Potential Impacts of Inshore Hydraulic Clam Dredges on Inshore Area Habitat with Focus on Lobster Habitat

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2006

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2759

Fisheries and Oceans Canada   Pêches et Océans Canada

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Cat. No. Fs 97-4/2759E ISSN 0706-6473

Correct Citation for this publication:

Hawkins, C.M. 2006. Potential Impacts of Inshore Hydraulic Clam Dredges on Inshore Area Habitat with Focus on Lobster Habitat. Can. Manuscr. Rep. Fish. Aquat. Sc. 2759: v + 33 pp.

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ABSTRACT

Results of recent scientific examination of the impact of offshore commercial hydraulic clam dredging on the benthic habitat and associated resources has led inshore lobster fishery representatives to express concern on the potential impact of nearshore commercial hydraulic clam dredging (primarily for the ocean quahog, *Artica islandica*) on the benthic habitat and lobster resources of harbours and bays along the south shore of Nova Scotia. This report addresses their concerns through a review of existing information presently available on the potential impact, both long and short term, of commercial hydraulic clam dredging on inshore area habitat (within 12 nm of the coast) with a primary focus on lobster habitat and juvenile lobsters.

RÉSUMÉ

À la lumière des résultats d'un examen scientifique récent des incidences qu'ont sur l'habitat benthique et les ressources connexes les dragues hydrauliques utilisées dans la pêche commerciale des palourdes, les représentants de l'industrie de la pêche côtière du homard se sont dits inquiets de l'incidence possible de la pêche commerciale semi-hauturière des palourdes (en particulier du quahog nordique *Artica islandica*) à la drague hydraulique sur l'habitat benthique et les populations de homard des ports et baies de la côte sud de la Nouvelle-Écosse. On traite ici de la question en passant en revue l'information dont on dispose actuellement au sujet des incidences éventuelles, à court et à long terme, de l'utilisation de dragues hydrauliques sur l'habitat des eaux côtières (dans un rayon de 12 milles marins de la côte), l'accent étant mis principalement sur l'habitat du homard et sur les homards juvéniles.

INTRODUCTION

The ocean quahog, *Arctica islandica*, has been commercially fished by hydraulic dredges by both the offshore and inshore fishing interests on the outer relatively shallow water banks occurring off Nova Scotia for some time (DFO 1998). The hydraulic clam dredge utilizes high-pressure water jets, mounted on the dredge, to liquefy surficial sediments in advance of the dredge cutting blade; a dry dredge has no such pressurized water system. Ocean quahogs are very slow growing clams, which means that low exploitation rates must be set for sustainable management. Presently, there are three inshore limited entry quahog licenses with two active. This report examines the impact potential of a small commercial inshore quahog fishery on the benthic habitat as well as potential impact on other harvested resources in the region, most notably the American lobster, *Homarus americanus*. This report is a review of the information available on the potential impact of hydraulic clam dredges, both long and short term, on inshore area habitat (inside 12 nautical miles) with a primary focus on lobster habitat and juvenile lobsters (terms of reference, Appendix A). The report is based on examination of relevant literature and personal communication with Department of Fisheries and Oceans scientific experts at the Bedford Institute of Oceanography.

HISTORY OF THE INSHORE HARDSHELL CLAM FISHERY IN SOUTHWEST NOVA SCOTIA

The presence of ocean quahogs, *Arctica islandica*, in Nova Scotian waters has been noted for over 80 years. The earliest cited attempt to fish for ocean quahogs was made during the 1920s by Capt. McKenzie Bower of Jordan Bay, NS who after finding quahogs in his lobster traps and attached to his ground lines, built a dry dredge which he towed behind his gas-powered boat. He caught small quantities of quahogs that he used for baiting his long-lines (Chandler 1983).

In 1968-69, while exploring for gold deposits off Southwestern Nova Scotia, Triton Explorations Ltd. began to land a species of clams that were identified as *Arctica islandica* or ocean quahogs. In 1970, Triton established an ocean quahog fishery and processing facility in Port Medway, Nova Scotia called Triton Sea Products Ltd. The company shipped live or frozen quahogs to the United States for the half-shell trade. Larger clams were shucked, minced and shipped frozen to the United States for use in the canned chowder and stuffed clam market. The company reported landings of 907 t to 1,361 t for 1970 to 1971 (Rowell and Chaisson 1983). Operations abruptly ended at Triton Sea Products Ltd. in 1971. Several factors influenced the owners of the enterprise to cease operations: re-allocation of working capital to higher priority investments, lack of adequate management to run both the fishing and processing operations, and difficulties using product labels that were acceptable to the Canadian government which would have market acceptance in the United States. The economics of fishing, processing, and marketing of the ocean quahogs was not a significant factor in the decision to cease operations (Bissell 1972).

There are landings of quahogs reported from Nova Scotia up to 1983, but there was no requirement for logbooks during this period. In 1983, surveys of inshore quahog areas were conducted by DFO, the results of which are shown in Appendix B. Exploratory licences were issued starting in 1984. In 1988, a 3 year development phase was initiated. This was the first requirement for logbooks from the fishery. Two of the three exploratory licences were converted to limited entry licences in 1992; the third was converted in 1994.

The exploratory licences in 1985 were restricted to fishing in 4VW and 4X, East of 66°45' outside of the Bay of Fundy. In 1986 the licences were restricted to 4W and 4X east of 66°45' excluding the Bay of Fundy and confined to waters inside the Territorial Sea boundary (12 mile) but outside the headlands and in waters greater than 5 miles from shore. This was changed to outside of headlands and in water greater than 10 fathoms in May 1989. The co-ordinates for that headland line was drawn up by the SWNS Area office. The 1990 licence conditions indicate the area of operation to be 4W and 4X that is East of 66°45' and West of 63°00' excluding Bay of Fundy and confined to waters inside the territorial Sea Boundary (12 mile) but outside the headlands and in > 10 fathoms.

In 1997/98, geographic clam fishing zones were established to identify traditional and potential areas along the shore to the Bay of Fundy (Figure 1). In 1998, the boundaries between inshore and offshore quahog fisheries were modified and the inshore quahog licence was permitted access to grounds out to 20 nautical miles but still inside the headlands and greater than 10 fathoms.

In 2002, after lobster fisher concerns to DFO, the "headlands" were changed to the Territorial Sea Geographic Baseline (this is the baseline from which the 12 mi line is drawn) which then denied access to several previously accessible quahog beds. DFO indicated that there would be consultations with the lobster fishers and other stakeholders with the intent of identifying seasonal access to the quahog beds. This consultation was initiated in 2004 with access granted in 2005.

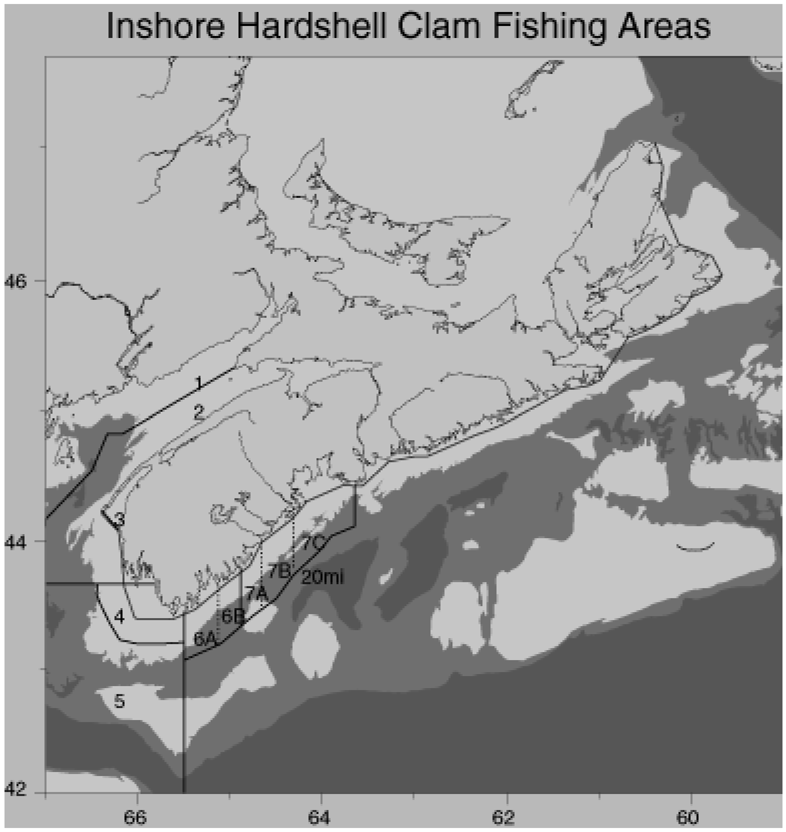

Figure 1. Inshore Hardshell Clam Fishing Areas.

LITERATURE REVIEWED

There has been much literature published on the impact of dredging, of which hydraulic dredging is just one method, on marine benthic habitat. A substantial collection of material is provided in a 79 page listing of literature on dredging impacts available on the web site of Gadus Associates (2002). Other reviews have been published by Watling and Norse (2000), Coen (1995), Rester (2001), Wion and McConnaughey (2000), Deiter et al. (2003), Auster and Langton (1999), Collie et al.(2000), NRC (2002), Gilkinson (1999), Gilkinson et al. (2002, 2003, 2005), Prena et al.(1996), and Messieh et al. (1991). Recently, a DFO Expert Opinion has been produced that specifically addresses offshore hydraulic clam dredging off Nova Scotia (Gordon 2002). These reviews, along with examination of specific references and consultations with regional scientific experts were used to develop this report. Generally, there is a lack of published information on the specific impact related to inshore hydraulic clam dredging. The majority of references pertain to offshore hydraulic clam dredging. Inshore references were found to deal exclusively with hydraulic escalators and not hydraulic clam dredges.

INSHORE HYDRAULIC DREDGING

Inshore hydraulic dredging differs from that which takes place in the offshore. Although the inshore gear basically resembles the offshore gear (Figure 2), the dredge gear used for harvesting in the inshore is smaller than what is used offshore (Table 1).

Figure 2. New England style hydraulic clam dredge (Lambert and Goudreau 1996)

Table 1. Inshore/Offshore Clam Dredge Specifications (Roddick *pers.com.*, 2005).

Location	Gear Blade Width (m)	Fishing Tow Speed (knots)	Tow Duration (min)
Inshore	1.4	<2	5 - 10
Inshore	0.53	<2	5 - 10
Offshore	3.7	<2	10 – 20

The large inshore hydraulic clam dredge cutting blade (essentially the width of the dredge) is about 1.4 m in width (Roddick *pers. comm*., 2005) while those of commercial offshore clam hydraulic dredges are in the order of 3.7 m. The speed of dredging by inshore and offshore vessels is less than 2 knots. The tow time of the inshore dredge is generally less than 5 to 10 minutes, depending on catch rate (Roddick *pers. com.,* 2005) while that of the offshore is 10 to 20 minutes. The footprint of a single inshore hydraulic clam dredge for a 5 to10-minute tow is approximately 216 to 432 m^2.

GENERAL OVERVIEW OF HYDRAULIC DREDGING IMPACTS

Impacts on the benthic seascape due to hydraulic dredging are primarily related to: size of gear, length of time towing, and nature of the surficial substrate. The footprint left by a single inshore hydraulic clam dredge is smaller than that produced by an offshore hydraulic clam dredge (see above). Nevertheless, this hydraulic method of fishing produces dramatic and immediate effects on the seabed topography and surficial sediment properties. The hydraulic dredge creates a furrow (a function of the hydraulic water pressure and the cutting blade depth of 10 to 20 cm) of 1 to 5 metres in width (Meyer et al.1981). Due to the hydraulic nature of this fishing method, the sediment inside dredge furrows becomes more fluidized compared to adjacent non-dredged areas (Lambert and Goudreau 1996, Tuck et al. 2000). Other physical effects include sediment re-suspension and redistribution (Meyer et al.1981, Lambert and Goudreau 1996), as well as changes in the geotechnical properties of the fluidized sediments by sorting (Brambati and Fontolan 1990, Hall et al.1990, Tuck et al. 2000).

Impacts of hydraulic dredging on benthic resources are also related to size of gear, length of time towing, hydraulic flow rate, depth of the cutting blade, as well as the speed of towing. The size of the gear has some bearing on the impact footprint, the smaller the gear size the smaller the footprint as it relates to potential impact to the benthic fauna and flora. Duration of towing is a function of the density of the harvestable resource, here if the resource is marginal for harvest it is likely that the dredge times will be longer and hence create a much larger footprint on the bottom as opposed to an area with high densities of harvestable resource where shorter dredge times are needed to fill the dredge. The depth of the cutting blade and hydraulic flow rate as well as speed of towing bears upon the benthic organisms found in association with the harvestable resource.

General biological impacts, in addition to the removal of the target species, may be distinct, and include reduction in abundance, biomass and diversity of benthic fauna (Kauwling and Bakus 1979, Murawski and Serchuk 1989, Hall et al.1990, Pranovi and Giovanardi 1994, Kaiser et al.1996). In association, there may be a temporary increase in predators feeding on fauna exposed in the dredge furrow (Kauwling and Bakus 1979, Meyer et al.1981, Murawski and Serchuk 1989). If the cutting blade is not adjusted properly for the depth of the resource there may be significant damage to the uncaught target species (Lambert and Goudreau 1996) and an associated increase in their predators. Sessile organisms, living on or within the surficial sediments and in association with the target resource, will be impacted by hydraulic dredging. These organisms will not be able to move out of the way of an operating dredge and may be damaged or killed by the procedure. Those individuals that are not sessile and freely able to move may escape the dredge provided the speed of towing is relatively slow.

In October of 2001, a workshop on the Effects of Fishing Gear on Marine Habitats, primarily offshore off the Northeastern United States, was held in Boston (Northeast Region Essential Fish Habitat Steering Committee 2002). Here the current understanding of the environmental impact of various types of bottom dredges (including hydraulic clam dredges) was evaluated. The workshop reached several broad conclusions with respect to the impact of clam dredges generally, they include (adapted from Gordon 2002):

- Habitat effects are limited to sandy bottoms since the gear is not used on gravel and mud bottoms.
- Changes in physical and biological structure occur at high fishing effort levels.
- Changes to benthic prey are unknown.
- Recovery of physical structure can range from days in high-energy environments to months in low energy environments.
- Recovery of biological structure can take months to years depending upon the species affected.
- Hydraulic dredges have important impacts but even in the worse case scenario (i.e. severe biological impacts) only a small area of the seafloor is affected.
- Therefore, this gear type is less destructive than other gear types like bottom trawls and scallop dredges, which affect much larger areas.
- However, even though effects are limited to a small area, they could be very significant if the area was important habitat for other species i.e. the settlement of larval fish.

In 2002, under the aegis of the US National Research Council (NRC 2002), an expert committee reviewed the effects of trawling and dredging on the seafloor habitat. This document focused on offshore seafloor habitat. Their summary is quoted below:

"For the most part, existing information about the direct responses of benthic communities to trawling and dredging is consistent with the general principles that govern how ecologists expect communities and ecosystems to respond to acute and chronic physical disturbance. Trawling and dredging change the physical habitat and biological structure of ecosystems and therefore can have potentially wide-ranging consequences. Mobile gear reduces benthic habitat complexity by removing or damaging the actual physical structure of the seafloor, and it causes changes in species composition. The reduction of physical structure in repeatedly trawled areas results in lower overall biodiversity. Of direct concern to commercial and recreational fisheries is the possibility that losses of benthic structural complexity and shifts in community composition will compromise the survival of economically important demersal fishes. Mobile gear also can change surficial sediments and sediment organic matter, thereby affecting the availability of organic matter for microbial food webs."

IMPACTS OBSERVED DURING OFFSHORE EXPERIMENTS ON HYDRAULIC CLAM DREDGING

From the information gained on the impact of offshore hydraulic clam dredging in Nova Scotian offshore waters (Gordon 2002, Gilkinson 1999, Gilkinson et al. 2002, 2003, 2005) as an indicator of the potential impact that a commercial inshore hydraulic clam dredge fishery would impose on the benthic habitat and communities, one may conclude that similar types of impact would occur inshore; based on similar substrate types (i.e. particle size), dredging methods and epifauna/infauna organisms. (Note: This is speculative at this time since there have been no definitive studies to examine the specific impact of hydraulic clam dredges in inshore waters with similar physical and biological parameters to those found offshore.) Nevertheless, due to the reduced size of the inshore footprint (see below) the level of potential impact would be markedly reduced.

One such offshore field experiment was conducted in 1998-2000 by DFO and Natural Resources Canada on Banquereau under a Joint Project Agreement with the offshore clam industry (Gilkinson et al. 2005). The purpose of the experiment was to increase knowledge of the impacts of offshore hydraulic clam dredges on benthic habitat and communities. Key issues to be addressed were the longer term impacts of hydraulic clam dredging and the rates and processes of recovery (Gilkinson et al. 2003, Gilkinson et al. 2005). The experiment was located on Banquereau in 70-80 m of water. Site selection criteria included uniformity of sediment and topology, no previous disturbance by clam dredges, and the presence of a benthic community with a high biomass and diversity, including commercial densities of clams. Three treatment boxes and two reference boxes (approximately 100 m by 500 m) were established in a 1.5 km by 2 km area. The treatments were dredging and discarding, dredging only and discarding only. Twelve tows were done in each of the dredged treatments (dredged only and dredged and discard boxes) by the *Atlantic Pursuit*, a commercial offshore clam vessel. It used two dredges 4 m wide, 3.6 m long and 1 m high, weighing approximately 12 tonnes. The mouth openings were 3.8 m, and the knife blades set to a depth of 20 cm. The "cage" of the dredges had a bar spacing of 3-4 cm. The fishing tracks were mapped with sidescan sonar, and covered approximately 53% and 68% of the bottom of the dredged and dredged and discard boxes respectively.

Sampling consisted of grab samples, sidescan sonar, video transects and high resolution colour photographs taken before dredging, immediately after dredging, and 1, 2 and 3 years after dredging from both the treatment and reference boxes. There was also a sample using all except the grab samples two weeks following dredging.

Given the present available information, the following are generalized impacts determined from offshore studies that may be applicable, to some degree, to an inshore commercial hydraulic clam fishery.

Hydraulic clam dredging may produce substantial immediate impacts to biological communities.

The immediate effects on benthic invertebrates may be dramatic and a large number of species may be affected in the inshore. Decreases in epibenthic and infaunal (i.e. sanddollars, polychaetes) species biomass and abundance could occur due to a combination of factors including capture, burial, resuspension / advection and consumption by scavengers. Effects will no doubt be greater inside dredge furrows than immediately outside.

Exposed and damaged benthic invertebrates represent an enhanced food supply for numerous scavenging species including fish, crabs, lobsters and other benthic community members that are attracted to areas of disturbance.

After two years of no fishing, the offshore macrofaunal community showed evidence of substantial recovery in terms of species composition based on abundance. This was due to the increase in abundance of many species, particularly polychaetes and crustaceans. Inshore benthic invertebrate populations may recover quicker (Hall et al. 1990).

Hydraulic clam dredging may alter seabed habitat through sediment resuspension and sedimentation, changes in seabed topography (e.g. creation of deep furrows), exposure of subsurface sediment and destruction of microhabitat structures (e.g. burrows, tubes, detritus patches, etc.).

The dramatic changes to offshore seabed topography, seen immediately after dredging, were no longer visible (in video or photographs) one year after dredging. At these water depths (70-80 m), the furrows had been eroded likely due to sediment transport (infilling) associated with storm waves, although bioturbation could also be a contributing factor. (These processes may have greater influence in shallower depths such as found in the inshore.)

Over the course of the experiment, there were no detectable changes in the species composition of the benthic community, just shifts in the relative abundance of species.

It appears that non-target species, initially reduced in abundance, have recovered to pre-dredging levels (or above) in about two years.

DESCRIPTION OF THE INSHORE ENVIRONMENT

Many inshore areas off the south shore of Nova Scotia have been identified from surveys as having the potential to support a small inshore quahog fishery based on biomass estimates. Other inshore areas of Nova Scotia, yet to be identified, may also hold commercial quantities of offshore quahogs or other clam species. Some historical locations of the quahog beds in identified inshore areas of Nova Scotia are shown in Appendix B. The surficial sediment texture where quahog beds are found in surveyed areas is coarse to fine sand, 0.5 –0.063 mm (Chandler 1983, JWEL 2003, Piper et al. 1986). Commercial quantities of quahogs are not found in cobble, gravelly areas but may occur in commercial abundance in very fine silts and clays, as occurs in southwest New Brunswick and Maine (Roddick *pers. comm*., 2005). No data were found on benthic inshore currents for any surveyed area.

Underwater video of a hydraulic clam dredge fishing quahogs in Shelburne Harbour by Roddick in 1989 shows that the sediment plume generated by the dredging activity dissipates quickly, in the order of 10s of minutes with both the horizontal and vertical displacement of the plume being in the order of 1 to 2 meters at maximum. On this basis, the re-suspension of surficial sediments will not induce a measurable impact on the water column. In addition, because the plume dissipates in such a short time, any benthic filter feeder will unlikely be markedly impacted by the plume. The dredge footprint produced by the inshore quahog dredge is estimated to be in the order of 432 m^2 (for a dredge blade width of 1.4 m, duration of tow of 10 minutes and speed of tow of 1.5 knots). The dredge furrow may reach a maximum depth of 20 cm, depending on the depth at which the cutting blade is set. Visual evidence of a furrow in the relatively shallow waters of quahog beds may persist for no more than 1 year and may not be discernable in a very much shorter temporal period due to the influence of tidal currents, wind driven circulation and natural catastrophic events that may occur (i.e. summer and winter storms (Hall et al. 1990). If the underwater video taken by Roddick in 1988 and 1989 is somewhat representative of commercial inshore clam fishing sites under consideration (similar depth, target species present, similar sediment composition and size as well as epifaunal composition) the dredge furrow is unlikely to have a measurable sustained impact on the abundance and species composition of benthic macroinvertebrates (MacKenzie 1982). The underwater video shows no aggregations of epifauna associated with commercial concentrations of the target species, other that a few sanddollars in one area. However, there were solitary lobsters and crabs in the area of dredging. These mobile epibenthic feeders were able to move out of the way of an advancing quahog dredge. Upon dredge departure, lobsters and crabs frequented the furrow to feed. Due to the high mobility of both lobster and crab, along with the low towing speed of the dredge (< 2 knots), these mobile epifauna species easily move out of the way of the advancing dredge. With specific reference to adult lobster and lobster habitat it is doubtful that any sustained measurable impact will occur as a result of hydraulic clam dredging. The basis of this conclusion is:

1. the substrate of the target species is not prime adult lobster habitat during the lobster fishing season
2. adult lobsters are able to avoid the fishing dredge
3. the substrate that quahogs inhabit is not conducive to burrowing by juvenile lobsters (< 40 cm carapace length). Underwater video (Roddick 1988 and 1989) of divers attempting to make burrows in surficial sediments inside and outside a dredge furrow clearly show that burrows cannot be established in the coarse sandy sediments
4. the short duration of the sediment plume as well as it remaining close to the bottom is unlikely to influence lobster pelagic phases

Few sessile epifaunal representatives colonize the coarse surficial sediments where quahogs are found in commercial quantities. This may be the result of the coarse nature of the surficial sediments, shallow waters subject to strong tidal action and wind driven circulation and natural catastrophic events. Without direct assessment by divers or remote video surveillance, the nature of the sessile benthic community cannot be ascertained for any of the previously surveyed sites. Nonetheless, if the underwater video taken by Roddick in 1988 and 1989 is representative of the region as a whole that supports commercial quantities of quahogs, the impact of hydraulic clam dredging may not be measurable over the impact natural catastrophic events.

Harvesting of the target resources may have some related ecological consequences. Here, quahogs, in some inshore beds, may be key food resources for higher trophic levels and their disappearance through harvesting may influence regional ecosystem structure, function and energy flow. Hawkins and Angus (1986) have shown that the ocean quahog is a key food resource of the Atlantic wolfish, *Anarhichas lupus*, in Port Mouton, Nova Scotia and the moon snail, *Lunatia heros*, also feeds on ocean quahogs.

POTENTIAL INTERACTIONS WITH THE LOBSTER FISHERY

At present there are 3 inshore limited entry quahog licenses with two actively quahog fishing in Southwest Nova Scotia. Lobster licenses in the areas that may be fished for quahogs (primarily LFA 33 and LFA 34) exceed 1600 (Tremblay *pers. comm.*, 2005). As documented earlier in this report, the fishing season for quahogs has not been fully assigned. Presently, hydraulic clam fishing is not allowed inside the Territorial Sea Geographical Baseline (the baseline) during the lobster season. The lobster season runs from the last Monday in November to the 31st of May in the following year. Consequently the quahog fishery will be prosecuted during the summer when adult lobsters are moving inshore to shallower waters. Without direct knowledge of the increase in adult lobster density in areas where the quahog fishery may take place, the impact of hydraulic clam fishing on adult lobster is unknown. However, as mentioned above, the mobility of adult lobsters combined with a slow dredging speed for the hydraulic clam dredge, and the few numbers of licensed fishers, significantly reduces the potential of lobster-dredge interaction. Therefore, during the summer, it is unlikely that a significant number of adult lobsters will be impacted. In regards to this latter point, underwater video of hydraulic clam dredge fishing off of Lockeport in 1988 and Shelburne Harbour by McNutts Island in 1989 by Roddick (DFO, BIO) clearly shows that the adult lobsters and crabs are able to move out of the way of the hydraulic clam dredge fishing at speeds of less than 2 knots.

SUMMARY AND CONCLUSIONS

Table 2 summarizes results relating the potential impact of hydraulic clam fishing on benthic habitat (surficial sediment grain size ranging from 0.063 to 0.5 mm). It is considered unlikely that a fishery with only three licenses will significantly impact the benthic physical and biological environment for any extended period of time. In addition, it is questionable whether this small quahog fishery will significantly impact the lobster fishing industry in the region. Without data on the increase in lobster densities during the summer when the quahog fishery is prosecuted, the potential impact on adult lobsters remains uncertain. However, given that adult lobsters have been observed avoiding an active hydraulic clam dredge, significant detrimental interaction between the two is considered to be unlikely. Furthermore, the physical substrate in the surveyed quahog beds is not considered to be prime adult lobster habitat during the lobster fishing season, although they are found in sandy/mud habitat in the summer and fall in some areas (Pezzack *pers. comm.*, 2005), and the coarse nature of the surficial sediments makes it unsuitable to maintain the integrity of a juvenile lobster burrow. Planktonic phases of lobsters are unlikely be impacted due to the rapid sediment plume dissipation (in the order of minutes).

Table 2: Summary of Potential Impacts of Hydraulic Clam Dredging on Benthic Habitat.

Potential Impact	**Expected Duration of Effect (specific for coarse-to-fine sediments*)**	
	Short Term (< 1 year)	Medium Term (1 – 5 years)
Increase in suspended sediments	X (1), (3)	
Production of dredge furrows	X (2)	X (1), (5)
Reduction in numbers of non-target epi-infauna		X (1), (3)
Reduction in biomass of benthic organisms		X (1), (3)
Altered benthic community structure		X (1), (3)
Increase in benthic scavengers	X (4)	

* no long term studies have been conducted in the inshore

(1) Based on DFO (2002).
(2) 40 days furrows disappeared (Hall et al.1990).
(3) Silt plume settled out within 4 minutes of tow (Meyer et al. 1981)
(4) After 24 hours, distribution and abundance of predators appeared to have returned to normal (Meyer et al. 1981).
(5) Based on Gilkinson et al. (2003).

ADULT LOBSTERS

The mortality of adult lobsters as a result of inshore hydraulic clam dredging is unknown but is expected to be minimal -- even during summer when lobsters migrate inshore. Analysis of underwater video taken by Roddick in 1988 and 1989 indicates that adult lobsters are able to avoid a towed, active, inshore hydraulic clam dredge.

ADULT LOBSTER HABITAT

The impact of inshore hydraulic clam dredging on adult lobster habitat is expected to be minor. Quahog beds are not prime adult lobster habitat. Adults prefer substrate characterized by sand-rock, bedrock-rock, and mud-rock (Thomas 1968, Cobb 1971, Cooper and Uzmann, 1977, 1980, Mackenzie et al. 1985). In soft substrates, sand to clay, adult lobsters may burrow or excavate bowl shaped depressions for cover and protection (Thomas 1968, Cooper and Uzmann 1980, MacKenzie et al. 1975, Cooper et al. 1975). Burrows in very soft fine textured sediments must have sufficient structural integrity to prevent collapse and highly fluid sediments are thus less suitable as burrowing substrates for adult as well as juvenile lobsters.

JUVENILE LOBSTERS

No measurable mortality of juvenile lobsters is expected as a result of inshore hydraulic clam dredging (see below).

JUVENILE LOBSTER HABITAT

Inshore clam beds of coarse-to-fine sand are not conducive to the construction of burrows by juvenile lobsters; therefore, the impact of inshore hydraulic clam dredging is expected to be negligible. Bolder and cobble bottom is considered the habitat most suitable for juvenile lobsters < 40 mm carapace length (Miller et al.1992).

LOBSTER PLANKTONIC PHASES

Sediment plumes and increased turbidity in the water column as a result of inshore hydraulic clam dredging is expected to have no measurable impact on planktonic larvae. Underwater video taken by Roddick in 1988 and 1989 shows that the sediment plume generated by the dredging activity dissipates quickly, in the order of 10s of minutes, with both the horizontal and vertical displacement of the plume being in the order of 1 to 2 meters at maximum. On this basis, the re-suspension of surficial sediments will not induce a measurable impact on the water column and, consequently, lobster planktonic phases.

GEAR CONFLICTS

Inshore hydraulic clam dredging is not allowed inside the Territorial Sea Geographical Baseline during lobster season; therefore, the impact on lobster fisheries is expected to be negligible.

DATA GAPS, RESEARCH NEEDS, AND MONITORING

The following provides a brief list of data gaps and or research needs required to address the impact of hydraulic clam dredging in inshore waters off Nova Scotia.

1. Detailed surficial sediment maps for inshore areas identified as having potential commercial quantities of clam resources are required. Specifically, surficial sediment grain size, penetrometer measurements, depths of grain sizes and geotechnical properties.
2. Detailed benthic community analysis, including species diversity, abundance, biomass, composition, etc.
3. Identification of predators of target species to assess how harvesting affects higher trophic levels as well as energy flow.
4. Quantification of the intensity of lobster fishing within inshore areas that may have commercial quantities of clam resources.
5. Estimation of the size of area to be impacted: to include size of the clam fishing area, the size of the lobster fishing area and size of the total clam bed.
6. Monitoring of potential impacts of hydraulic clam dredging should follow similar methods and time frames as completed for offshore studies, specifically those of Gilkinson et al.(2002, 2003, and 2005) among others. However, for the inshore (relatively shallow waters compared to the offshore) it may be more prudent to conduct detailed monitoring over the first year due to physical events (such as storms) that may influence recognition of dredge-induced impacts and recovery rates.

ACKNOWLEDGEMENTS

I wish to thank the following for their assistance in the development of this study, information acquisition and manuscript review: D. Gordon Jr., D. Gregory, S. Nolan, R. Duggan, D. Pezzack, R. Miller, J. Tremblay, D. Piper, D. Roddick, and E. King.

REFERENCES

Auster, P.J. and R.W. Langton. 1999. The effects of fishing on fish habitat. In: L.R. Benaka (ed) Fish habitat: essential fish habitat and rehabilitation. Am. Fish. Soc. Symp 22, Bethseda, MD, pp. 150-187.

Bissell, G.E. 1972. Review of the East Coast Quahog Fishery (Guidelines for Development) October 31, 1972. Prepared by Western Consultants, West Vancouver, B.C. 1972: 93 p.

Brambati, A. and G. Fontolan. 1990. Sediment resuspension induced by clam fishing with hydraulic dredges in the Gulf of Venice (Adriatic Sea). A preliminary experimental approach. Boll. Oceanol. Teor. Applic., 8: 113-121.

Chandler, R.A. 1983. Ocean Quahog Survey, South Shore of Nova Scotia, 1971-72, With Observations on a Preliminary Survey by SCUBA and a Commercial Fishery. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1726.

Cobb, J.S. 1971.
The shelter-related behaviour of the lobster, Homarus americanus. Ecology 52:108-115.

Coen, L.D. 1995. A Review of the Potential Impacts of Mechanical Harvesting on Subtidal and Intertidal Shellfish Resources. South Carolina Department of Natural Rsources Marine Resources Research Institute

Collie, J.S., S.J. Hall, M.J. Kaiser and I.R. Poiner. 2000. A quantitative analysis of fishing impacts on shelf-sea benthos. J. Animal Ecology 69:785-798.

Cooper, R.A., and J.R. Uzmann. 1980.
Ecology of juvenile and adult Homarus . Pages 97-142 in J.S. Cobb and B.F. Phillips, eds. The biology and management of lobsters, Vol. II. Academic Press, New York.

Cooper, R.A., R.A. Clifford, and C.D. Newell. 1975.
Seasonal abundance of the American lobster, Homarus americanus , in the Boothbay region of Maine. Trans. Am. Fish. Soc. 104:669-674.

DFO 1998. Scotian Shelf Ocean Quahog. DFO Science Stock Status Report C3-37 1998.

Dieter, B. E., D. A. Wion, and R. A. McConnaughey. 2003. Mobile fishing gear effects on benthic habitats: A bibliography (second edition). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-135, 206 p.

Duggan, R., E. Kenchington, S. Smith, and J.T. McLane. 1998. Preliminary Stock Survey of the Ocean Quahog (*Arctica islandica*) in St. Marys Bay, Nova Scotia. CSAS Res. Doc. 98/54.

Gadus Associates 2002. Bibliography of the Effects of Fishing Gear on the Seabed and Benthic Communities 2002 Edition Trevor Kenchington Gadus Associates, Musquodoboit Harbour, Nova Scotia. http://home.istar.ca/~gadus/ImpactBiblio.pdf

Gilkinson, K.D. 1999. Impact of otter trawling on infaunal bivalves living in sandy bottom habitats on the Grand Banks. PhD Thesis, Memorial University.

Gilkinson, K.D., D.C. Gordon Jr., G.B. Fader, D.L. McKeown, E.L.R. Kenchington, D. Roddick, C. Bourbonnais, K.D. MacIsaac, R. Charron, M. Lamplugh and W.P. Vass. 2002. Banquereau hydraulic clam dredging experiment 1998-2000, Interim summary report, March 2002. Internal DFO/NRCan Project Report for Joint Project Agreement F5244-7-0868.

Gilkinson, K.D., G.B.J. Fader, D.C. Gordon Jr., R. Charron, D. McKeown, D. Roddick, E.L.R. Kenchington, K. MacIssac, C. Bourbonnais, P. Vass and Q. Liu. 2003. Immediate and longer-term impacts of hydraulic clam dredging on an offshore sandy seabed: effects on physical habitat and processes of recovery. Continental Shelf Research 23:1315-1336.

Gilkinson, K. D., Gordon, D. C. Jr., MacIsaac, K. G., McKeown, D. L., Kenchington, E. L. R., Bourbonnais, C., and Vass, W. P. 2005. Immediate impacts and recovery trajectories of macrofaunal communities following hydraulic clam dredging on Banquereau, eastern Canada. ICES Journal of Marine Science, 62: 925-947.

Gordon D.C Jr. 2002. Expert opinion on Clearwater/Deep Sea Clam Ocean Quahaug Development Proposal DFO, Maritimes Internal Document.

Hall, S.J., D.J. Basford and M.R. Roberston. 1990. The impacts of hydraulic dredging for razor clams *Ensis* sp. on an in faunal community. Neth. J. Sea Res. 27: 119-125.

Hawkins, C.M. and R.B. Angus 1986. Preliminary observations of predation on ocean quahaugs, Arctica islandica, by Atlantic wolffish, Anarhichas lupus. Nautilus Vol.100:126-129.

JWEL 2003. Blue Atlantic Transmission system project Benthic survey data report in support of the environmental assessment. Jacques Whitford Environment Limited, Dartmouth, Nova Scotia

Kaiser, M.J., D.B. Edwards and B.E. Spencer. 1996. Infaunal community changes as a result of commercial clam cultivation and harvesting. Aquatic Living Resources 9: 57-63.

Kauwling, T.J. and G.J. Bakus. 1979. Effects of hydraulic clam harvesting in the Bering Sea. Tetra Tech Report TC 3324, North Pacific Fishery Management Council (Council Document # 5), Anchorage, Alaska, 183 p.

Lambert, J. and P. Goudreau. 1996. Performance of the New England hydraulic dredge for the harvest of Stimpson's surf clams (*Mactromeris polynyma*). Can. Ind. Rap. Fish. Aquat. Sci. 235.

MacKenzie, C.L. Jr. 1982. Compatibility of invertebrate populations and commercial fishing for ocean quahogs. North American Journal of Fisheries Management 2:270-275.

MacKenzie, C., J.R. Moring and L. Shanks 1985
Species Profiles: life histories and environmental requirements of coastal fisheries and invertebrates (North America) -- American Lobster. U.S. Fish and Wildl. Serv. Biol. Rep. 82(11.33). U.S. Army Corp of Engineers, TR EL-82-4. 19 pp

Messieh, S.N., T.W. Rowell, D.L. Peer, and P. Cranford. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. Cont. Shelf Res. 11: 1237-1263.

Meyer, T.L., R.A. Cooper, and K.J. Pecci. 1981. The performance and environmental effects of a hydraulic clam dredge. Mar. Fish. Rev. 43: 14-22.

Miller, R.J., A. Cambell, G. Sharp and C. Hudon. 1992.
Are small juvenile lobsters habitat limited. pages 55 - 61, In. de Lafontaine, Y, T. Lambert, G.R. Lillym W.D. McKone, and R.J.Miller (eds.) 1992. Juvenile Stages: The Missing Link in Fisheries Research. Report of a Workshop. Can. Tech. Rept. Fish. Aquat. Sci. 1890: 139 pages

Murawski, S.A. and F.M. Serchuk. 1989. Environmental effects of offshore dredge fisheries for bivalves. ICES Shellfish Committee. C.M. 1989/K:27

Northeast Regional Essential Fish Habitat Steering Committee. 2002. Workshop on the Effects of Fishing Gear on Marine Habitats off the Northeastern United States, October 23-25, 2001, Boston, Massachusetts. Northeast Fish. Sci. Cent. Ref. Doc. 02-01; 86 p.

NRC. 2002. Effects of trawling and dredging on seafloor habitat. National Academy Press, 126 p. (NRC=National Research Council)

Piper, D.J.W., P.J. Mundie, J.R.J. Leston, N.E. Barnes and R.J. Luliucci 1986. The marine geology off the South Shore of Nova Scotia. Geological Survey of Canada Paper 85-19.

Pranovi, F. and O. Giovanardi. 1994. The impact of hydraulic dredging for short-necked clams, *Tapes* spp., on an infaunal community in the lagoon of Venice. Scientia Marina 58: 345-353.

Prena, J., T.W. Rowell, P. Schwinghamer, K. Gilkinson and D.C. Gordon Jr. 1996. Grand Banks otter trawling impact experiment: I. Site selection process, with a description of macrofaunal communities. Can. Tech. Rep. Fish. Aquat. Sci. 2094.

Rester, J.K. 2001. Annotated Bibliography of Fishing Impacts on Habitat - October 2001 Update Gulf States Marine Fisheries Commission

Roddick, D., and K. Mombourquette. 2005 (in prep). 2002 Survey for Ocean Quahogs (*Arctica islandica*) at the mouth of St. Marys Bay, Nova Scotia. CSAS Res. Doc.

Rowell, T.W. and D.R. Chaisson. 1983. Distribution and abundance of the ocean quahog (*Arctica islandica*) and Stimpson's surf clam (*Spisula polynyma*) resource on the Scotian Shelf. Can. Industry Rept. Fish. Aquat. Sci. 142: v + 75 p.

Thomas, M.L.H. 1968.
Overwintering of American lobster Homarus americanus, in burrows in Bideford River, Prince Edward Island. J. Fish. Res. Board Can. 35:2725-2727.

Tuck, I.D., N. Bailey, M. Harding, G. Sangster, T. Howell, N. Graham and M. Breen. 2000. The impact of water jet dredging for razor clams, *Ensis* spp., in a shallow sandy subtidal environment. J. Sea Res. 43: 65-81.

Watling, L and E A. Norse 2000. Disturbance of the Seabed by Mobile Fishing Gear: A Comparison with Forest Clear-Cutting Darling Marine Center, University of Maine, Walpole, ME 04573 U.S.A., email watling@maine.maine.edu

Wion, D.A. and R.A. McConnaughey. 2000. Mobile fishing gear effects on Benthic habitats. NOAA Technical Memorandum NMFS-AFSC-116, 2000.

APPENDIX A: TERMS OF REFERENCE

Government of Canada | Gouvernement du Canada

MEMORANDUM NOTE DE SERVICE

Security Classification – Classification de sécurité

Our File – Notre référence

Your File – Votre référence

Date MAY 10 2005

To / À: Bob O'Boyle, DFO Science
Ross Claytor, DFO Science
Don Gordon, DFO Science

From / De: D. Leslie Burke, Regional Director
Fisheries and Aquaculture Management

Subject / Objet: **Request for Expert Opinion on potential impact of clam dredges on inshore habitat primarily lobster habitat**

In the early 1980's, stock surveys conducted by DFO determined there were commercial quantities of the slow growing hard shell clam ocean quahog, *Arctica islandica* in many of the harbours and bays along the south shore of Nova Scotia. St Mary's Bay has been surveyed as recently as 2002. Precautionary quotas are available for these areas from the survey biomass estimates.

In the late 1980's, there was fishing activity by the quahog licence holders in some of these inside bays and harbours which resulted in DFO receiving strong concerns on habitat disruption from lobster fishery representatives. Quahog dredge fishing was then limited to outside a defined baseline.

The current Elements for a Conservation Harvesting Plan for the inshore hard shell clam fishery in South West Nova Scotia (SWNS) identifies five potential areas of activity. It outlines the requirements in each area the three licence holders must consider prior to receiving approval to conduct a fishery. Currently they are not permitted to fish inside the headlands (Baseline) without consultation with other stakeholders, primarily the lobster industry.

Consultations between the quahog licence holders and representatives of the lobster fishery advisory committees were completed in March 2005. The lobster fishery representatives' referred to information found in the offshore/deep water habitat assessment proposal "the Expert Opinion on Clearwater/Deep Sea Clam Ocean Quahog Development", indicating there was negative impact of the quahog dredge on the habitat. Although a video of a dredge in a near shore area indicating that the lobster can avoid the clam dredge was viewed and discussed, there were continuing concerns about the impact of a quahog fishery on the lobster habitat and in particular, incidental harm to juvenile lobsters at very small sizes. Concerns were that these very small animals may not be able to avoid a clam dredge as is the case with larger lobsters that are more mobile.

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The committee representatives requested a review of all science information available on the short and long term habitat impacts and direct impact on juvenile lobsters of the inshore clam dredge in inshore areas.

As a result of the concerns raised at the Lobster advisory committees, I am requesting DFO Science and Habitat prepare a report in the form of an Expert Opinion to provide the following information:

1. A review of the information available on the potential impact of clam dredges both long and short term on the inshore area habitat (inside 12 miles) with a primary focus on lobster habitat and juvenile lobsters. It is realized that this would primarily be a literature review.

2. Identify and outline recommendations for projects to provide further information on clam dredge/habitat interactions with emphasis on juvenile and adult lobsters interactions which could be conducted by both the lobster and quahog fishers under the direction of DFO.

Please confirm an expected completion date for this Expert Opinion.

Leslie D. Burke

Cc: M. Sinclair
S. Smith
D. Roddick
J. McMillan
M. Butler
I. Marshall
J. Jamieson
D. Pezzack

APPENDIX B: AREAS SURVEYED FOR QUAHOGS IN COSTAL NOVA SCOTIA.

Maps are from Rowell and Chaisson (1983), Duggan et al. (1998), and Roddick and Mombourquette (2005, in prep): a) St. Marys Bay, b) Meteghan and Port Maitland, c) Lobster Bay, d) Cape Sable Island, e) Barrington Bay, Port LaTour and Negro Harbour, f) Shelburne Harbour, Jordan Bay and Green Harbour, g) Port Herbert, Port Joli and Port Mouton, h) Medway Harbour, i) Green Bay, False LaHave, LaHave and Lunenburg Bay, j) Mahone Bay, k) St. Margarets Bay, l) and m) St. Marys Bay. Quahog densities (no/m^2) are shown in a-i; j-m show survey tow locations.

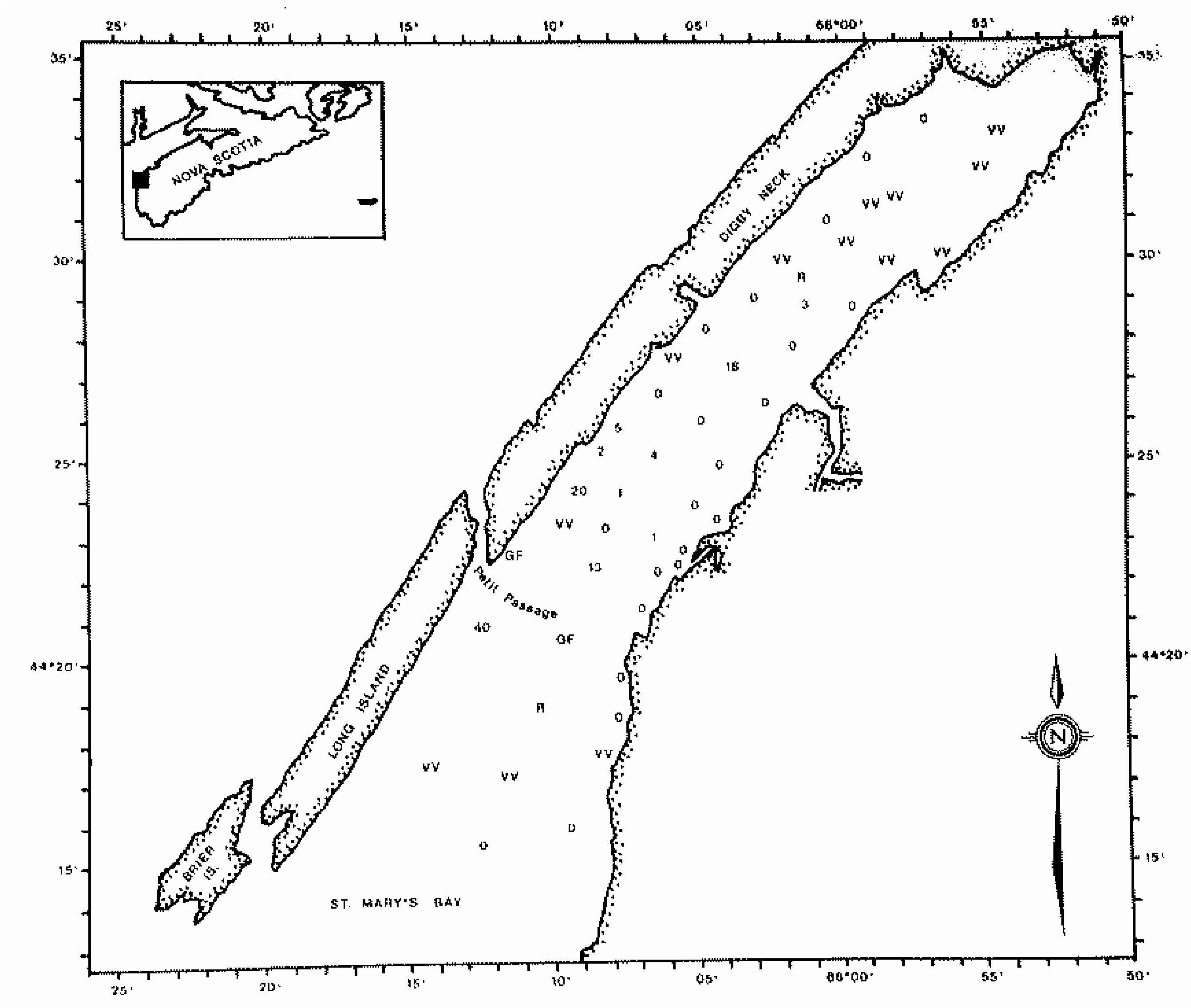

Figure 3. Quahog Densities (no/3 minute tow) in St. Marys Bay

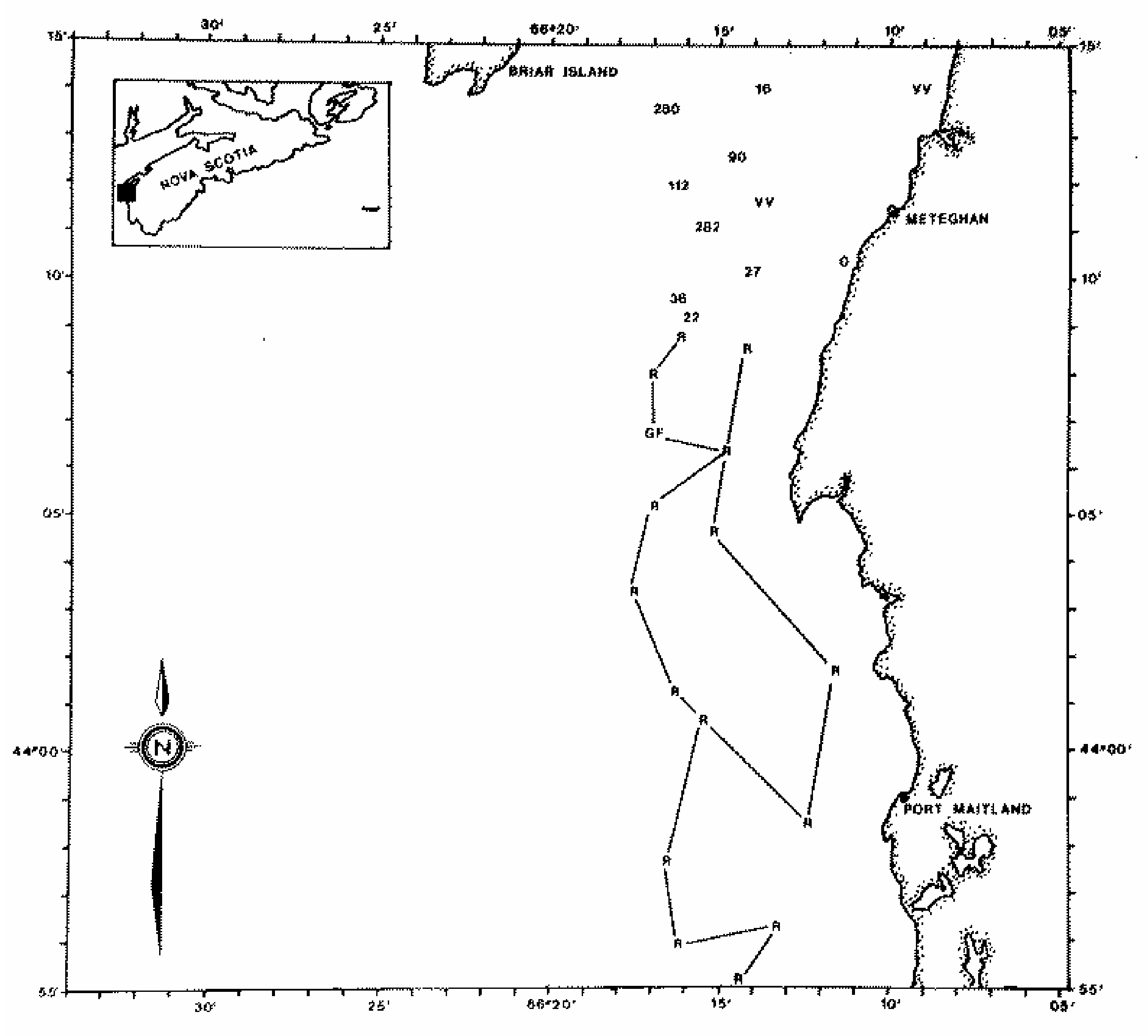

Figure 4. Quahog Densities (no/3 minute tow) off Meteghan and Port Maitland

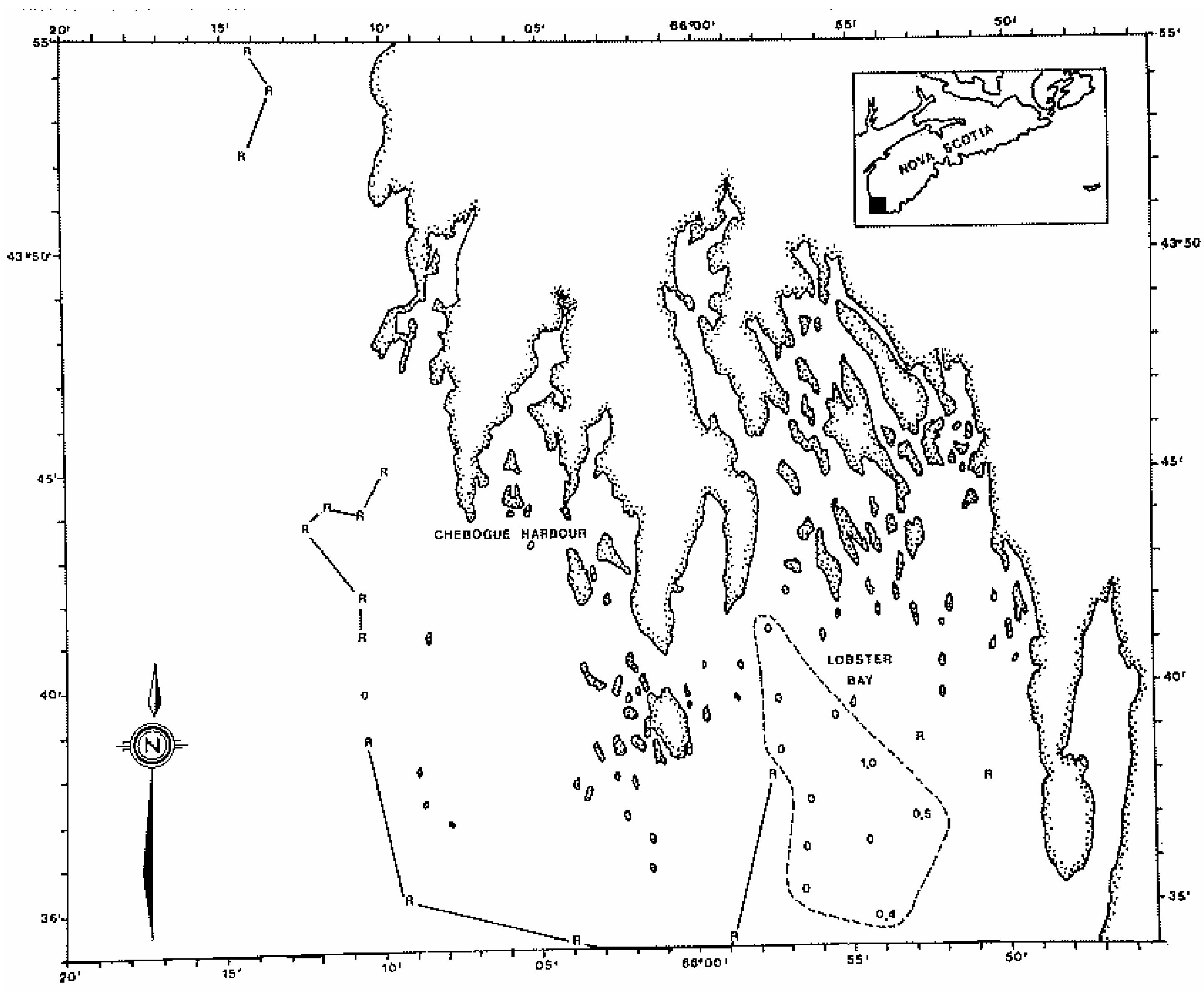

Figure 5. Quahog Densities (no/m^2) near Lobster Bay

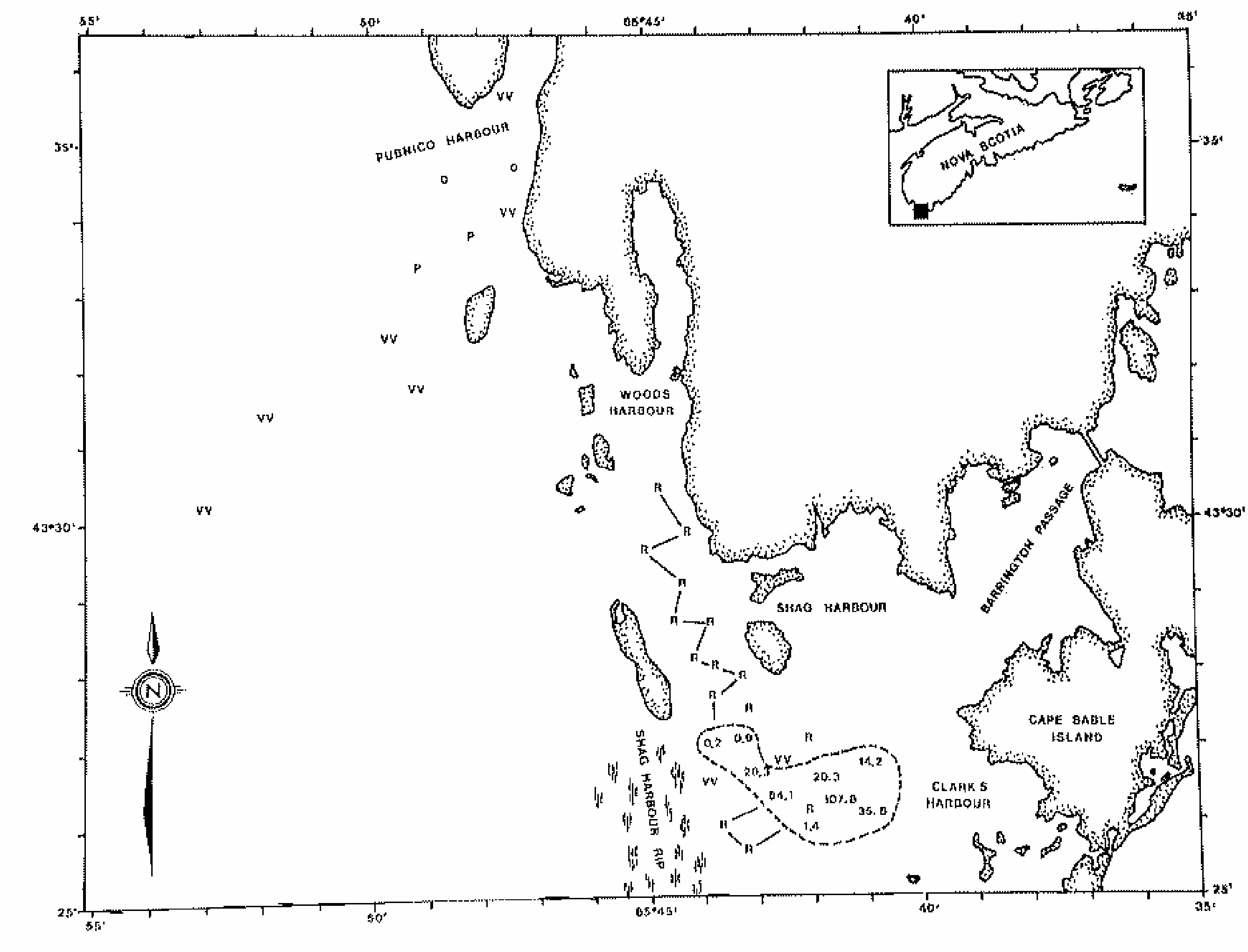

Figure 6. Quahog Densities (no/m^2) off Cape Sable Island

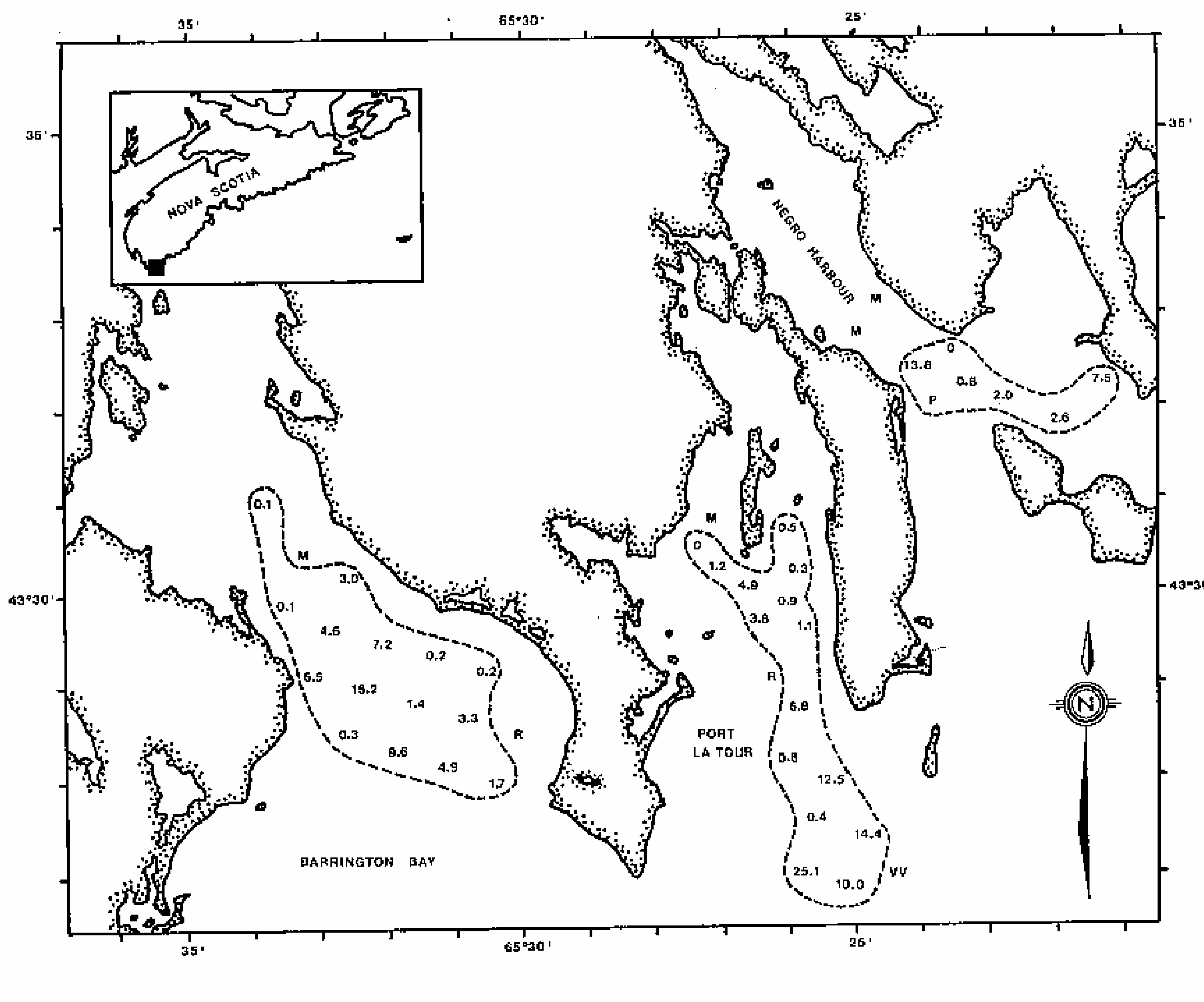

Figure 7. Quahog Densities (no/m^2) in Barrington Bay, Port LaTour and Negro Harbour

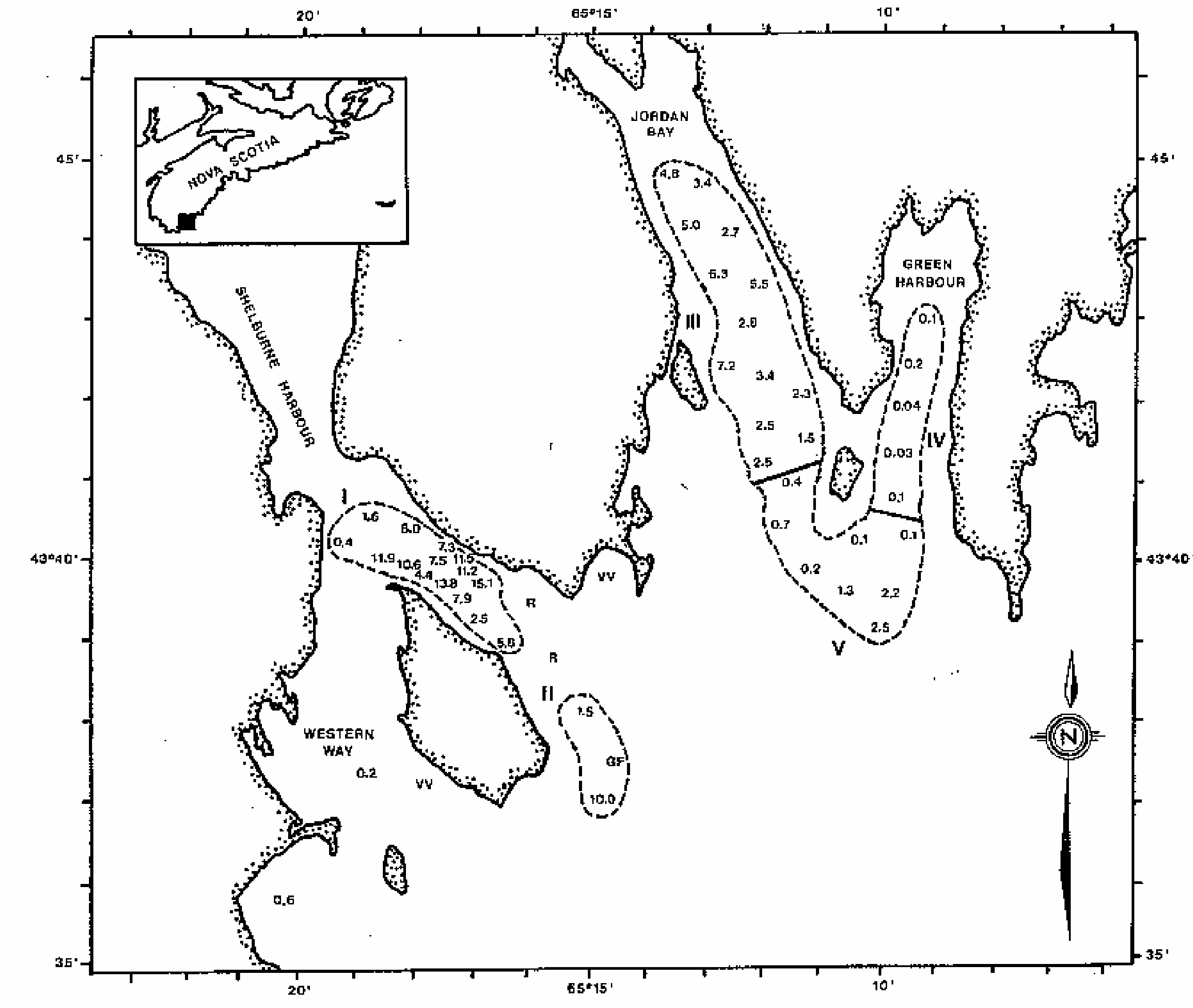

Figure 8. Quahog Densities (no/m^2) in Shelburne Harbour, Jordan Bay and Green Harbour

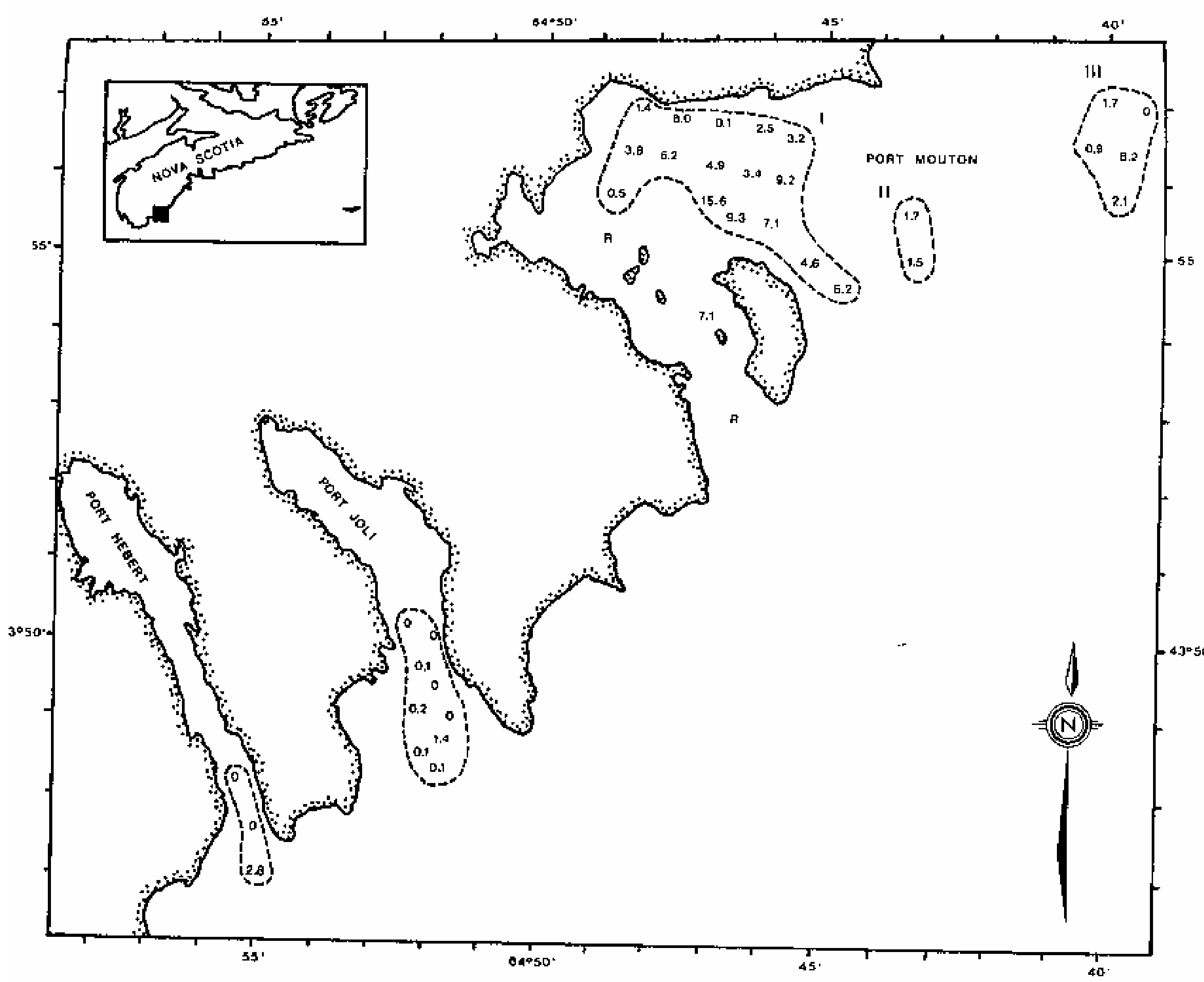

Figure 9. Quahog Densities (no/m^2) in Port Herbert, Port Joli and Port Mouton

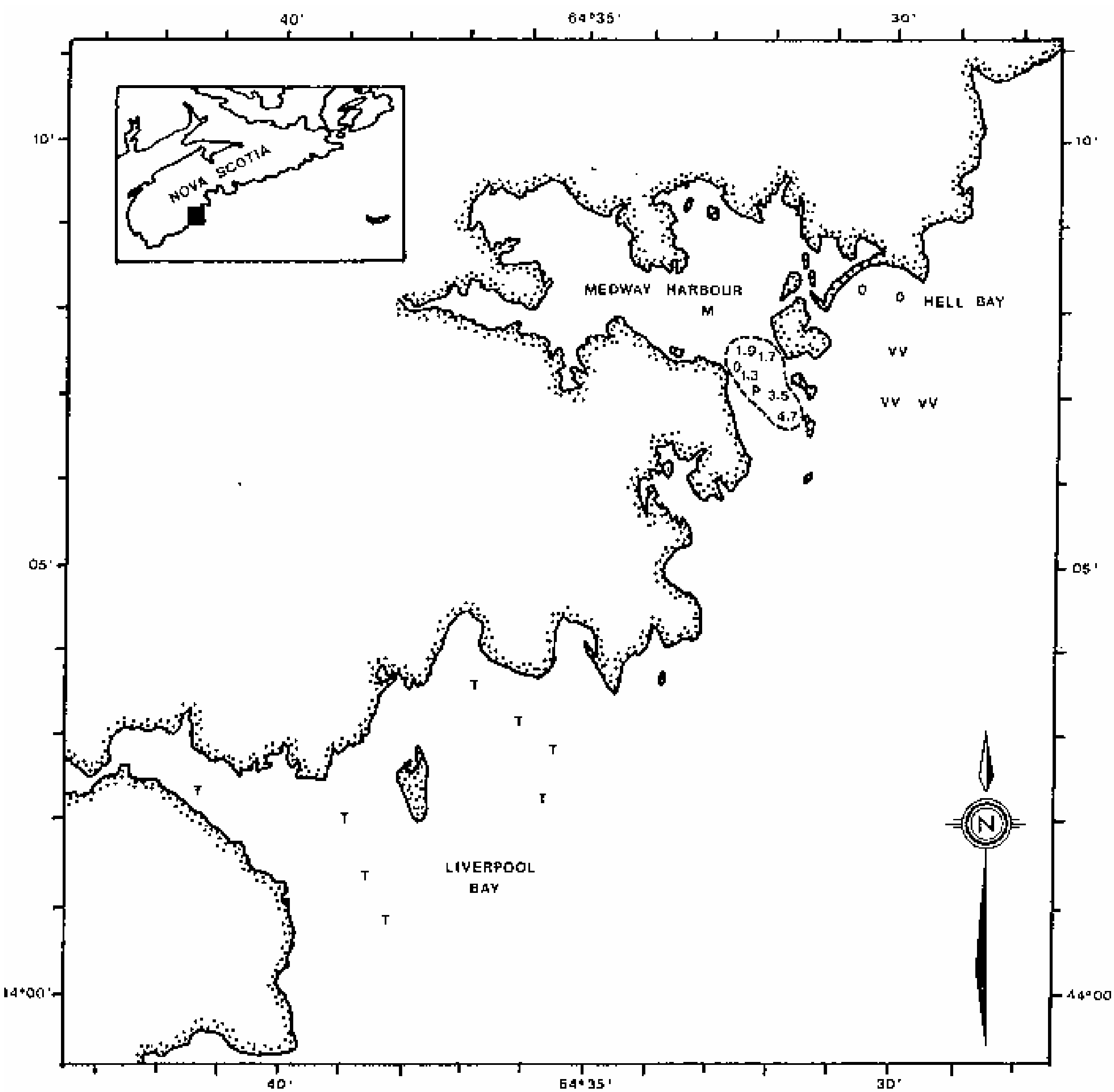

Figure 10. Quahog Densities (no/m^2) from Medway Harbour

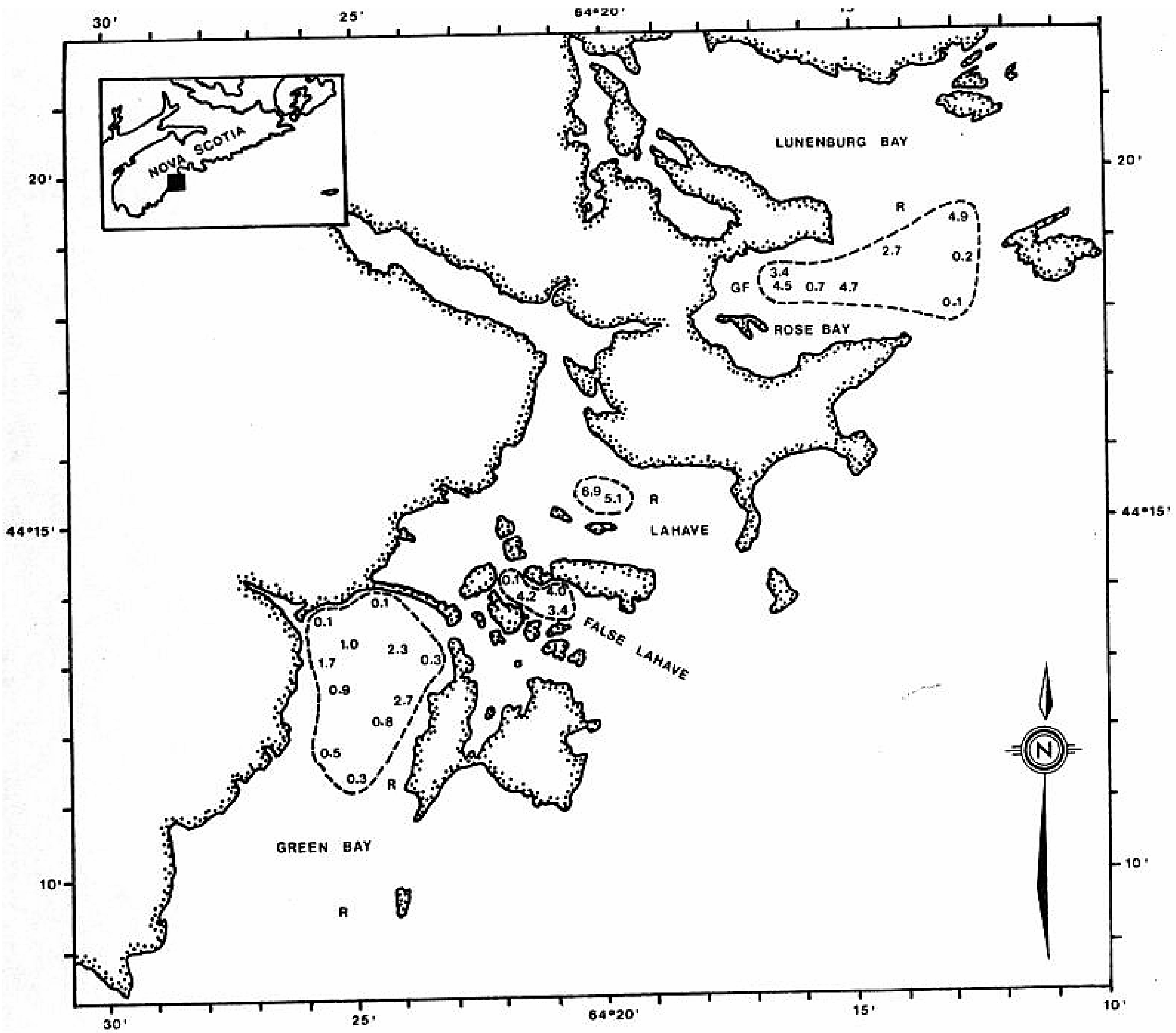

Figure 11. Quahog Densities (no/m^2) in Green Bay, False LaHave, LaHave and Lunenburg Bay

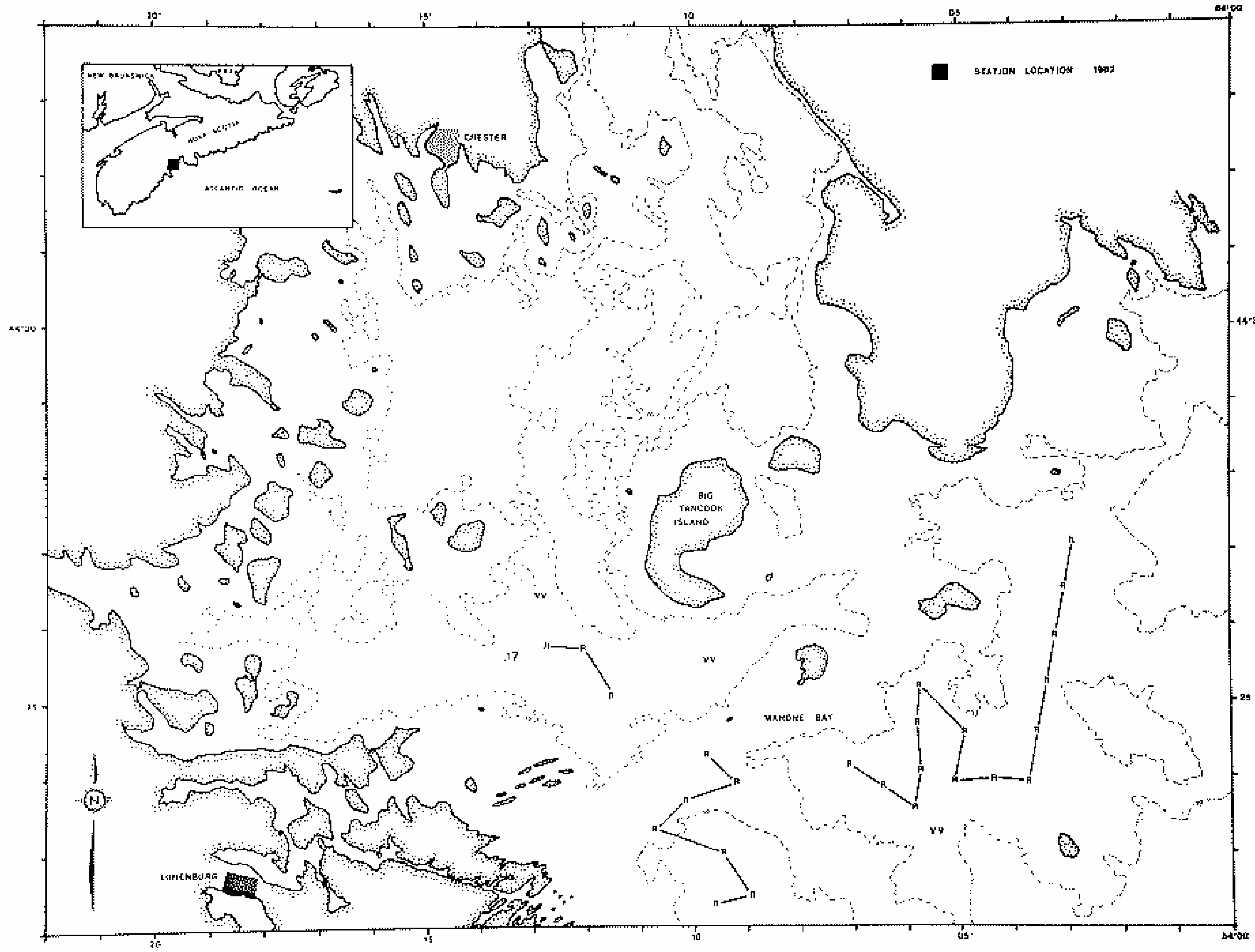

Figure 12. Areas surveyed in Mahone Bay showing station locations and vessel cruise tract

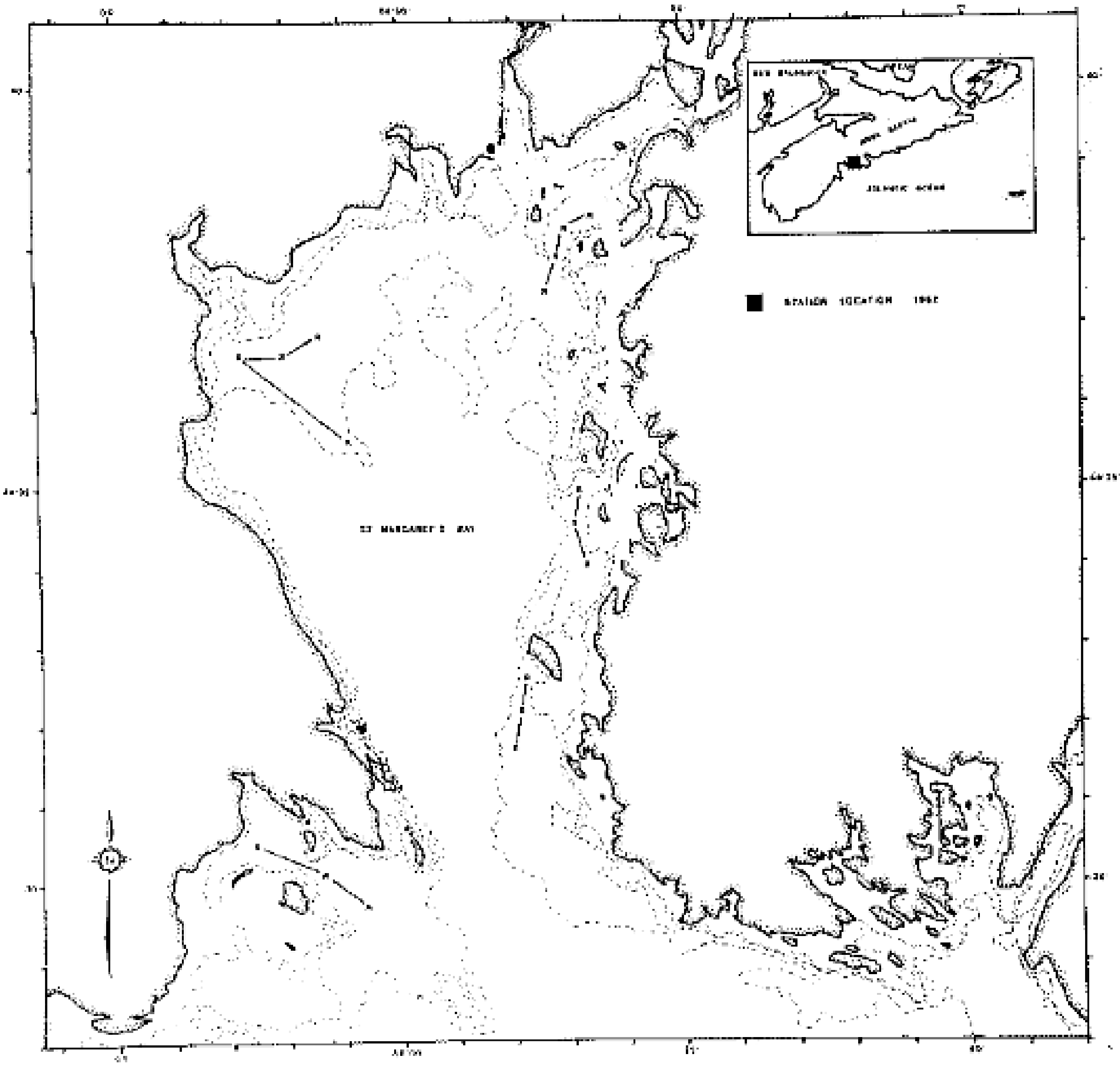

Figure 13. Areas surveyed in St. Margarets Bay

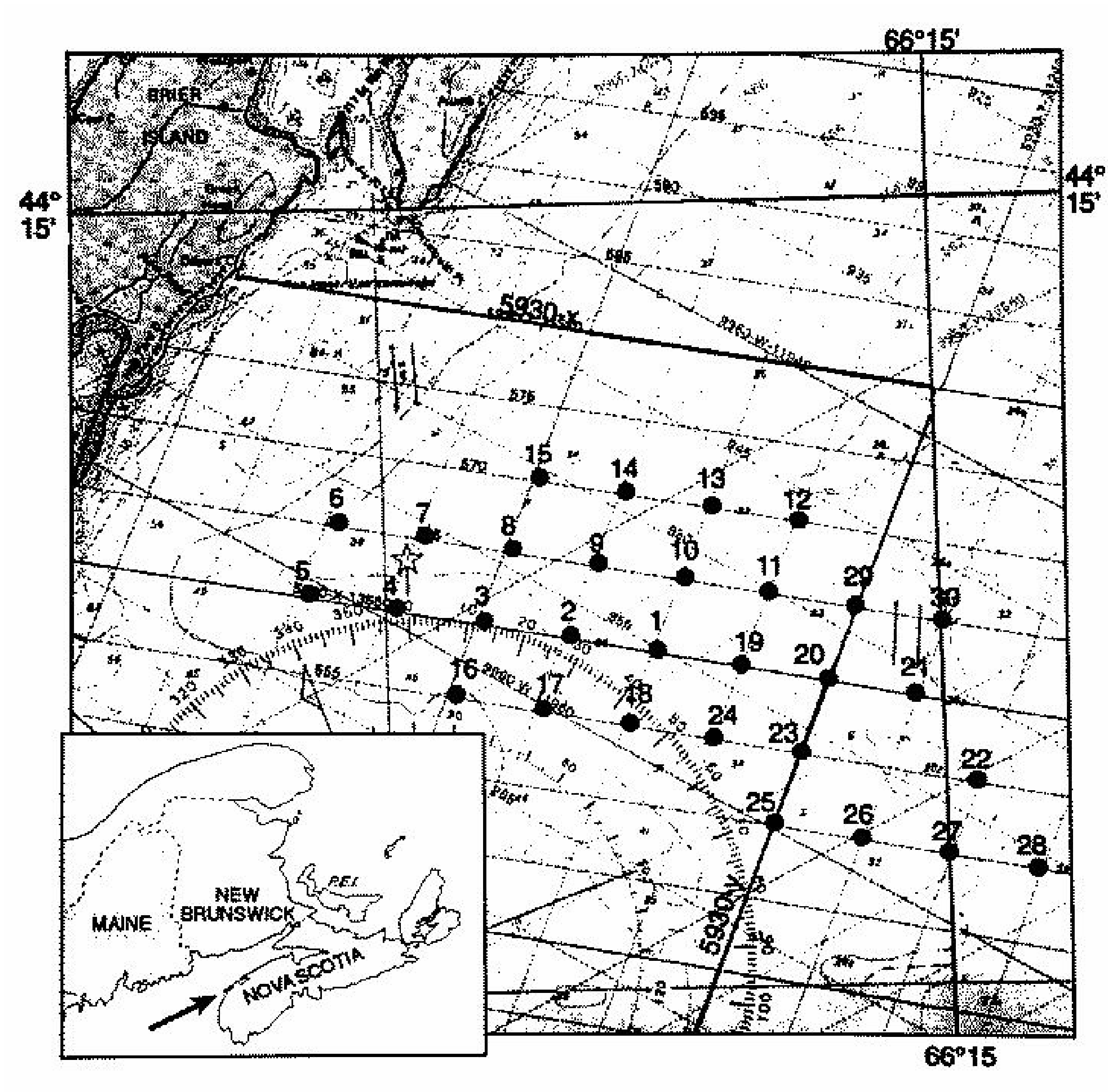

Figure 14. St. Marys Bay Ocean Quahog Survey - location of stations and station numbers

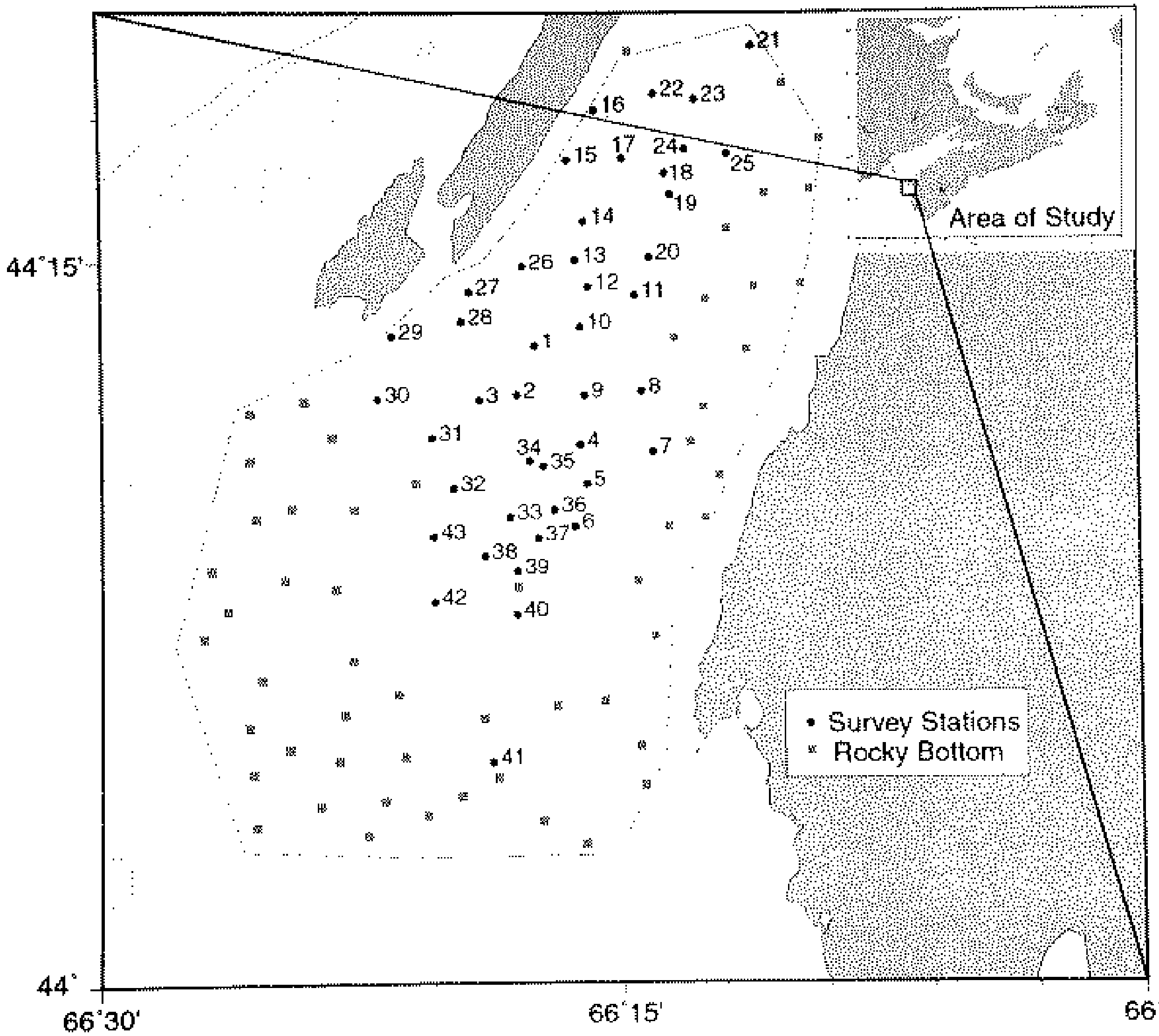

Figure 15. St Marys Bay study area with locations of survey tows and rocky areas