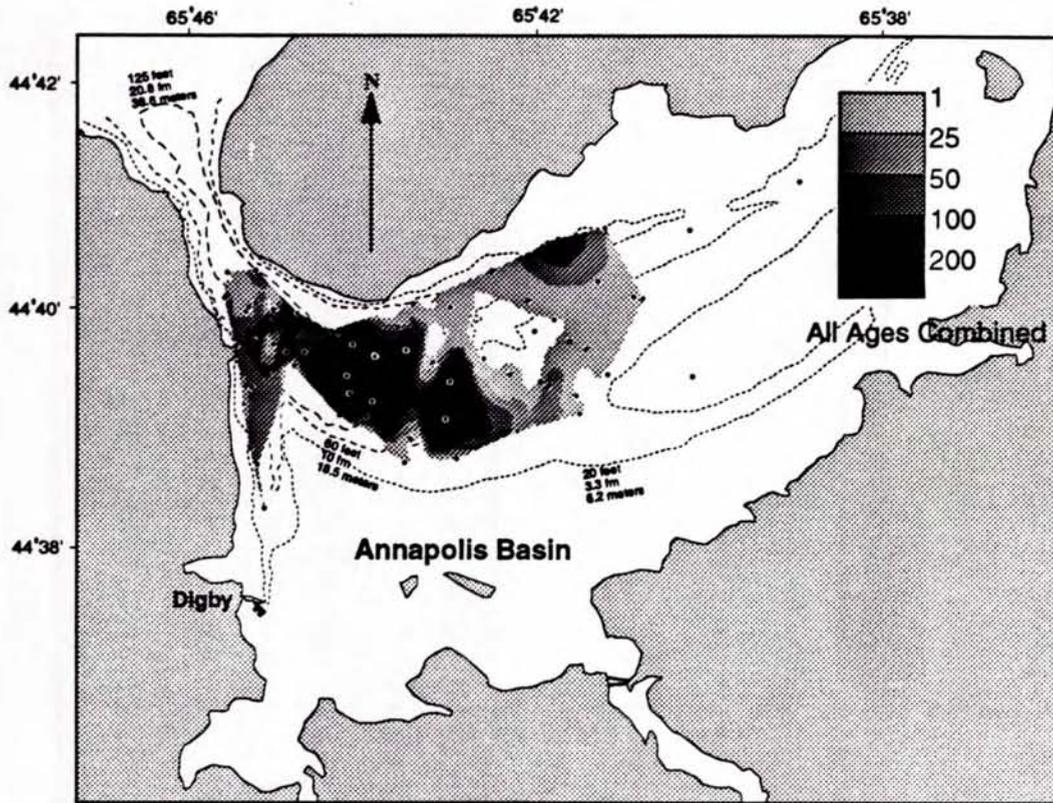


Figure 5. Spatial distribution of scallops in the Annapolis Basin determined from the 1993 June stock survey.

Condition: RNA/DNA Ratios

The mean and one standard deviation of adductor muscle RNA/DNA values were determined for each of four size classes of scallops, and these were compared with comparable data available for the Bay of Fundy beds off Digby obtained in June of 1993 (Kenchington and Lundy, unpubl. data):

Size Class	RNA/DNA Values (Mean \pm Standard Deviation)			
	Annapolis Basin		Bay of Fundy	
< 80 mm	0.651 \pm 0.108	(N=9)	0.751 \pm 0.259	(N=5)
80-95 mm	0.553 \pm 0.064	(N=9)	0.847 \pm 0.171	(N=39)
96-110 mm	0.529 \pm 0.109	(N=9)	0.692 \pm 0.150	(N=56)
> 110 mm	0.485 \pm 0.109	(N=12)	0.562 \pm 0.144	(N=65)

The mean RNA/DNA values show a general decrease with increasing size. This was also observed for the scallop stocks in the Bay of Fundy in June (Kenchington 1994).

Although the values for the equivalent size class in the Basin appear smaller than those reported for the Bay of Fundy beds, the standard deviations of the latter encompass the mean values of those determined for the Basin.

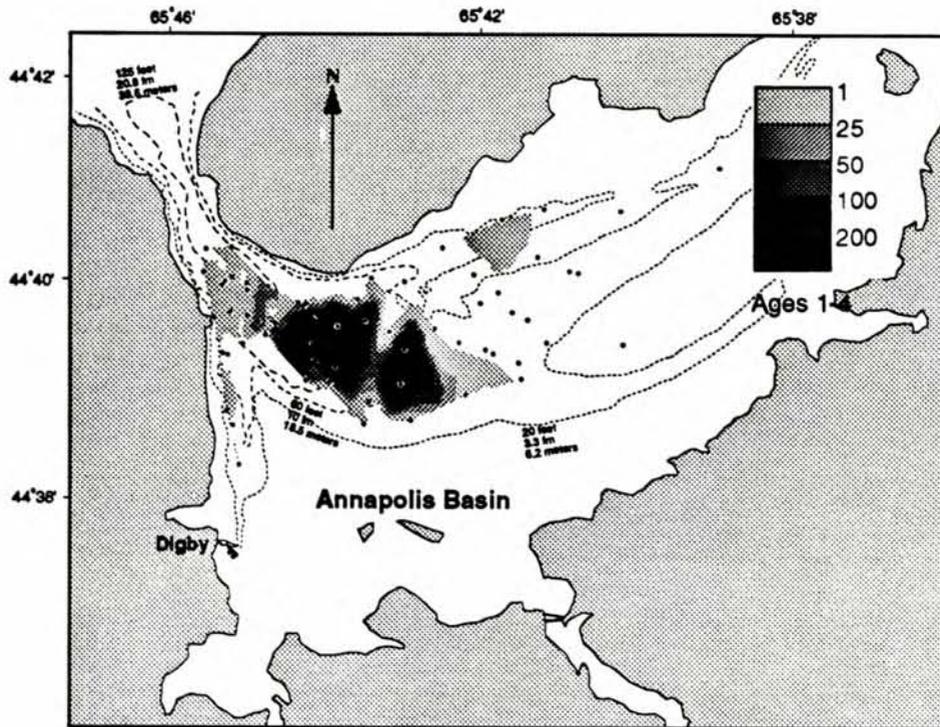


Figure 6. Spatial distribution of prerecruit scallops aged 1-4 in the Annapolis Basin determined from the 1993 June stock survey.

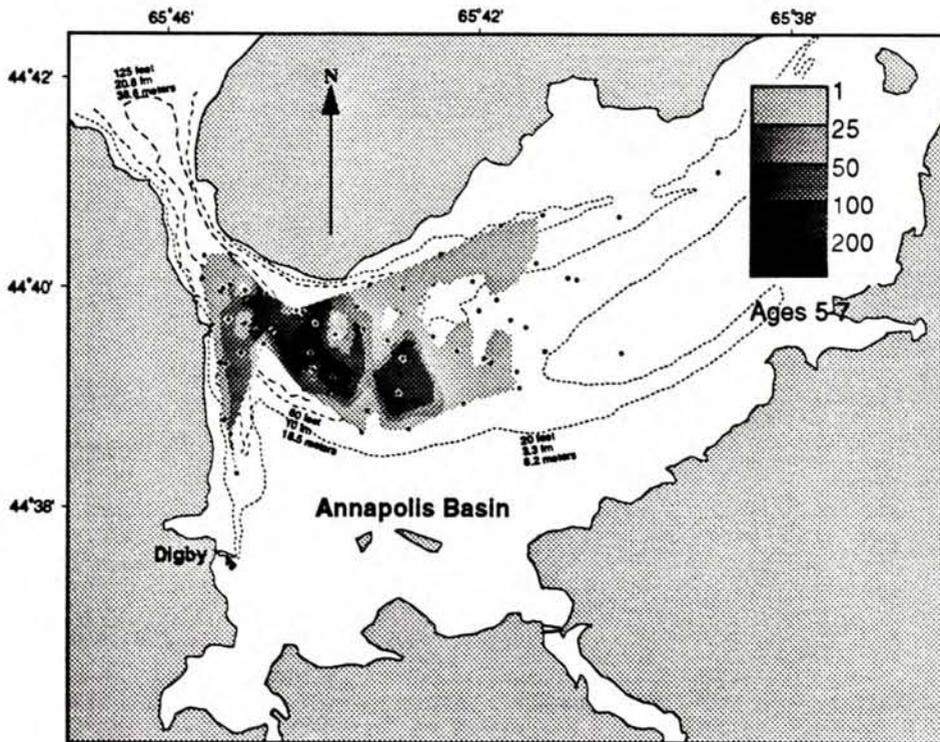


Figure 7. Spatial distribution of scallops aged 5-7 years in the Annapolis Basin determined from the 1993 June stock survey.

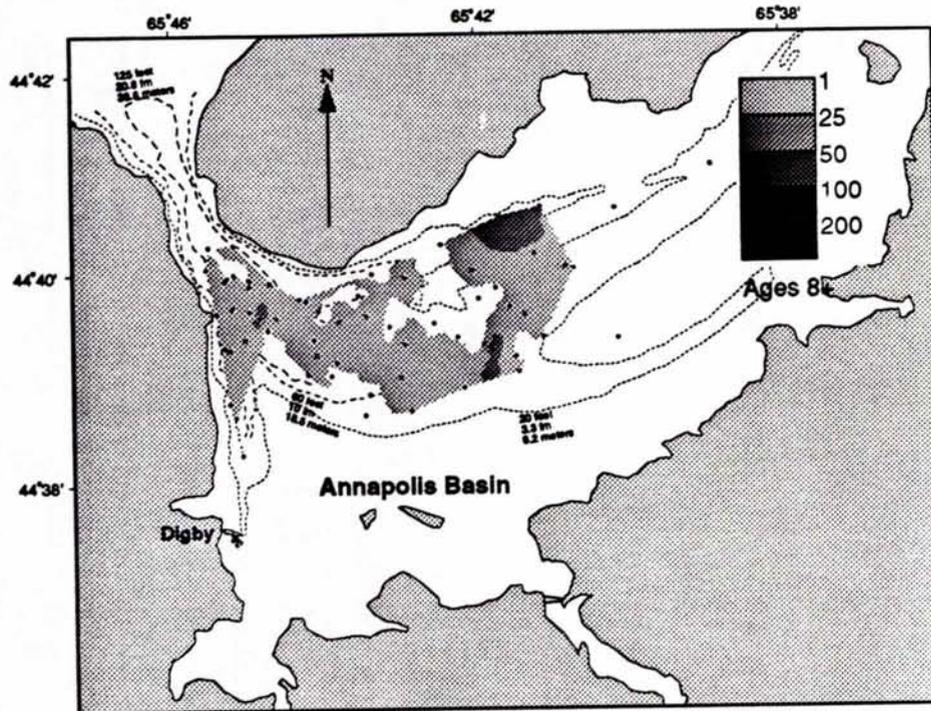


Figure 8. Spatial distribution of scallops 8 years and older in the Annapolis Basin determined from the 1993 June stock survey.

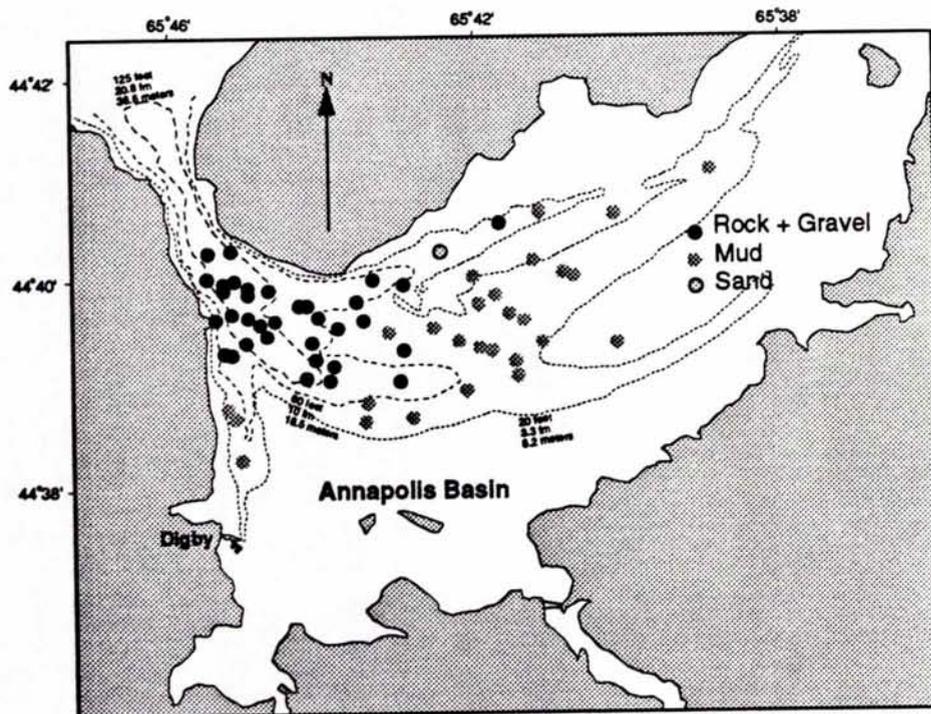


Figure 9. Substratum class (rock and gravel, mud, and sand) determined from the June, 1993 Annapolis Basin survey.

Shell Growth and Meat Yield

The parameters of the von Bertalanffy equation are: $L_{inf} = 188.35$, $K = 0.176$, $T(0) = 0.937$. The curve is inaccurate in the size-at-age for larger animals as there were no scallops greater than 140 mm amongst the random sample of 149 shells included in the data set. The curve is well-defined for animals less than 7 years old. Figure 10 compares the growth curve of the Annapolis Basin stock with those for the Digby stock (Robert et al. 1985). The scallops in the Annapolis Basin have significantly faster growth than the stocks off Digby in the Bay of Fundy proper. A fast growth rate has been noted for the Basin scallops previously (Stevenson 1936), although no growth curves were calculated.

The regression of meat weight on shell height is illustrated in Figure 11 and given below. This regression equation can be compared to ones determined for an area off Digby Gut. As part of a study to assess seasonal variability in meat yield on the Digby scallop beds, similar regressions were calculated for areas 2 - 6 miles, and 6 - 12 miles off Digby Gut (Kenchington et al. 1994) in June of 1990.

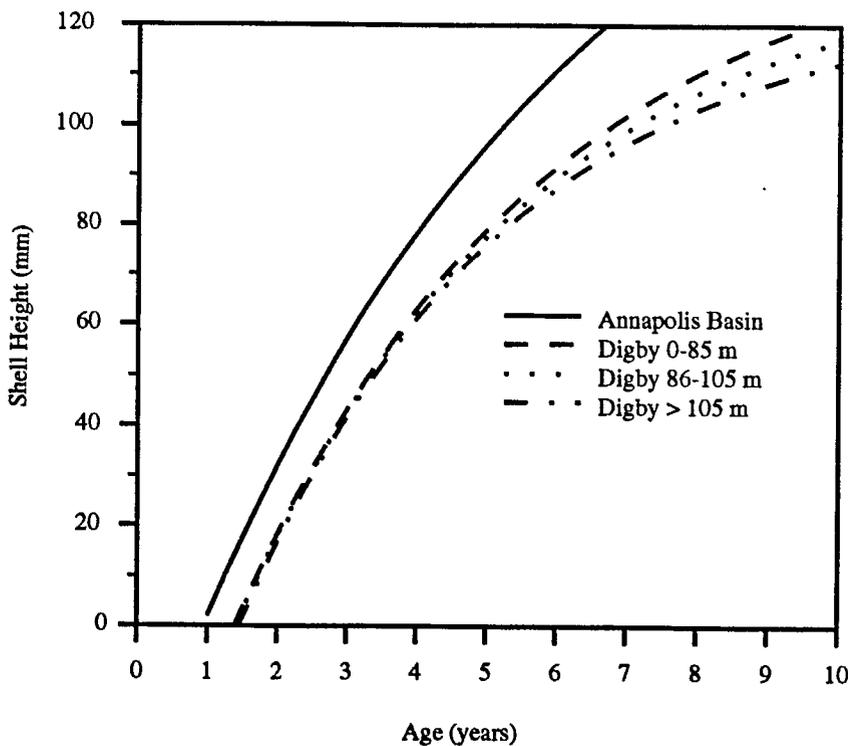


Figure 10. Von Bertalanffy growth curves for the Annapolis Basin and the Bay of Fundy (Digby) scallop beds.

These equations are:

Basin	$\ln(\text{wet weight adductor muscle}) = -10.334 + 2.85 \ln(\text{shell height})$	$r^2 = .73$
2-6 miles	$\ln(\text{wet weight adductor muscle}) = -10.996 + 2.97 \ln(\text{shell height})$	$r^2 = .77$
6-12 miles	$\ln(\text{wet weight adductor muscle}) = -12.407 + 3.23 \ln(\text{shell height})$	$r^2 = .88$

Thus, there is a decrease in meat yield from the Basin out into the deeper water of the Bay of Fundy. A scallop with a 100 mm shell height would yield a 16.3 g meat in the Basin, a 14.6 g meat 2-6 miles out from Digby Gut, and a 11.79 g meat 6-12 miles out from Digby Gut.

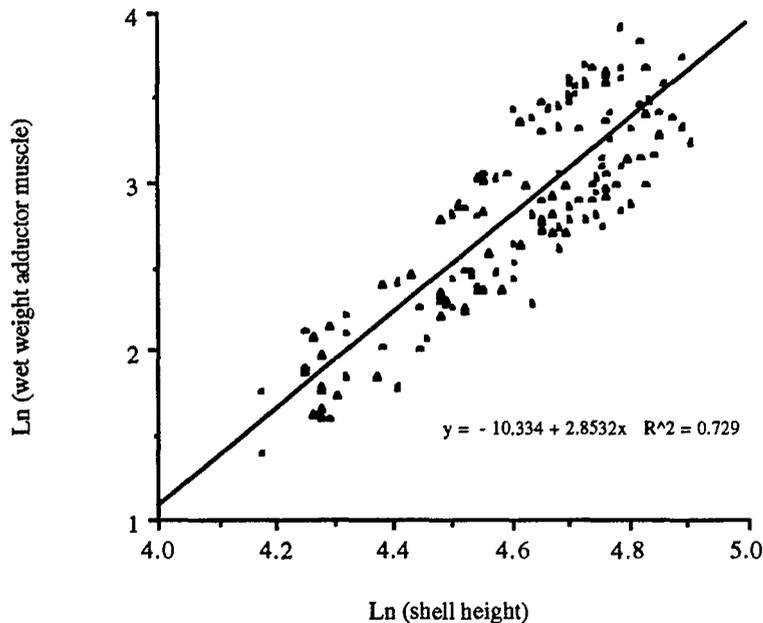


Figure 11. Regression of adductor muscle weight (g) against shell height (mm), N = 150.

Movement

Six scallops were re-captured in August 1993 during a pre-season search aboard the government research vessel the *J.L. Hart*. All six scallops were recovered from the same general area in which they were released. One of the six scallops was dead with the hinge intact. However it had grown approximately 4 mm since the time of tagging and release (7 weeks) and death, indicating that mortality was probably not due to tagging. The five live scallops showed a shell growth of 8 to 12 mm during this same time period.

The fishery opened to commercial vessels January 1, 1994 and to date (January 28) nine scallops have been captured. Data on these animals is still forthcoming. To date there has been a 1% tag return.

RECOMMENDATIONS FOR FUTURE RESEARCH AND MONITORING

A number of areas require additional research in order to provide complete baseline data on the Annapolis Basin scallop stock: 1) More data are needed on growth rates in order to better define the von Bertalanffy growth curve for the older aged animals. Without this information it will not be possible to detect significant changes to the curves over time. 2) This study has not provided any data on spawning or larval production in the Basin. We recommend that a spat collection program be undertaken to determine the spatial and temporal distribution of larvae in the Basin. Spat collection should be determined in both the spring and fall as there may be a spring spawn with this stock. 3) Genetic analysis of the year classes south of Victoria Beach may provide evidence of whether the stock is self-sustaining (as we suspect), or stocked from other sources in the area. Appropriate genetic tools are now available to provide this level of discrimination. These tools can also be used on the settled spat collected above. 4) Seasonal collections for RNA/DNA analysis would provide a broader comparison scale (restricted to June only with this data set) of condition should such changes appear with increased activity in the Basin. The seasonal RNA/DNA ratio and meat weight curves are available for the beds off Digby, but these may not be reflective of the seasonal response in the shallower water. 5) Gut analysis on a seasonal basis will provide an understanding of the present energy sources of these scallops. 6) A survey of the common parasites and bacteria associated with the scallops on the Victoria Beach bed should be completed prior to the installation of cages.

In order to monitor the biomass of the stock it is recommended that an annual survey be conducted. This could effectively be done in June to coincide with the annual stock assessment of the scallop beds off Digby in the Bay of Fundy.

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Appendix 1. The number of scallops captured per tow according to age. Tow position and bottom temperature are listed.

Tow	Age (years)											Lat.	Long.	°C
	1	2	3	4	5	6	7	8	9	10	11			
1	0	0	0	0	7	0	0	0	0	0	0	443950	654249	5.7
2	0	0	0	33	25	25	21	17	2	0	0	443935	654342	5.5
3	0	0	0	0	0	0	0	6	9	7	6	444029	654033	5.8
4	0	0	5	0	7	10	0	13	13	11	15	444023	654106	5.6
5	0	0	0	0	0	0	8	0	0	0	0	444007	654153	5.5
6	0	0	0	0	0	0	4	2	0	0	0	443948	654223	5.5
7	0	0	0	6	0	7	20	0	0	0	0	443938	654300	5.6
8	0	2	5	16	18	23	5	9	1	0	0	443936	654347	6.3
9	0	12	0	0	8	7	16	12	2	0	0	444007	654440	6.3
10	0	0	0	0	6	2	19	0	6	0	0	443907	654443	5.9
11	0	0	0	7	0	7	7	5	5	3	0	443928	654454	5.9
12	0	0	0	0	7	7	4	6	0	0	0	443908	654447	6.5
13	0	0	0	0	14	11	8	10	2	0	0	443828	654439	5.9
14	0	0	0	6	0	6	0	0	0	0	0	443920	654235	8.6
15	0	0	0	0	0	0	0	0	0	0	0	443922	654159	7.0
16	0	0	0	0	0	0	0	0	0	0	0	443910	654119	6.4
17	0	0	0	0	0	0	0	0	0	0	0	443914	654031	6.4
18	0	0	0	0	0	0	0	5	5	0	0	443954	654013	7.2
19	0	0	0	0	0	0	0	0	0	0	0	444053	653816	8.6
20	0	0	0	0	0	0	4	6	1	6	0	444028	653933	7.2
21	0	0	0	0	0	0	0	0	0	0	0	443953	654006	7.3
22	0	0	0	0	0	0	0	0	9	13	0	444002	654038	7.2
23	0	0	0	0	0	0	0	0	6	0	0	443952	654128	6.1
24	0	0	0	0	0	0	0	0	0	0	0	443942	654109	6.5
25	0	0	0	0	0	0	0	0	0	7	0	443931	654058	6.5
26	0	0	0	0	0	0	0	0	0	0	0	443936	654123	6.4
27	0	0	0	0	0	0	0	0	3	3	0	443927	654046	6.3
28	0	0	0	0	0	0	11	6	15	12	0	443908	654113	7.0
29	0	0	0	0	0	0	5	0	0	0	0	443914	654140	6.4
30	0	0	0	0	0	0	0	0	0	0	0	443913	653931	8.7
31	0	0	0	0	0	0	0	5	1	0	0	443854	654051	8.6
32	0	0	0	0	0	0	0	0	0	0	0	443903	654053	7.1
33	0	0	6	8	0	0	8	3	9	8	0	443845	654135	7.1
34	0	0	0	0	2	0	0	0	0	6	0	443831	654218	7.3
35	0	0	0	0	0	0	0	0	0	0	0	443829	654255	7.8
36	0	2	3	0	0	5	0	0	0	0	0	443841	654251	7.2
37	0	17	39	82	47	34	6	6	0	0	0	443851	654226	7.0
38	0	27	91	57	22	53	9	5	1	0	0	443910	654223	7.0
39	0	18	79	38	8	12	26	14	1	0	0	443926	654254	7.0
40	0	3	36	50	12	63	42	0	0	0	0	443929	654332	7.0
41	0	0	0	6	2	5	0	11	1	0	0	443929	654428	7.1
42	0	0	0	5	0	10	4	5	7	2	0	443953	654502	8.2
43	0	2	3	12	1	16	11	7	2	0	0	443853	654341	7.1

Appendix 1 cont'd. The number of scallops captured per tow according to age. Tow position and bottom temperature are listed.

Tow	Age (years)											Lat.	Long.	°C
	1	2	3	4	5	6	7	8	9	10	11			
44	0	0	28	6	21	14	0	0	0	0	0	443852	654322	7.1
45	0	11	73	145	35	41	59	2	0	0	0	443900	654318	7.8
46	0	28	86	55	5	16	4	4	1	0	0	443923	654316	7.7
47	0	0	3	10	5	1	4	4	1	0	5	443836	654444	7.4
48	0	0	0	0	0	0	4	6	1	0	0	443806	654434	7.4
49	0	4	5	0	5	0	3	6	0	0	0	443946	654447	7.4
50	0	0	0	19	11	6	37	15	0	0	0	443943	654428	7.3
51	0	8	13	13	14	30	31	9	3	2	0	443945	654411	7.4
52	2	3	0	0	14	5	9	0	0	0	0	443950	654440	7.4
53	0	0	0	0	0	0	0	0	0	0	0	444006	654500	7.5
54	0	0	0	0	1	3	0	0	0	0	0	443948	654445	7.5
55	0	0	2	7	6	12	16	21	3	0	0	443931	654441	8.4
56	0	0	0	0	0	0	0	0	0	0	0	443947	654428	8.1
57	0	5	0	10	15	29	12	11	5	0	0	443925	654406	9.0
58	0	0	5	31	12	26	25	23	6	0	0	443925	654419	7.4
59	0	0	0	0	16	9	14	7	1	4	0	443913	654431	7.6
60	0	2	39	216	39	78	22	0	5	0	0	443913	654336	8.7
61	0	5	22	66	11	23	20	10	2	0	0	443904	654334	7.9
62	0	4	0	0	0	4	0	0	0	0	0	443918	654410	7.4

