Lobsters and other invertebrates in relation to bottom habitat in the Bras d'Or Lakes: Application of video and SCUBA transects

M. John Tremblay[1], K. Paul[2] and P. Lawton[3]

[1]Fisheries and Oceans Canada
Bedford Institute of Oceanography
P.O. Box 1006 Dartmouth, NS
Canada B2Y 4A2

[2]Eskasoni Fish and Wildlife Commission
4123 Shore Rd
P.O. Box 8097 Eskasoni, NS
Canada B1W 1C2

[3]Fisheries and Oceans Canada
Biological Station
531 Brandy Cove Rd
St. Andrews, NB
Canada E5B 2L9

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LOBSTERS AND OTHER INVERTEBRATES IN RELATION TO BOTTOM HABITAT IN THE BRAS D'OR LAKES: APPLICATION OF VIDEO AND SCUBA TRANSECTS

by

M. John Tremblay[1], K. Paul[2] and P. Lawton[3]

[1]Fisheries and Oceans Canada
Bedford Institute of Oceanography
P.O. Box 1006 Dartmouth, NS
Canada B2Y 4A2

[2]Eskasoni Fish and Wildlife Commission
4123 Shore Rd
P.O. Box 8097 Eskasoni, NS
Canada B1W 1C2

[3]Fisheries and Oceans Canada
Biological Station
531 Brandy Cove Rd
St. Andrews, NB
Canada E5B 2L9

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ABSTRACT

Underwater bottom video and SCUBA transects were used to assess habitat and to measure the density of lobsters (*Homarus americanus*), crabs and other invertebrates in the Bras d'Or Lakes in July and September of 2002 and 2003. A total of 88 video transects were conducted in East Bay, West Bay, the Barra Strait area and the outer Great Bras d'Or (New Campbellton and Cape Dauphin). A total of 50 dive transects were completed in the same areas as the video transects.

Few lobsters and crabs were seen during the video transects. Bottom habitats ranged from low structure bottoms such as mud or sand with sea urchins to moderate structure bottoms (occasional boulders and cobbles on mud or sand) to high structure bottoms (extensive boulders with macrophyte cover). East Bay in particular was dominated by low structure bottom types. West Bay had more of the moderate structure bottoms and Cape Dauphin had the highest proportion of high structure bottom.

The densities of lobsters from dive transects ranged from 0.019 m^{-2} off Cape Dauphin to 0.0005 m^{-2} in East Bay. Rock crab (*Cancer irroratus*) densities were highest in the outer Great Bras d'Or Channel (0.045 m^{-2}) in a commercial rock crab fishing area, followed by Cape Dauphin (0.023 m^{-2}), and were lowest in East Bay (0.002 m^{-2}). Green crab (*Carcinus maenas*) densities were highest off Crammond Islands in West Bay (0.009 m^{-2}) and lowest off East Bay (0.0005 m^{-2}) and Cape Dauphin (none observed).

Quadrat sampling during SCUBA transects provided data on other epibenthic invertebrates. The most abundant group was sea urchins (*Strongylocentrotus droebachiensis*) followed by starfish (*Asterias vulgaris*) and periwinkles (*Littorina* sp.).

Although good lobster habitat appears to be in short supply in Bras d'Or Lake, several areas of good lobster habitat in West Bay had much lower lobster densities than comparable areas outside of Bras d'Or Lakes. As such, factors other than physical habitat alone appear to be limiting the abundance of lobsters in these areas of West Bay. The success of attempts to enhance lobster stocks in Bras d'Or Lakes will depend on understanding what the key limiting factors are.

RÉSUMÉ

On a eu recours au balayage de transects du fond sous-marin par caméra vidéo et par plongeurs autonomes pour évaluer l'habitat du homard (*Homarus americanus*), des crabes et autres invertébrés dans le lac Bras d'Or ainsi que pour y mesurer la densité de ces animaux en juillet et septembre 2002 et 2003. En tout, 88 transects ont été balayés par caméra vidéo dans le secteur de la baie East, de la baie West, du détroit de Barra et des approches du Grand Bras d'Or (New Campbellton et Cape Dauphin). Dans le même secteur, les plongeurs ont balayé un total de 50 transects.

Durant les opérations de relevé par caméra vidéo, peu de homards et de crabes ont été observés. L'habitat du fond variait, allant de fonds à basse structure de vase ou de sable garnie d'oursins à des fonds de moyenne structure (blocs rocheux et galets occasionnels sur de la vase ou du sable) et à d'autres de haute structure (vastes blocs rocheux recouverts de macrophytes).Dans la baie East, en particulier, les habitats de basse structure dominaient, tandis que dans la baie West on trouvait davantage de moyennes structures et que c'est alentour de Cape Dauphin que les fonds à haute structure étaient les plus nombreux.

Les densités de homard mesurées sur les transects de plongée se situaient entre 0,019 m^{-2} au large de Cape Dauphin et 0,0005 m^{-2} dans la baie East. Le crabe commun (*Cancer irroratus*) était le plus dense dans une zone de pêche commerciale de ce crabe située dans les approches du chenal du Grand Bras d'Or (0,045 m^{-2}), puis dans la région du Cape Dauphin (0,023 m^{-2}); c'est dans la baie East qu'elles étaient les plus basses (0,002 m^{-2}). Quant aux densités de crabe vert (*Carcinus maenas*), elles étaient les plus fortes au large des îles Crammond, dans la baie West (0,009 m^{-2}) et les plus basses au large de la baie East (0,0005 m^{-2}) ainsi qu'à Cape Dauphin (aucun crabe observé).

Un échantillonnage par quadrats pendant les relevés en plongée a permis d'obtenir des données sur d'autres invertébrés benthiques. Les plus nombreux étaient les oursins (*Strongylocentrotus droebachiensis*), suivis des étoiles de mer (*Asterias vulgaris*) et des bigorneaux (*Littorina* sp.).

Bien que l'habitat favorable au homard soit apparemment peu abondant dans le lac Bras d'Or, les densités de homard dans plusieurs secteurs offrant un bon habitat pour ce crustacé dans la baie West étaient bien inférieures à celles qui ont été observées dans des endroits comparables hors du lac Bras d'Or. Il en ressort que des facteurs autres que l'habitat physique à lui seul semblent limiter l'abondance des homards dans ces parties de la baie West. La réussite des tentatives de mise en valeur des stocks de homard du lac Bras d'Or dépendra de notre connaissance des plus déterminants de ces facteurs limitatifs.

INTRODUCTION

Landings of lobsters (*Homarus americanus*) in Bras d'Or Lake have been low compared to adjacent areas of the outer coast of Cape Breton (e.g. LFA 27, and 29) for some time (Figs. 1 and 2). Landings statistics for Bras d'Or Lake as a separate unit (LFA 28) are available only from 1988 onwards but lobster fishing has a long history in the Lakes (Appendix I). Traditional knowledge of First Nations peoples and other long-time residents indicates that lobsters were more abundant in the Lakes in the past but this is not well documented. Historical landings would help quantify the change in abundance but these records do not exist.

Lobsters in Bras d'Or Lake may be limited by insufficient habitat, food, sub-optimal environmental conditions (e.g. low salinity), or egg production that is insufficient to provide enough recruits to the bottom. In support of a sustainable lobster fishery, and to explore possible lobster enhancement projects, a better understanding of what is limiting lobster production in the Lake is needed.

This report focuses on an assessment of the current availability of lobster habitat within the Lakes. It is the result of Joint Project Agreements in 2002 and 2003 between the Eskasoni Fish and Wildlife Commission and the Department of Fisheries and Oceans. The overall objective was to develop and apply bottom video and SCUBA methodologies for assessing habitat and measuring the density of lobsters, crabs and other invertebrates in the Bras d'Or Lakes.

METHODS

In both 2002 and 2003 field work was undertaken in July and September. Most video transects were completed in July, while all SCUBA transects were done in September. All video and SCUBA transects were completed in daylight.

VIDEO SURVEYS

A surface-deployed underwater video system ("URCHIN" - Strong and Lawton 2004) was used to assess bottom habitat (Fig. 3). URCHIN's surface equipment package includes a monitor for real-time viewing, GIS (geographic information system) software to track the precise location of the vessel through GPS (Global Positioning System), and automatic recording of location information to a computer file. The video image was recorded on mini-DV format video tape using a Sony Digital Camera recorder (Handicam). The fixed focal length black and white underwater camera had high resolution and low light capability (525 lines @ 60 hz and light sensitivity of 0.03 lux) reducing the need for auxiliary lights that can cause backscatter (a 250-watt floodlight was available for use in very dark conditions). To provide a size reference on the bottom, two laser lights were fixed to the tripod so that the beams were 25 cm apart.

We used the Eskasoni fishing vessels Pie'lalo or Nancy Lenore as the platforms for conducting the video surveys. The underwater video camera was mounted on a light tripod frame and was easily deployed. Video transects were conducted in a "controlled drift" mode. The camera and frame were deployed over the side and the skipper used the currents and winds together with the vessels power to take the vessel in a pre-determined direction in a more or less straight line. When the tripod was near the bottom an operator monitored its position in relation to the bottom on a video screen and manually raised and lowered the tripod as it drifted over the bottom with the vessel. The skipper attempted to keep the vessel speed to less than one knot.

The URCHIN system provided a software utility (Class-Event software) that enabled geo-referenced observations to be recorded during the survey operations. Two file types were created: one for habitat, the other for observed events. When the camera tripod initially touched bottom, the operator selected the habitat type by hitting the appropriate key on a keypad. This habitat type was then automatically written to a habitat file every 2 seconds until the next habitat key assignment was made when the habitat type changed. Habitat types available for selection were: Mud, Sand, Gravel (< 6 cm diameter), Cobble (6-25 cm), Boulder (> 25 cm), and Macrophytes. The event file allowed for particular organisms (lobsters and crabs for example), or habitat features to be recorded as they occurred. For each record in both files the time and location (latitude and longitude) were recorded.

In addition to the above data, temperature and depth profiles were recorded for each video transect using a self-contained data-logging unit (VEMCO TDR minilog) which was attached to the camera frame. The temperature and depth data were set to record every 15 seconds, and were downloaded from the minilog at the end of each day.

DIVE TRANSECTS

Diving survey operations were conducted using a smaller DFO skiff to tend the divers and the Pie'lalo as a platform for tanks and other equipment. Transect lines 150 m in length were deployed from the skiff. The lines were marked in 5 m intervals. Two divers then swam either side of the transect line, counting lobsters and crabs within 2 m of the transect line (total transect width = 4 m). The exception was Cape Dauphin where transects were narrower (2 m wide in total) because of the more complex bottom type. All lobsters and crabs found within the width of the transect were measured and sexed. Undercounting of lobsters and crabs due to behavioral avoidance of divers is thought to have been minimal since few crustaceans were seen moving away, and the habitat was for the most part highly searchable. In addition to lobster and crab counts, habitat type and the presence of other fauna were recorded qualitatively on underwater dive slates.

QUADRAT SAMPLES

In 2003 only, divers deployed 0.25m^2 quadrats every 10 m along the transect line and counted and recorded major taxa larger than about 5 mm. The quadrats were placed in the same orientation on the marks of the transect line.

RESULTS

VIDEO AND DIVE TRANSECTS

A total of 29 video transects were conducted in 2002, representing a total coverage of about 25 km. Transects were 0.3-1.6 km in length. The areas surveyed were East Bay, North of Barra Strait including Washabuck, and the outer Great Bras d'Or (Fig. 4, Table 1). Transects were run to depths as great as 48 m (156') and frequently to depths of 25 m. Transect widths were generally 0.5-1m, depending on the distance of URCHIN from the bottom. In 2003 a total of 59 video transects were completed representing about 46 km. All were in the western half of Bras d'Or Lake, mainly in West Bay (Fig. 4, Table 2). To better sample lobster habitat, transects were restricted to shallower depths than in 2002, usually less than 20 m.

A total of 18 dive transects were completed in 2002 and 32 in 2003 (Fig. 5, Tables 3, 4). The areas surveyed reflected where the video transects were done in each year and where possible the dive transects were done in the same locations as the video transects. This practice was limited by depth since no dive transects were deeper than 19 m with most less than 14 m.

OBSERVATIONS OF LOBSTERS AND CRABS IN VIDEOS

We saw few lobsters with URCHIN (5 in total) along the approximately 71 km length of sea bottom traversed with the system. Three lobsters were apparent from the video transects in 2002: one on the south side of East Bay (Middle Cape), one north of Barra Strait (off Washabuck) and one just south of Barra Strait (off Hectors Point). Just two lobsters were seen in the video transects in 2003: both were found on a single transect (transect no. 30, Table 2). There were some parts of transects in virtually all areas where boulders occurred that appeared to be capable of providing reasonably good shelter for lobsters. In several sites in West Bay what appeared to be lobster excavations were present. In areas where mussels were attached to the boulders food appeared to be available, not only from the mussels but also from organisms we might expect to be associated with the mussels e.g. small crustaceans and snails.

Crabs were more numerous than lobsters but were also not seen in abundance except on the video transects in the outer Great Bras d'Or. In the outer Great Bras d'Or Channel, off New Campbellton we saw numerous rock crabs (*Cancer irroratus*) and the video system would be an excellent tool to count them. They were often partially buried but the tops of the carapace were visible. Off Cape Dauphin no lobsters or rock crab were observed. The bottom there was much rougher than other areas however, and dive transects showed them to be present (see below).

OVERVIEW OF HABITATS AND MAJOR FAUNA

Details of the video transects (locations, times and depths), along with a summary of notes made when viewing the videos in real time are provided in Tables 1 and 2. Habitat type varied with area and depth, and ranged from flat, featureless mud to sandy mud, to gravel-cobble, to cobbles and boulders. In shallow depths (< 6 m) there was eelgrass (*Zostera marina*) at more protected sites, and kelp (*Laminaria* sp.) and/or Irish moss (*Chondrus crispus*) at more open sites. A fine layer of silt was present on many transects from East Bay to Washabuck. Kelp (often drift kelp) was observed at depths up to 16 m in some areas.

Echinoderms were the dominant epifaunal group in Bras d'Or Lake. Sea urchins (*Strongylocentrotus droebachiensis*) on mud and or sand ("sea urchin flats") were most characteristic of depths greater than about 16 m. Many of the sea urchins were small (< 2-3 cm in diameter). Starfish (mainly *Asterias vulgaris*) were also common, while sand dollars (*Echinarachnius parma)* were more limited in distribution. Fish seen during the videos included flounders on mud and sand, cunners near reef areas, and an occasional cod.

Transects in East Bay area were dominated by sandy-mud and mud bottoms, but there were patches of cobbles and some isolated boulders. An exception was a video transect off Benacadie where cobble and boulders were present at 25 m. In general there appeared to be more cobble-boulder habitat in West Bay than in East Bay. There were patches of habitats associated with the islands where lobster habitat appeared reasonably good in West Bay. Hectors Point (just south of Barra St.) had some well-developed shell beds (likely quahogs) at about 16 m and some areas of kelp. Off Washabuck there was a narrow fringe of cobbles and some boulders in sandy-mud at depths less than about 12 m. In the outer Great Bras d'Or Channel, off New Campbellton the bottom was flat sandy-mud to mud in the area where rock crab were abundant. Off Cape Dauphin the bottom was considerably rougher with a mix of boulders, and cobbles on sand, offering many shelters for lobsters and crabs.

Bottom habitats observed in Bras d'Or Lakes can be characterized by the degree of physical structure and characteristic fauna or flora as follows.

1. Low structure
    a. Muddy-sand to mud with small urchins – usually deeper than 9 m, examples everywhere but frequent in East Bay
    b. Sand sometimes sand waves, sand dollars
    c. Mud or sand with worms or worm mounds evident

2. Moderate structure – boulders scattered or patchy
    a. Gravel-cobble-sand with periwinkles (*Littorina* sp.) on rocks– usually < 6-7 m
    b. Sand-boulders
    c. Cobble-boulder deep

3. High structure – boulders common
    a. Cobble-boulder with kelp or Irish Moss, typically with cunners – shallow < 9 m
    b. Cobble boulder deep e.g. off Benacadie Point
    c. Kelp, Irish moss

To provide examples of the above bottom types frame grabs were obtained from the video footage. Examples of low structure bottoms are shown in Fig. 6. These range from mud, to sand to gravel. Lobsters and crabs were rare but were generally seen on these types of bottom, probably because boulders and macrophytes did not obscure them. Examples of moderate structure bottom are shown in Fig. 7. These consist primarily of cobble–boulder habitats in sand or mud. Excavations likely made by lobsters are apparent in several of the images. High structure bottoms (Fig. 8) were those that had different sizes of cobbles and boulders as well as macrophytes. The best examples of this bottom type were off Cape Dauphin, but there were examples within Bras d'Or Lake as well.

QUANTIFYING HABITAT CLASSES FROM HABITAT FILES

Mud and sand were not always easy to distinguish but if the tripod sank in to the bottom, or there were clouds of suspended sediment created when the bottom was touched, the bottom type was classified as mud. Mixes of mud and sand were more of a challenge to characterize. The gravel, cobble, boulder classes were distinguished by size. Where there were mixes of these sediment classes, the operator chose the one that was most characteristic.

The percent of bottom with the different sediment classes is shown for different areas in 2002 (Table 5) and 2003 (Table 6). These percentages should be interpreted as the percentage of the transects where the sediment was present, rather than the area actually covered by the sediment class. For example on some transects boulders may have covered < 20% of some segments of the transect, but habitat was classified as boulder for at least part of these segments.

A plot of the percentage cover of boulders and cobble combined shows that East Bay had a lower percentage of this type of bottom than West Bay or Cape Dauphin (Fig. 9).

TEMPERATURE PROFILES

Temperature and depth data from the temperature-depth logger attached to the underwater video are shown in Figs. 10 and 11. Most of the data are from when the unit was on bottom. As the unit was moved through the water column, the temperature data are to some extent "smeared" because of time delays in equilibrating to a new temperature. For example if the unit was lowered from 0 m to 10 m in 10 seconds and the temperature was 18 °C at the surface and 12 °C at 10 m, the Vemco sensors would indicate the temperature at 6 m was several degrees higher than it actually was. This problem was most evident in the upper 5 m, which was usually less than the depth of the bottom and thus the unit was just lowered or retrieved through these depths. For depths > 5 m, the video unit was usually on bottom long enough to stabilize and get an accurate temperature.

In July 2002 bottom temperatures in the Barra Strait area (Fig. 10b) were above 10 °C even at 45 m. This contrasts with the shallower thermocline in East Bay where temperatures ranged from about 7 °C at 20 m to 19 °C at 5 m (Fig. 11). This difference likely results from greater vertical mixing in the Barra Strait area.

The three lobsters seen with the video system in 2002 were found at 11 m, 12 m, and 15 m. One of these lobsters is shown in Fig. 6G. Temperatures at these depths were 15-16 °C.

In 2003 a controlled temperature profile was completed in West Bay (Crammond Islands area) to allow the temperature sensor to adjust as it was moved down through the water column (Fig. 11a). The unit was lowered in 1 m intervals, maintaining it at the new depth for at least 10 seconds. The resultant profile and another close by (Fig. 11b) indicated a shallow and steep thermocline, with temperatures as low as 3.7 °C at 15 m.

The two lobsters seen in the videos in 2003 (Fig. 6F and 7F) were found at 9.7 m and 8.2 m Temperature at these depths was 7.6 °C and 10.6°C.

OBSERVATIONS OF LOBSTERS AND CRABS DURING DIVE TRANSECTS

Substantially more lobsters and crabs were observed during the dive operations than during the videos. This was expected since during the dive transects we were able to move cobbles and some boulders, and to look underneath larger boulders. Macrophytes could also be pushed aside. Although the precise habitat information was not recorded for each lobster and crab, most lobsters were found amongst boulder type habitat, while rock and green crab (*Carcinus maenas*) tended to be found on mixes of mud or sand with gravel and cobble.

Total counts of lobsters, rock crabs and green crabs by transect and by area are shown in Table 7 (2002) and Table 8 (2003). Other lobsters and crabs were seen beyond the transect width; these are not included here.

Mean densities (no. per m^2) by area are shown in Table 9. Lobster densities off Cape Dauphin were more than 35 times those of East Bay. The size of lobsters off Cape Dauphin ranged from 40-109 mm CL, with about equal numbers of males and females (Fig. 12). Within the whole of East Bay and off Washabuck (11 transects) the five lobsters measured ranged from 60-139 mm CL. In West Bay in 2003 (all dive transects combined), lobsters ranged from less than 20 mm CL to 130-139 mm CL (Fig. 12). The two smallest lobsters (15 and 28 mm CL) were observed in the Crammond Islands area. In 2003, females outnumbered males by almost 2:1, and half of the females had eggs.

Rock crab densities (no. per m^2) were highest off New Campbellton, a commercial rock crab fishing area (0.045), followed by Cape Dauphin (0.023) and Washabuck (0.010) (Table 9). Lowest densities (less than $1/20^{th}$ those off New Campbellton) were in East Bay (0.002). A wide size range of rock crab were present in most areas (Fig. 13). The Cape Dauphin area had decidedly smaller rock crab than the New Campbellton area. Males greatly outnumbered females at all sites (e.g. 2.3 males for every female off New Campbellton, and 2.5 males for every female during the 2003 transects). Rock crab females with eggs were rare (West Bay) or unobserved (other areas in Fig. 13).

Green crab densities (no. per m^2) were highest off Crammond Islands (0.009), followed by Malagawatch (0.003). East Bay (0.0005) and Cape Dauphin had the lowest measured densities (Table 9). Green crab mean density in the Crammond Islands area was about 17 times that in East Bay. Too few green crab were measured in 2002 to present meaningful size frequencies. In 2003 in West Bay, green crab ranged from less than 20 mm CW to 70-79 mm carapace width (Fig. 14). As for rock crab, the sex ratio was male biased, with 2.3 males for every female.

Within the depth range covered by the dive transects, the highest percentage of lobsters was found from 6-9 m (20-29') (Fig. 15). The percentage of rock crab found was about the same from 3-9 m (10-29') and then diminished at greater depths, while the highest percentage of green crab was found from 3-6 m (10-19').

OCCURRENCE AND DENSITY OF MAJOR EPIBENTHIC TAXA DURING 2003 TRANSECTS AND DIVE QUADRATS

A total of 32 taxa were recorded during dive operations in 2003 (Table 10). Some of these were recorded to the taxonomic level of species while others were recorded at coarser taxonomic levels e.g. worms, bryozoans, sponge). Starfish and rock crab were the most common taxa on the transects, with starfish observed on every transect and rock crab on all but 3 transects.

Within the quadrats, sea urchins had the highest densities, followed by starfish, periwinkles, anemones, worms and mussels (*Mytilus* sp.) (Fig. 16). Starfish and urchins were the most ubiquitous taxa in the quadrats (Fig. 17).

The depth distribution of these taxa showed some clear patterns when compared with the depth distribution of all quadrats (Fig. 18). Most urchins for example were in the deeper quadrats (9-12 m or 30-40'), as were anemones (11-14 m or 35-45'). Periwinkles were restricted to shallower quadrats (8 m and less). Starfish were found everywhere so their depth distribution mirrored that of all quadrats. Mussels were found mainly at depths < 9 m.

DISCUSSION

This study successfully developed methods for assessing habitat and estimating densities of lobsters, crabs and other epibenthic organisms in the Bras d'Or Lakes system. It is clear that Bras d'Or Lake has substantially lower densities of lobsters and rock crabs than can be found at the mouth of the Great Bras d'Or Channel. The dive based estimates of density correspond to trap catch rates which were considerably higher off Cape Dauphin and in the Great Bras d'Or Channel than in Bras d'Or Lake (Tremblay 2002). Within Bras d'Or Lake, there is good evidence that West Bay has higher concentrations of lobsters and crabs than East Bay. Before discussing this data further, we review our methods.

METHODS

The URCHIN underwater video system worked well in Bras d'Or Lakes. It was portable and easy to deploy from the two vessels used. Although lobsters and to some extent crabs were underestimated in the videos, this was expected given the affinities of lobsters for shelter. It is important to note that URCHIN has been used on more productive lobster bottoms (e.g. Lobster Bay, Nova Scotia) and numerous lobsters were apparent on unstructured bottoms of mud and sand in the summer.

The geo-referenced files were indispensable in the later analysis. They provide a record of where the vessel was at each point during the transects. Temperature data can then be matched with the positional information.

Similar to other systems of this type, there is an operator effect related to the classification of bottom types in the URCHIN system, particularly when the analysis relies solely on the real-time classification of bottom types during the field survey activity. The operator effect has 3 aspects:

i. Prior training in habitat classification and concurrence between operator designations;
ii. classifying whether a particular bottom type is mud, sand, gravel, cobble or boulder assuming it is uniform;
iii. classifying non-uniform and patchy bottoms. Bottom types were often mixed, and often patchy on the scale of 10's of metres.

Initial transects were used for training and the operator effect was minimized by having a rotation of 3 individuals classifying habitat and usually 2 individuals conferred on classification in real-time. No comparisons were made between different operators.

Distinguishing sand from mud was not too difficult (dropping the frame onto the bottom and observing how much it sank was one measure) but there were often gradations (sandy mud to muddy sand, silt) that different observers might classify differently. Distinguishing boulders from cobble was objective because a size criterion was used and the laser lights provided a reference. There were no objective criteria for distinguishing whether a given patch of bottom that had for example 20% boulder cover, 20% gravel and 60% sand was best characterized as boulder or sand or gravel. Typically the operator would alternate between the above substrates when passing over such an area so that the mix of types was recorded. As indicated in the Results, the percentages should be interpreted as indicating the percentage of the transect where a particular sediment class was present, rather than a quantification of the actual area of the transect covered by the particular sediment class.

Post-processing of the video footage permits the operator to move back and forth through the video record, and thus permits a more complete assessment of non-uniform and patchy bottoms. No post-processing of the video transects is available for the present report.

From the perspective of survey methodology, the video and dive survey locations were chosen haphazardly rather than randomly. They were selected based on a combination of local knowledge and expectations of where lobsters would be found. Survey intensity varied by area, being highest in West Bay.

The dive surveys provided more meaningful density estimates of lobsters, crabs and associated fauna than the video surveys. Depth was a limiting factor with the dive transects, with just one dive transect to 19 m and most less than 14 m but in summer most lobsters in coastal waters are found at temperatures above 10 °C. Reproductive female lobsters off Canso move to shallower, warmer (10-15 °C) waters in spring and early summer. Ugarte (1994) hypothesized this movement was to gain a thermal advantage in the rate of egg maturation in warmer waters. Lobsters ready to settle to the bottom are thought to choose depths above the seasonal thermocline (Boudreau et al. 1992). In the current study it is likely that most lobsters were shallower than 15 m since bottom temperatures decreased rapidly around this depth (July 2003, Fig. 11a, c,d,e) or were well below 10 °C (July and Sept 2003, Fig. 11). The exception to this could be in the well-mixed area of Barra Strait where warmer waters (> 12 °C) extended to 30 m depth in July 2002 (Fig. 11b).

FACTORS LIMITING THE PRODUCTION OF LOBSTERS IN BRAS D'OR LAKES

Four potential limiting factors for lobsters in the Bras d'Or Lakes are discussed in Tremblay 2002. These are (i) marginal salinities, (ii) limited bottom habitat, (iii) low food availability and (iv) insufficient egg production. The present report bears most on the question of habitat.

Habitat as a potential limiting factor

Lobsters are found on a wide variety of habitats. Inshore populations of juvenile, adolescent and adult lobsters are found on mud, cobble, bedrock, peat reefs, eelgrass beds and within sandy depressions (Lawton and Lavalli 1995 and references therein). Juveniles require shelter of some kind and are principally found among cobble, rocks on sand and peat reefs (Lawton and Lavalli 1995 and references therein). Sand substrate with overlying rocks and boulders is the most common habitat (Cooper and Uzmann 1980).

Boulder type habitat was not dominant anywhere in Bras d'Or Lake and was least common in East Bay. In West Bay, boulders and or cobbles were often present on 30% or more of individual video transects. Within this 30%, the bottom cover could vary from scattered boulders or cobble in mud, sand or gravel, to small patches of bottom with extensive boulder-cobble cover, to extensive boulder-cobble bottom.

In comparison to other areas with similar bottom types, the cobble-boulder habitat in West Bay had much lower lobster densities. Moderate structure bottoms similar to those shown in Fig. 7 had much higher densities in Lobster Bay, Nova Scotia (Tremblay and Smith, 2001). Mud dominated bottoms in Lobster Bay had a mean of 14 lobsters per 300 m^2 in June, and 15 per 300 m^2 in September. Moderate boulder bottoms in the same area had 25 lobsters per 300 m^2 in both July and Sept. These mean densities are 4-8 times the densities measured on the highest density transect in West Bay (7 lobsters in 600 m^2). As such, the physical structure of the bottom habitat in West Bay does not appear to be limiting the abundance of lobsters.

To further quantify lobster habitat within Bras d'Or Lakes, it may be possible to use bottom maps of sediment type created by Natural Resources Canada from multibeam surveys as proxies for lobster habitat down to depths of 10-20 m. For shallower areas other types of bottom mapping are needed. Even without further work, it appears that in Bras d'Or Lake not only is the availability of good lobster habitat low, but the good lobster habitat that is available is under-saturated with lobsters. This under saturation could be related to a number of other factors.

Other potential limiting factors

This study does not address the question of whether low salinity is a limiting factor. Suffice to say that in laboratory studies of lobsters from other areas, lobster larvae did not survive well at salinities of 20 ppt and below. Lobsters within Bras d'Or Lakes, where salinities are generally 20 to 25 ppt may well be adapted to the low salinities, but this has not been tested.

With regard to food availability, one large difference between Lobster Bay and Bras d'Or Lake is the inherent productivity. In Lobster Bay tides are several metres and tidal currents can be quite strong. As such nutrients are recycled more rapidly and the bottom generally has a lot more flora and fauna than is seen in the Lakes. The current study presents some data on potential prey items for lobsters in Bras d'Or Lake. Rock crab are likely very important to the diet of lobsters in the Lakes as they are elsewhere (Gendron et al. 2001), but other potential food items for lobsters in the Lakes are bivalves (mussels, quahogs), gastropods (periwinkles) hermit crabs and worms (Sainte-Marie and Chabot 2002). With the limited sampling, this study cannot realistically compare the availability of these prey items in Bras d'Or Lake relative to other areas.

With regard to the issue of egg production as a potential limiting factor, the current study found that the Bras d'Or Lake has a higher proportion of female than male lobsters, and that a high percentage of these females have eggs compared to females outside the Lakes e.g. off Cape Dauphin. This has also been seen in the trap catch of lobsters in Bras d'Or Lake (Tremblay 2002). The overall production of larvae is likely low because of the low density of lobsters, but on a per lobster basis, larval production is likely higher in Bras d'Or Lake than on the outer coast.

POSSIBILITIES FOR LOBSTER ENHANCEMENT

Any efforts to enhance lobsters in Bras d'Or Lakes must grapple with the likelihood that several factors may limit current lobster production in the Lakes. We assume that traditional knowledge is meaningful and that lobster abundance was at higher levels within the Lakes in previous years. As such even if low salinities or low food prevent lobsters within the Lakes from reaching the levels seen on the outer coast, it may still be possible to increase lobster abundance in the Lakes above current levels. Adding lobster habitat in the form of concrete blocks or natural boulders may contribute to increased lobster biomass in some areas (e.g. East Bay) but would not likely help in West Bay. If pilot studies of this type of enhancement are undertaken it will be important to quantify habitat before and after and to monitor lobsters of all sizes in and adjacent

to the new habitat. If there is no increase in juvenile lobsters in the new habitat, it is doubtful that any enhancement will have taken place.
There may well be insufficient egg production within Bras d'Or Lakes. If so then adding habitat alone may not be sufficient. The addition of hatchery produced juveniles of a suitable size to appropriate habitats in Bras d'Or Lakes would be worth doing on an experimental basis. Such an experiment would need accurate estimates of the abundance of all sizes of lobsters before and after the addition of hatchery produced juveniles.

ROCK CRAB, GREEN CRAB AND OTHER EPIBENTHIC INVERTEBRATES

Estimated densities from dive transects of rock crab were higher than those of green crab in all areas (Table 9). This is likely related to the habitats we chose which were deeper and less protected than where we might expect green crab to dominate. The finding of higher densities of green crab in West Bay than in East Bay corroborates the trap catch rates estimated from a green crab survey in 1999-2000 (K. Paul, unpublished data; Tremblay 2002). That study found catch rates in West Bay to be about twice those of East Bay; our dive based estimates suggest that during the study period green crab densities in West Bay were at least four times greater than East Bay.

It is of interest that rock crab, green crab and lobster were found together on seven of the 150 m transects in West Bay (Table 10). Rock crab and green crab almost certainly interact in some areas, since on some transects they were in close proximity (within 1 metre). This raises questions about whether there is competition or predation, and whether green crab is adversely affecting the rock crab and lobster populations in the Lakes.

Of interest to rock crab population biology is the sharp contrast in size structure between rock crab found off Cape Dauphin, and those found off New Campbellton, just 2-3 km distant. Off Cape Dauphin most rock crab were less than 70 mm CW, while off New Campbellton, in a commercial rock crab fishing area, most rock crab were greater than 60 mm CW. In fact the density of rock crab < 50 mm CW off New Campbellton was 0.008 per m^2, less than half of that estimated for off Cape Dauphin (0.018 m^2), even though overall rock crab densities were almost twice as high off New Campbellton. This suggests that smaller rock crab need the cover afforded by the cobble boulder habitat off Cape Dauphin.

Echinoderms currently dominate the invertebrate biomass in Bras d'Or Lake. Sea urchins and starfish were most important but sand dollars were also apparent at a few sites (East Bay and Cod Shoal). Sand dollars were not in a species list referenced in Tremblay (2002).

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Appendix 1. Historical recollection of lobster fishing in Bras d'Or Lakes – Mr. Michael MacLean, Washabuck

Mr. Michael MacLean, 92 years old, was interviewed by John Tremblay in his home on the Washabuck shore on July 19, 2004. Michael's son Vince was also present. Mr. Michael MacLean has lived his entire life in Washabuck, on the shore opposite Baddeck Bay. Washabuck is just north of Barra Strait and is part of LFA 27.

1920's to 1940's

Michael was 14 when he started fishing lobsters with his father in about 1926. At that time lobsters fetched just 2 cents a pound, and were purchased by lobster smacks, boats that made their way from Big Harbour or Ross Ferry. He recalls his father saying he did not have enough crates for the lobsters he was catching. In these early days his father fished about 60 traps out of an open boat powered by a "one-lunger" engine. His traps were spread out along the Washabuck shore over an area of about 5 miles, mainly to the south of MacKay's Point (south to Maskell's Harbour Cove). The fishing season then was the same as it is today, May 15th to July 15th. There was a government wharf that had been constructed in about 1909 at the foot of the MacLean property at MacKay's Point, but it didn't provide enough protection from weather for fishing boats. These were moored in a small cove (MacKay's Point harbour) a few hundred meters westward of the wharf and fronting the MacLean property.

Michael remembers more lobsters in the early days. He recalled one of the first times he set a couple of traps just 100 feet from shore. He found 7 lobsters in these traps the next day. An average catch in those days was 100 lbs in 60 traps. The lobster grounds his father fished were shared by just a couple of other fishermen who set 60-70 traps.

The wooden traps Michael and his father used were 2 compartment types. There was just one entrance with a 7" hoop. They tended to catch and sell mainly market sized lobsters (> 3 3/16" or 81 mm CL). Michael recalls some large lobsters being captured but they were not particularly common. One was a 15 lb male that had its claw in the entrance when the trap came up. Another was a male of similar size that had its claw caught in a trawl line.

1940s-1980s

By the 1940s there were 7-8 fishermen in the Washabuck area fishing 70-80 traps each. Lobsters were sold to the Boston market through the buyers Dent and Harvey. The lobsters were transported by boat to Iona and then put on a refrigerated rail car to Boston. This was not the best arrangement because the lobsters sometimes didn't do well during the 8-12 hour delay in getting on the refrigerated cars. The cheques Michael and the other fishermen received from the buyers in Boston reflected any losses of lobsters on the way to the United States.

By the time Michael stopped fishing lobsters in 1982, he had been at it for about 56 years. By then lobster catches were not as good as the early days. Most fishermen were setting 80-90 traps and he was typically catching ¾ of a crate (about 75 lbs) after letting them set for 2 days. Another factor in Michael's decision to stop fishing was the fact that Maskell's Harbour Cove had by then silted in, and it was difficult to keep a fishing boat close by.

<u>Fishing depths</u> – Over the years Michael fished most of his traps at depths less than 9 fathoms but fished some as deep as 14 fathoms, and some as shallow as 6 fathoms. Typically he would set some traps shallower (6 fathoms) in June when lobsters were closer to shore, and then deeper again as lobsters moved off in July.

<u>Size, sex and colours</u> – Michael indicates fishermen generally returned canner lobsters, focussing on market sizes. He does not recall males or females as being more abundant but does remember seeing a lot of females with eggs, both large and small females. As far as coloured lobsters are concerned, Michael came across both orange ones and blue ones, but thinks the orange variety were more common.

The present

There are now 3 licensed vessels that fish the Washabuck shore. Two are class "B" licences, with a trap limit of 83. One vessel is from Baddeck, while the other is from Little Narrows. The "A" license from Bras d'Or has a trap limit of 275, and puts some traps on the Washabuck shore for part of the season. Catches are a lot lower now than what they once were.

Some of the reasons Michael believes the lobsters are not as abundant now are pollution, siltation, and possibly cormorant predation on small lobsters. He notes that other fish are down in the Lakes – cod, salmon and herring among them. Michael believes that dumping in the past contributed to poor water quality. Apparently, before Baddeck had proper garbage disposal sites, garbage was hauled out from the Village and dumped into the Lake in front of Beinn Bhreagh (the summer home of Alexander Graham Bell). This was easily visible from MacKay's Point.

Siltation through natural processes has not only reduced access to his harbour, but has changed some of the better fishing grounds he used to set traps on. Spectacle Island, just off his property, used to be about 8 acres and was surrounded by rocky bottom. Now it is 2 small islands surrounded primarily by sand. No one fishes lobsters there now. Cormorants arrived in the area 40-50 years ago. Michael and his son Vince feel that cormorants are effective underwater predators and may well feed on small lobsters.

Table 1. Bottom video transects completed in 2002. A summary of field note comments is also provided. NR = not recorded. Note: comments were recorded from start of transect regardless of whether started at deep or shallow end.

Transect no.	Area	Length (km)	Depth range (m)	Comments on habitat and biota in field notes
1	East Bay	1.3	NR	Initial transects – no comments
2	East Bay – Off Eskasoni	1.0	NR	Initial transects – no comments
3	East Bay – Off Eskasoni	0.5	NR	Initial transects – no comments
4	East Bay – Off Eskasoni	0.6	NR	Initial transects – no comments
5	North of Barra Strait	1.0	4-12	Gravel, eelgrass shallow (4 m), some kelp, cobble, sea urchins , sand dollars deeper
6	North of Barra Strait, deep	1.1	20-34	Urchins on mud, tracks (hermit crabs?)
7	Washabuck shore, loop	1.2	4-12	9 m kelp, sand dollars 11 m, loose kelp, shell **lobster at 12 m**, flounder, green crab 9 m
8	South of Barra Strait, Hectors Pt., including deep	1.2	5-48	5 m cobble, shells, 8 m gravel, eelgrass, 12 m sea urchins, shells, **lobster at 14 m**, loose kelp, shell hash. From > 24 to 47 m: sandy mud & mud; tracks
9	East Bay, Middle Cape	0.7	6-18	Gravel, "waves", sand dollar silt on sand, quahog? **Lobster at 11 m**; Shells, 15 m urchins on mud, 17 m flounder, hermit crab?
10	East Bay, Middle Cape	0.6	6-14	7 m sand waves, 2 flounder, 8-12 m mud, sand dollars, quahogs?, drift kelp 12 m,
11	East Bay, 1st of five across the bay	1.6	6-25	Shallow: gravel, sand, cobble 10 m, urchin flats 12-18 m, some gravel sand, scallop shells,19 m, sand dollars, 23 m: mud, flounder,18 m worm mounds, 16 m sand dollars
12	East Bay, 2nd of five across the bay	1.2	11-22	14 m: sand, sand dollars, gravel, off boulder,13 m gravel odd boulder, mussels, 11 m mussels, cobble, 14 m sand, urchins, 15 m urchin flats, 15-12 m coarser, mussels…
13	East Bay, 3rd of five across the bay	1.4	15-25	15 m sand, sand dollars, urchins, mud, sand gravel, 17 m: cobble, boulder, 21 m: mud, sand, urchins, sand mud, 19 m: basket worms
14	East Bay, 4th of five across the bay	1.5	12-23	22 m: mud, urchins, worms, 19-15 m: cobble, odd boulder, mussels, 14 m: gravel, sand, urchins, 13 m: mussels on cobble, urchin plain 14-18 m,
15	East Bay, 5th of five across the bay	1.4	13-22	14 m: sand, urchins, 14 m basket worms, 18-15 m: mud, urchins, 13 m: cobble, odd boulder, mussels
16	East Bay, off Benacadie	1.0	10-25	24 m:odd boulder, cobble in sand, decent shelter, 24 m: sand mud, urchins, 21-13 m, odd boulder, sand, 12-9 m: sand, odd boulder, cobble, crab
17	East Bay, Middle Cape	1.1	10-20	10 m: sand, gravel; 13 m sand, silt, gravel, quahogs?, 15 m: sea urchins, gravel, sand, sand mud, 13-20 m, sand, mud
18	East Bay – Off Eskasoni	0.5	12-18	17 m: silt on sand, mud, urchins, 15 m more sandy, gravel, 14 m more cobble, odd boulder, 12 m: mussel reef, urchins
19	East Bay – Off Eskasoni	0.6	8-15	15 m: mud, sand, urchins, 14 m: gravel, cobble, 8 m, cobble in gravel,8 m isolated boulders
20	Washabuck shore	0.3	13-17	13 m: gravel sand, loose kelp, tracks, 14 m sandy, scallop,16 m: starfish, mud, 17 m mud, scallop shell
21	Washabuck shore	0.4	6-17	6 m: sandy, 7 m fish, boulders, kelp, 12 m: gravel, kelp, 14 m: boulder,12 m: sand, gravel,14 m kelp, tracks in mud, 16 m kelp, scallop, 17 m mud, kelp, starfish
22	Washabuck shore		5-17	5 m: kelp, gravel, 7 m: rock crab, gravel, 11 m Lobster depressions?, 14 m kelp, sand, sand dollar, 15 m kelp, tracks, starfish, 16 m: mud
23	Washabuck shore, most northerly	0.5	4-31	4 m: boulder, sand, fish, cobble, 12-14 m: sand, oysters?, 18-30 m: mud, starfish

Table 1. Cont'd.

Transect no.	Area	Length (km)	Depth range (m)	Comments on habitat and biota in field notes
24	Washabuck shore, parallel to shore	0.6	5-31	9-5 m: mud, starfish, sand, gravel, razor clam, rock crab, flounder, kelp 9-10 m: sand, rock crab, starfish, flounder, kelp
25	South of Barra Strait, Hectors Pt.	1.3	5-31	5-9 m: cobble, boulder, kelp, fish, 9-15 m: sand, mussels, loose kelp, sand dollars, 15-18 m: shells, sand, urchins, quahogs, gravel, shell debris,
26	Cape Dauphin, off Hectors Pt (different from than in Barra St!)	0.5	6-32	Lots of kelp, boulders, cobble on sand.
27	Cape Dauphin, off Hectors Pt	0.6	6-32	Lots of kelp, boulders, cobble on sand.
28	Outer Great Bras d'Or Channel, New Campbellton area	0.8	9-32	Flat sand, mud, lots of rock crab
29	Outer Great Bras d'Or Channel, New Campbellton area	0.3	6-33	Flat sand, mud, lots of rock crab

Table 2. Bottom video transects completed in 2003. BL = Bras d'Or Lake

Transect no.	Date	Area	Length (km)	Depth range (m)	Comments on habitat and biota in field notes
1	8-Jul-03	Chapel Is	0.7	4-12	4-7 m: Cobble, boulder; 10 m: sand, gravel; 14-17 m: sandy mud-mud, starfish, urchins, 8 m:
2	8-Jul-03	Kelly's Shoal	0.9	8-13	7 m: Cobble, boulder, some kelp, cunners; 9 m: urchins, sandy-boulder; 10 m: mussel reef; 11 m: gravel, urchins, gravel, sandy gravel
3	8-Jul-03	Kelly's Shoal	1.2	3-10	4-7 m: Kelp, Irish moss, cobble, gravel, some boulders; 7-10 m: sand/gravel , quahogs
4	8-Jul-03	Red Is	0.8	2-23	3 m: sand, boulder, gravel, rock weed, brown seaweed,8-12 m: gravel, sandy; 17 m: clam shells, sand$
5	9-Jul-03	Chapel Is	1.0	5-18	Shallow- cobble, gravel, some boulder, mussels, 14 m: sandy mud, holes, starfish, urchins, 16 m worm mount
6	9-Jul-03	Cape George	0.6	3-16	3 m: boulder gravel, kelp, 6-9 m: sand, some sandwaves,13 m: mud, holes, starfish
7	9-Jul-03	MacRae's Pt	0.5	4-5	9 minutes (pulled cam up), gravel cobble 4 m; boulders, kelp
8	9-Jul-03	MacRae's Pt	1.2	3-13	12 m: gravel cobble, urchins, flat boulders, sand patches with sand dollars; 6-3 m: boulders, kelp, cobble
9	9-Jul-03	Morrison Head	0.8	7-15	10 m: boulder, urchins, fish, rock crab 9 m; 12 m: gravel sand, urchins, 15 m sand worms, 7 m: mussel reef
10	9-Jul-03	Morrison Head	1.1	4 -24	23 m: mud, tracks, urchins; 14 m sandy mud, starfish, urchins, 12 m: gravel, sand; 9 m boulders, mussel reef
11	9-Jul-03	Poor Pt	0.6	9-19	19 m: mud, small urchins; 13 m gravel worms, urchins, 9 m: cobble, boulder, mussel reef
12	9-Jul-03	MacLeodsShoal	1.0	9-21	20 m: mud, tracks, urchins; 16-10 m: gravel, cobble, sand, urchins; 11-9 m: gravel, cobble urchins, fan worms
13	10-Jul-03	Outer Shoal	1.0	7-23	24 m: mud, urchins, sand$, 19-13 m: sand, gravel, cobble, ,urchins, worms; 10-7 m: Boulders: **Good lobster bottom;**
14	10-Jul-03	East of Poor Pt	0.8	7-14	14 m: mud, urchins, hermit crab, sandy, worms; 10 m: boulders cunners; 7 m; small boulders, urchins, fish; mussel reef
15	10-Jul-03	Floda Is	0.8	3-11	3-6 m: boulder, cobble, fish, mussels, brown seaweed; mussels; 7-11 m: urchins, anemones, cobble, gravel, starfish
16	10-Jul-03	Crammond Is	0.6	3-14	4-8 m: cobble, boulders, sand, starfish; 10-13 m: gravel, cobble, crab, sand, urchins, mud, quahogs (12 m)
17	10-Jul-03	Crammond Is	0.9	3-20	10-3 m: mud, cobble, boulder, sand; 11-15 m: sand, mud sand$, urchins, odd boulder; 15-20 m mud, urchins, tracks
18	10-Jul-03	S of Spruce Pt	0.7	2-19	10-7 m: mud, worms; 4-2 m: gravel, eel grass, sand, boulders, gravel, odd boulder; 10-19 m: mud on sand, worms, starfish, urchins
19	15-Jul-03	Poor Pt	0.7	6-14	14 m sand, crab, urchins, worms, quahogs?; 12-9 m: urchins, drift kelp, cobble; 9-6 m: drift kelp, cobble sand, boulder
20	15-Jul-03	Pringle Shoal	0.9	3-21	21 m: tracks, mud, urchins, starfish; 12-9 m: urchins, boulder, sand; 9-6 m: boulders, sand, gravel cobble; 6-5 m: gravel, cobbl kelp
21	15-Jul-03	Campbells Pt	0.3	6-15	6 m: sand, kelp; 10-15 m: mud, starfish
22	15-Jul-03	Campbells Pt	0.6	3-10	3 m: reef, eelgrass, kelp; boulder, gravel, 7 m: cobble, boulder, urchins,10 m: fan worms, urchins, gravel some boulder
23	15-Jul-03	West Bay	0.9	6-19	6-9 m: gravel, boulder, urchins, 9-12 m: cobble, gravel, boulder, urchins, 12-18 m; cobble, boulder, urchins, sand, mud (17 m)
24	15-Jul-03	McInnes Shoal	0.7	5-13	5-9 m: boulder, sand- gravel, mud, gravel, drift kelp;9-13 m: mud, starfish, gravel
25	15-Jul-03	Island	0.8	4-18	12-9 m: mud, sand, urchins, gravel; 9-4 m: starfish, urchins, gravel, cobble, boulder; 14 m: boulder, urchins, cobble, mussels, flounder
26	15-Jul-03	MacRae Is	0.8	3-9	8-4 m: eelgrass, muddy sand, starfish, gravel cobble; 3-5 m: cobble, boulder, algae, urchins; 8-9 m: gravel, boulder sand & sand$
27	16-Jul-03	MacKenzies Pt	0.8	5-14	5-9 m: mud, boulders, eelgrass, starfish, muddy-sand, gravel; 9-13 m: mud, sand, starfish, gravel

Table 2. Cont'd.

Transect no.	Date	Area	Length (km)	Depth range (m)	Comments on habitat and biota in field notes
28	16-Jul-03	MacKenzies Pt	0.7	6-20	18-11 m: mud, starfish, urchins, shells; 11-6 m: sandy gravel mud, mussels on boulder, "perfect burrows"; 8 m lobster excavation
29	16-Jul-03	Dumpling Is	0.6	4-18	18 m: mud, urchins, 12 m: sandworms; 12-6 m: gravel, boulders, urchins, muddy sand, hermits, sand$; 6 m urchins, boulder cobble
30	16-Jul-03	Mid Shoal	0.4	5-18	17 m: mud, urchins; 14-9 m: fan worm, sand gravel, cobble, boulders **Lobster 11 m; Lobster 9 m**; 8-5 m: sand, boulder, urchins, excavation
31	16-Jul-03	MacRae's Is	0.5	2-18	18-14 m: mud, starfish; 12-8 m: muddy, gravel, sand; 6-2 m: boulders in sand, eelgrass
32	16-Jul-03	Ronald Is	0.4	2-9	9-5 m: gravel, sand, crab, periwinkles on boulder (5 m); 4-2 m: cobble, boulders, Fucus, gravel
33	16-Jul-03	Tailer Shoal	0.7	6-18	14-11 m: sand fan worm, small urchins on sand, gravel, some boulders; starfish; 9-7 m: cobble, urchins, fish, gravel
34	16-Jul-03	Crammond	0.5	2-18	3-6 m: Fucus, crab, sand, boulders some larger; green crab; 6-13 m: cobble, sand; 13-18 m sand turning to mud; starfish
35	17-Jul-03	Middle Shoal	0.8	5-13	13 m: cobble, boulder urchins; 11-6 m: sand, cobble, boulders w mussels; urchins
36	17-Jul-03	Green Is	0.8	3-11	11-7 m: sand, bivalve shells, worm mounds; founder; 7-3 m: sand, cobble, starfish, boulders, periwinkles; green crab
37	17-Jul-03	Shoal E of Calf Is	0.8	7-17	17-12 m: sand, urchins, mud, gravel; 12-9 m: sand, gravel urchins; 9-7 m: gravel, urchins, cobble
38	17-Jul-03	Calf Is	0.9	4-18	17-10 m: mud; 8-4 m crab, sand, boulders some w algae, gravel
39	17-Jul-03	Shoal North of Brook Is	0.9	5-23	18-23 m: mud, holes, urchins; 14-8 m: mud, shells, gravel, urchins, crab, 8-5 m: sand, boulders, cobble, gravel, starfish, urchins
40	17-Jul-03	Cameron Is	0.8	5-18	17-13 m: mud, starfish; 10-5 m: starfish, mud, boulders, sand, gravel; cobble scattered, sand dollar, worm mound; eelgrass
41	17-Jul-03	Magnus Point	0.7	4-12	7-9 m: gravel, cobble, urchins, mussels, odd boulder, sand; 9-12 m: gravel cobble urchins, starfish
42	17-Jul-03	MacIntosh Is	0.6	3-17	3-6 m: gravel, cobble, brown algae, urchins, winkles on boulders, mussels; 6-12 m: gravel, cobbles. Starfish, urchins. Crab molt 17 m
43	18-Jul-03	Paddle Shoal	0.6	5-18	18-12 m: sand, gravel, mud, urchins. 12-8 m: boulder, gravel cobble, sand fan worms, mussels, urchins; 8-5 m: gravel, boulders, urchins
44	18-Jul-03	George Shoal	0.8	3-21	21-14 m: mud, urchins, shell debris, worm mounds; 11-6 m: sand, gravel, starfish, boulders urchins; 6-3 m: cobble, boulder, seaweeds
45	18-Jul-03	MacKenzies Cove	0.6	3-18	12-6 m: sand, gravel, boulders, urchins, starfish, mussels , excavation; 6-3 m: gravel, cobble, urchins, boulders, mussels
46	21-Jul-03	McKinnons Shoal	NR	NR	14-11 m: sand, gravel, cobble, boulders, cunners, urchins, excavation?; 11-8 m: gravel some boulders, urchins, mussel reef
47	21-Jul-03	Red Point East	1.0	7-13	13-9 m: Cobble, gravel, mud, urchins, starfish, excavation?, odd boulder; 9-7 m: Boulder, gravel, sand, cobble, flounder, starfish,
48	21-Jul-03	Jamesville	0.8	5-9	9-6 m: Cobble, boulders, gravel, kelp; 6-4 m: Boulders, gravel, cobble, kelp
49	22-Jul-03	McKinnons Shoal	0.8	8-13	12-9 m: Gravel, urchins, cobble, boulders; 9-11 m: gravel, cobble, urchins, drift kelp, sand, gravel, odd cobble, boulder
50	22-Jul-03	Militia Point	0.9	5-20	20-11 m: mud, urchins, starfish, sand, gravel, shells; 11-8 m: sand, gravel, cobble, boulder, kelp, starfish, sand, skate
51	22-Jul-03	Militia Point	0.8	5-18	18-13 m: sand, mud, gravel, drift kelp, flounder; 11-6 m: sand, boulder, kelp; 6-5 m: boulder, gravel, kelp, algae, fish

Table 2. Cont'd.

Transect no.	Date	Area	Length (km)	Depth range (m)	Comments on habitat and biota in field notes
53	22-Jul-03	Gillis Shoal	1.0	4-14	14-8 m: sand, gravel, quahog shells, 2 crabs, kelp, boulders, 7-5 m: boulders, sand, kelp, gravel
54	22-Jul-03	Malagawatch Point	1.0	7-12	12-8 m: gravel, urchins, cobble, sand, starfish, kelp, sand; 7 m: sandy mud, kelp, gravel, odd boulder
55	23-Jul-03	Cod Shoal	1.1	8-13	13-8 m: gravel, cobble, urchins, boulders, mussels; urchins
56	23-Jul-03	Cod Shoal North	1.2	8-17	17-9 m: sand, urchins, gravel, boulders; 9-8 m: sand, urchins, starfish, boulders, gravel; 9-12 m: urchins, crabs, quahogs
57	23-Jul-03	MacRae's Cove	0.7	6-10	6-10 m: mud, **crabs (~10),** flounder, starfish, gravel cobble
58	23-Jul-03	Gramms Point	0.8	7-12	12-8 m: mud, flounder, starfish, kelp, boulders, gravel
59	23-Jul-03	East of Indian Island	1.0	7-14	14-8 m: mud, starfish, cobble. Gravel, starfish, boulders, kelp, crab

Table 3. Dive transect locations and characteristics for 2002. All transects were 150 m in length. DDM = Degrees decimal minutes. NR = no record.

Dive No.	Date	Area	Code	Trans width (m)	Depth Range (m)	Start Lat (North, DDM)	Start Long (West, DDM)
1	10-Sep 2002	Middle Cape,	MC1	4	6-11	45 52.0938	60 37.6590
2	10-Sep 2002	E Bay	MC2	4	7-13	45 52.0440	60 37.7172
3	10-Sep 2002		MC3	4	8-13	45 51.8220	60 38.0760
4	11-Sep 2002	Off Eskasoni	E1	4	8-9	45 55.8144	60 34.1562
5	11-Sep 2002	(1.5 Km S)	E2	4	NR	45 55.7130	60 34.1040
6	11-Sep 2002		E3	4	7-9	45 56.0046	60 34.6872
7	11-Sep 2002		E4	4	12-13	45 55.8954	60 35.4948
8	24-Sep 2002	New Campbellton	NC1	4	37 (max)	46 17.1120	60 26.4780
9	24-Sep 2002		NC2	4	11-12	46 16.9980	60 26.5980
10	24-Sep 2002		NC3	4	2-13	46 16.3104	60 27.3720
11	24-Sep 2002		NC4	4	3-13	46 16.2078	60 27.5466
12	25-Sep 2002	Cape Dauphin	CD1	2	5-9	46 20.0040	60 24.6198
13	25-Sep 2002		CD2	2	8-12	46 20.1828	60 24.5298
14	25-Sep 2002		CD3	2	8-11	46 20.3598	60 24.5712
15	26-Sep 2002	Washabuck	W1	4	8-13	46 00.1182	60 47.8860
16	26-Sep 2002		W2	4	8-14	46 00.2190	60 47.7540
17	26-Sep 2002		W3	4	3-9	46 00.3552	60 47.6958
18	26-Sep 2002		W4	4	3-10	46 00.2148	60 47.8998

Table 4. Dive transect locations and characteristics for 2003. All transects were 150 m in length. DDM = Degrees decimal minutes.

Dive No.	Date	Area	Code	Tran width (m)	Depth range (m)	Start Latitude (DDM)	Start Longitude (DDM)
1	10-Sep 2003	McKenzie Pt	28.1	4	8-9	45 45.857	61 07.292
2	10-Sep 2003	Dumpling Is	29.1	4	8-9	45 45.888	61 06.301
3	10-Sep 2003	Dumpling Is	29.2	4	7-11	45 45.770	61 06.327
4	11-Sep 2003	Floda Is	15.3	4	10-12	45 45.460	61 03.776
5	11-Sep 2003	Floda Is	15.2	4	6-10	45 45.536	61 03.854
6	11-Sep 2003	Floda Is	15.1	4	5-7	45 45.624	61 03.877
7	11-Sep 2003	Crammond Is	17.1	4	4-7	45 44.835	61 05.259
8	12-Sep 2003	Crammond Is	17.2	4	11-13	45 44.655	61 05.267
9	12-Sep 2003	Ronald Is	32	4	3-6	45 46.957	61 03.947
10	23-Sep 2003	Mid-Shoal	30.2	4	7-18	45 46.566	61 05.735
11	23-Sep 2003	Mid-Shoal	30.1	4	6-12	45 46.660	61 05.739
12	23-Sep 2003	Crammond Is	34	4	4-13	45 45.971	61 04.669
13	23-Sep 2003	McKenzie Pt	28.3	4	12-15	45 45.960	61 07.244
14	24-Sep 2003	McKenzie Pt	28.2	4	9-11	45 45.855	61 07.230
15	24-Sep 2003	Malcolm Cove	27	4	9-10	45 44.907	61 07.157
16	24-Sep 2003	Chapel Is	1.1	4	9-13	45 43.625	60 47.51
17	24-Sep 2003	Chapel Is	1.2	4	6-7	45 43.521	60 47.43
18	25-Sep 2003	Chapel Is	5.1	4	8-11	45 43.813	60 47.386
19	25-Sep 2003	Kellys Shoal	2.1	4	12-14	45 46.033	60 48.633
20	25-Sep 2003	Kellys Shoal	2.2	4	9-10	45 45.884	60 48.489
21	25-Sep 2003	Kellys Shoal	3.1	4	5-6	45 46.076	60 48.003
22	25-Sep 2003	Cape George	6.1	4	6-11	45 44.260	60 48.653
23	26-Sep 2003	MacKenzie Cove	45.2	4	5-9	45 50.011	60 58.430
24	26-Sep 2003	MacKenzie Cove	45.1	4	7-13	45 49.852	60 58.430
25	07-Oct 2003	Militia Is	51.2	4	6-11	45 49.959	60 56.033
26	07-Oct 2003	Militia Is	51.1	4	5-6	45 50.138	60 56.001
27	07-Oct 2003	Militia Pt.	50	4	5-9	45 49.881	60 56.751
28	09-Oct 2003	Pellier Pt Reef	52.2	4	9-15	45 50.667	60 55.532
29	09-Oct 2003	Pellier Pt Reef	52.1	4	11 (max)	45 50.834	60 55.544
30	09-Oct 2003	Gillis Shoal	53.2	4	6-12	45 51.201	60 54.888
31	09-Oct 2003	Gillis Shoal	53.1	4	7-10	45 51.434	60 54.91
32	09-Oct 2003	Malagawatch	54	4	8-9	45 52.003	60 54.629

Table 5. Habitat classes by underwater video transect in 2002. Based on analysis of different habitat types recorded to files while viewing bottom videos in real-time. Total number of records in file reflects time on bottom i.e. 1840 records = 3680 seconds or 61.3 minutes. Note that percentages may be biased if the speed of the video camera over the bottom varied during the transect.

Area	*Transect no.*	*Boulder*	*Cobble*	*Gravel*	*Macroalga*	*Mud*	*Sand*	*Total no. records*
East Bay	1	0%	0%	0%	0%	0%	100%	1840
East Bay	2	1%	4%	90%	0%	2%	2%	909
East Bay	3	1%	35%	59%	0%	0%	4%	504
East Bay	4	3%	56%	41%	0%	0%	0%	727
N Barra St	5	0%	9%	27%	28%	2%	34%	913
N Barra St	6	0%	0%	0%	0%	100%	0%	1723
Washabuck	7	0%	7%	54%	7%	5%	27%	1450
S Barra St	8	0%	1%	14%	5%	0%	81%	1504
E Bay- M Cape	9	0%	0%	0%	0%	0%	100%	965
E Bay- M Cape	10	0%	0%	0%	7%	21%	72%	672
East Bay	11	0%	4%	20%	0%	30%	45%	1747
East Bay	12	4%	32%	24%	0%	12%	29%	1713
East Bay	13	0%	6%	10%	0%	56%	28%	1724
East Bay	14	2%	15%	28%	0%	39%	17%	1722
E Bay- M Cape	15	1%	10%	5%	0%	73%	11%	1776
East Bay	16	16%	16%	17%	0%	5%	46%	1739
East Bay	17	0%	1%	23%	0%	0%	76%	1587
East Bay	18	7%	13%	22%	0%	28%	30%	874
East Bay	19	8%	40%	30%	0%	17%	6%	881
Washabuck	20	0%	0%	32%	0%	25%	44%	333
Washabuck	21	0%	0%	37%	0%	20%	43%	453
Washabuck	22	0%	6%	8%	0%	0%	86%	451
Washabuck	23	0%	0%	8%	0%	64%	28%	553
Washabuck	24	0%	0%	0%	0%	0%	100%	758
S Barra St	25	8%	9%	23%	3%	0%	57%	1629
C Dauphin	26	100%	0%	0%	0%	0%	0%	604
C Dauphin	27	23%	56%	22%	0%	0%	0%	665
O Great B d'Or	28	0%	0%	0%	0%	70%	30%	795
O Great B d'Or	29	0%	0%	0%	0%	0%	100%	329

Table 6. Habitat classes by underwater video transect in 2003. Based on analysis of different habitat types recorded to files while viewing bottom videos in real-time. Total number of records in file reflects time on bottom i.e. 1840 records = 3680 seconds or 61.3 minutes. Note that percentages may be biased if the speed of the video camera over the bottom varied during the transect.

Date	Area	Tran. No.	Boulder	Cobble	Gravel	Sand	Mud	Macroalga	Tot No. Records
08-Jul-03	Chapel Island	1	37.0%	41.3%	20.6%	0.9%	0.2%	0.0%	954
08-Jul-03	Kelly's Shoal	2	17.9%	47.5%	23.0%	11.6%	0.0%	0.0%	793
08-Jul-03	Kelly's Shoal	3	21.3%	34.4%	31.1%	11.8%	0.0%	1.3%	845
08-Jul-03	Red Island	4	8.9%	12.6%	16.3%	42.4%	13.0%	6.8%	799
09-Jul-03	Chapel Island	5	4.6%	30.2%	10.1%	9.2%	45.9%	0.0%	848
09-Jul-03	Cape George	6	38.5%	8.8%	0.6%	18.7%	33.5%	0.0%	684
09-Jul-03	MacRae's Point	7	17.5%	54.0%	15.1%	0.0%	0.0%	13.3%	285
09-Jul-03	MacRae's Point	8	3.8%	25.6%	13.6%	27.3%	20.9%	6.4%	1129
09-Jul-03	Morrison Head	9	28.3%	26.7%	42.1%	2.9%	0.0%	0.0%	731
09-Jul-03	Morrison Head	10	31.4%	24.0%	3.4%	1.4%	39.7%	0.1%	847
09-Jul-03	Poor Point	11	12.6%	7.5%	46.7%	10.5%	22.8%	0.0%	628
09-Jul-03	MacLeods Shoal	12	1.1%	47.2%	14.6%	30.3%	6.8%	0.0%	976
10-Jul-03	Outer Shoal	13	37.1%	10.6%	6.2%	21.9%	24.3%	0.0%	844
10-Jul-03	East of Poor Point	14	29.4%	20.3%	21.0%	23.0%	6.3%	0.0%	656
10-Jul-03	West Bay, Floda Is	15	48.3%	34.2%	17.5%	0.0%	0.0%	0.0%	847
10-Jul-03	Crammond Is	16	11.3%	34.2%	8.5%	34.2%	11.8%	0.0%	885
10-Jul-03	Crammond Island	17	15.5%	14.9%	24.3%	21.3%	23.6%	0.0%	827
10-Jul-03	,S of Spruce Point	18	8.1%	9.0%	18.4%	21.0%	43.4%	0.0%	689
15-Jul-03	Poor Point, West Bay	19	34.1%	17.1%	21.0%	25.1%	0.0%	2.6%	832
15-Jul-03	Pringle Shoal,	20	37.2%	15.4%	23.5%	8.8%	15.1%	0.0%	914
15-Jul-03	Campbells Point	21	0.8%	2.0%	0.0%	41.3%	46.1%	9.8%	254
15-Jul-03	Campbells Point	22	41.0%	22.5%	33.3%	0.2%	0.0%	3.0%	568
15-Jul-03	West Bay	23	18.6%	14.1%	49.2%	14.5%	3.6%	0.0%	786
15-Jul-03	McInnes Shoal	24	17.3%	5.9%	49.0%	7.0%	20.8%	0.0%	855
15-Jul-03	West Bay, Island	25	19.2%	8.8%	42.7%	27.6%	1.6%	0.0%	854
15-Jul-03	MacRae Island	26	14.2%	41.2%	16.8%	16.3%	10.9%	0.7%	855
16-Jul-03	MacKenzies Point	27	2.3%	2.1%	27.0%	36.1%	32.5%	0.0%	925
16-Jul-03	MacKenzies Point	28	16.7%	0.8%	3.6%	35.4%	43.6%	0.0%	783
16-Jul-03	Dumpling Island	29	46.4%	19.6%	18.5%	8.5%	7.0%	0.0%	929
16-Jul-03	Mid Shoal [2 lobsters]	30	9.7%	11.5%	38.5%	33.9%	6.5%	0.0%	629
16-Jul-03	MacRae's Island	31	22.2%	0.0%	15.3%	19.8%	42.0%	0.7%	541
16-Jul-03	Ronald Island	32	39.1%	9.7%	35.7%	15.1%	0.0%	0.4%	524
16-Jul-03	Tailer Shoal	33	16.2%	40.8%	22.6%	20.4%	0.0%	0.0%	747
16-Jul-03	Crammond	34	42.3%	16.2%	19.8%	9.9%	3.7%	8.1%	868
17-Jul-03	Middle Shoal	35	Error – No files created						
17-Jul-03	Green Island	36	Error – No files created						
17-Jul-03	Shoal E of Calf Island	37	Error – No files created						
17-Jul-03	Calf Island	38	Error – No files created						
17-Jul-03	Shoal North of Brook Is	39	Error – No files created						

Table 6 cont'd.

Date	Area	Tran. No.	Boulder	Cobble	Gravel	Sand	Mud	Macroalga	Tot No. Records
17-Jul-03	Cameron Island	40	Error – No files created						
17-Jul-03	Magnus Point	41	Error – No files created						
17-Jul-03	MacIntosh Island	42	Error – No files created						
18-Jul-03	Paddle Shoal	43	34.2%	31.2%	20.6%	12.2%	1.8%	0.0%	827
18-Jul-03	George Shoal	44	46.8%	18.8%	11.3%	6.8%	16.4%	0.0%	879
18-Jul-03	MacKenzies Cove	45	36.7%	27.4%	8.5%	27.5%	0.0%	0.0%	734
21-Jul-03	McKinnons Shoal	46	39.2%	25.7%	35.1%	0.0%	0.0%	0.0%	836
21-Jul-03	Red Point East	47	6.9%	29.7%	35.7%	16.6%	10.5%	0.6%	998
21-Jul-03	James Ville	48	44.9%	20.9%	34.2%	0.0%	0.0%	0.0%	831
22-Jul-03	McKinnons Shoal	49	11.4%	24.3%	41.9%	18.4%	4.0%	0.0%	823
22-Jul-03	Militia Point	50	23.6%	9.8%	7.6%	47.1%	12.0%	0.0%	899
22-Jul-03	Militia Point	51	57.1%	1.7%	2.8%	34.8%	3.7%	0.0%	849
22-Jul-03	Point Reef	52	39.2%	8.4%	11.7%	40.7%	0.0%	0.0%	742
22-Jul-03	Gillis Shoal	53	37.9%	11.1%	21.8%	29.3%	0.0%	0.0%	885
22-Jul-03	Malasawatch Point	54	14.0%	4.1%	35.4%	46.6%	0.0%	0.0%	885
23-Jul-03	Cod Shoal	55	14.1%	18.1%	62.5%	5.4%	0.0%	0.0%	839
23-Jul-03	Cod Shoal North	56	8.9%	5.7%	43.7%	39.7%	2.1%	0.0%	925
23-Jul-03	MacRae's Cove	57	0.0%	2.4%	13.5%	40.0%	44.2%	0.0%	890
23-Jul-03	Gramms Point	58	7.0%	1.6%	22.1%	12.9%	56.4%	0.0%	918
23-Jul-03	East of Indian Island	59	14.9%	33.6%	46.6%	0.2%	4.8%	0.0%	902

Table 7. 2002 dive data: Counts of lobsters, rock crabs and green crabs on transects. Transects were 150 m in length by 4 m in width for all areas except for Cape Dauphin (2 m in width). Tran ID is transect identification code.

Area	*Transect ID*	*Lobsters*	*Rock Crab*	*Green Crab*	*Grand Total*
Cape Dauphin	CD1	7	15		22
	CD2	7	4		11
	CD3	3	2		5
Cape Dauphin Total		17	21		38
East Bay (Eskasoni)	EB1			2	2
	EB2		1		1
	EB3		3		3
	EB4	1	1		2
East Bay (Eskasoni) Total		1	5	2	8
Middle Cape	MC1		2		2
	MC2		1		1
	MC3	1			1
Middle Cape Total		1	3		4
New Campbellton	NC1		44		44
	NC2		18		18
	NC3		21	2	23
	NC4	1	24		25
New Campbellton Total		1	107	2	110
Washabuck	W1		5		5
	W2	3	7		10
	W3		1		1
	W4		9		9
Washabuck Total		3	22		25
Grand Total		23	158	4	185

Table 8. 2003 dive data: Counts of lobsters, rock crabs and green crabs on transects. Transects were 150 m in length by 4 m in width for all areas. Tran ID is transect identification code.

Large Area	*Transect ID*	*Lobsters*	*Rock Crab*	*Green Crab*	*Grand Total*
Chapel Is - Kellys	1.2	1	2		3
	2.1		4		4
	2.2	3	8		11
	3.1	1	11	3	15
	5.1	2	1		3
	6.1		2	5	7
Chapel Is - Kellys Total		7	28	8	43
Crammond Is	15.1	2	13	9	24
	15.2	1	5	4	10
	15.3		4		4
	17.1	1	16	14	31
	17.2		5		5
	27		1		1
	28.1	7			7
	28.2	2	3		5
	28.3		4	1	5
	29.1	2	1	3	6
	29.2	2	2		4
	30.1		6		6
	30.2	1			1
	32	2	6	35	43
	34	3	14	9	26
Crammond Is Total		23	80	75	178
Malagawatch	45.1		7		7
	45.2		1		1
	50	1	13		14
	51.1	2	6	4	12
	51.2		2		2
	52.1		11	3	14
	52.2		2	2	4
	53.1	1	4	2	7
	53.2		7	3	10
	54	1	1	5	7
Malagawatch Total		5	54	19	78
Grand Total		35	162	102	299

Table 9. Densities of lobsters and crabs by area, 2002 and 2003 data combined. Tran = Transects.

	Transect info			*Total Counts*			*Density (no per m²)*		
Area	No. Tran	Tran area (m^2)	Total Area (m^2)	Lobster	Rock Crab	Green Crab	Lobster	Rock Crab	Green Crab
East Bay (both sides) (2002)	7	600	4200	2	8	2	0.0005	0.0019	0.0005
Cape Dauphin (2002)	3	300	900	17	21	0	0.0189	0.0233	0.0000
New Campbellton (2002)	4	600	2400	1	107	3	0.0004	0.0446	0.0013
Washabuck (2002)	4	600	2400	3	25	2	0.0013	0.0104	0.0008
Crammond Is (2003)	15	600	8700	23	80	75	0.0026	0.0092	0.0086
Chapel-Kellys (2003)	7	600	4200	7	28	8	0.0017	0.0067	0.0019
Malagawatch (2003)	10	600	6000	5	54	19	0.0008	0.0090	0.0032
TOTAL	50		28800	58	323	109			

Table 10. Presence ("1") or absence of different taxa from observations during 2003 dive transects, including 0.25 m^2 quadrats.

Area	Code	Cons No.	*Lobsters*	*Lobster Signs*	*Rock crab*	*Green crab*	*Hermit crab*	*Crangon*	*Urchin*	*Star-fish*	*Sand Dollars*	*Anemones (burrowing)*	*Anemones attached*	*Mussels*	*Quahogs*	*Cockles*	*Scallop*	*Razor Clams*	*Other Biv.*
McKenzie Pt	28.1	1	1						1	1				1	1				
Dumpling Is	29.1	2	1	1	1	1			1	1				1					
Dumpling Is	29.2	3	1		1					1				1				1	
Floda Is	15.3	4			1				1	1		1		1					
Floda Is	15.2	5	1	1	1	1			1	1				1					
Floda Is	15.1	6	1		1	1			1	1		1							
Crammond Is	17.1	7	1		1	1			1	1			1						
Crammond Is	17.2	8			1				1	1		1		1	1	1			
Ronald Is	32	9	1		1	1				1									
Mid-Shoal	30.2	10	1	1					1	1		1		1	1			1	
Mid-Shoal	30.1	11			1		1		1	1		1		1					
Crammond Is	34	12	1		1	1	1		1	1		1							1
McKenzie Pt	28.3	13			1	1				1		1							
McKenzie Pt	28.2	14	1	1	1				1	1									
Malcolm Cove	27	15			1		1			1		1			1				
Chapel Is	1.1	16					1		1	1		1		1	1				1
Chapel Is	1.2	17	1		1		1			1									
Chapel Is	5.1	18	1	1	1				1	1		1		1					
Kellys Shoal	2.1	19			1		1	1	1	1		1		1	1		1		
Kellys Shoal	2.2	20	1		1		1			1				1	1				
Kellys Shoal	3.1	21	1		1	1				1				1					
Cape George	6.1	22			1	1	1			1				1					
MacKenzie C.	45.2	23			1		1		1	1									
MacKenzie C.	45.1	24		1	1				1	1		1		1					
Militia Is	51.2	25			1					1				1					
Militia Is	51.1	26	1		1	1				1									
Militia Pt.	50	27	1		1				1	1		1		1					
Pellier Pt Reef	52.2	28			1	1	1			1			1	1	1				
Pellier Pt Reef	52.1	29			1	1	1			1									
Gillis Shoal	53.2	30			1	1				1	1		1		1				
Gillis Shoal	53.1	31	1		1	1				1				1					
Malagawatch	54	32	1	1	1	1				1									

Table 10. Cont'd

Area	*Code*	*Cons No.*	*Moon-snail*	*Peri-winkle*	*Whelk*	*Limpets*	*Other gastro-pods*	*Chitons*	*Worms*	*Cunners*	*Gunnels*	*Flounder*	*Shark egg case*	*Eel grass*	*Kelp*	*Fucus*	*Encrusting bryozoan*	*Sponge*
McKenzie Pt	28.1	1	1															
Dumpling Is	29.1	2		1														
Dumpling Is	29.2	3							1									
Floda Is	15.3	4																
Floda Is	15.2	5	1															
Floda Is	15.1	6		1			1											
Crammond Is	17.1	7		1			1							1				
Crammond Is	17.2	8																
Ronald Is	32	9		1		1		1		1							1	
Mid-Shoal	30.2	10								1		1						
Mid-Shoal	30.1	11	1								1							
Crammond Is	34	12		1	1				1	1	1	1				1		1
McKenzie Pt	28.3	13					1	1	1									
McKenzie Pt	28.2	14										1						
Malcolm Cove	27	15	1									1						
Chapel Is	1.1	16									1							
Chapel Is	1.2	17									1							
Chapel Is	5.1	18																
Kellys Shoal	2.1	19							1									
Kellys Shoal	2.2	20									1				1			
Kellys Shoal	3.1	21		1			1			1		1				1		
Cape George	6.1	22	1	1								1						
MacKenzie C.	45.2	23							1			1		1				
MacKenzie C.	45.1	24		1					1	1	1	1	1					1
Militia Is	51.2	25										1						
Militia Is	51.1	26		1		1				1		1			1	1		1
Militia Pt.	50	27								1	1	1			1			1
Pellier Pt Reef	52.2	28				1				1	1	1			1	1		
Pellier Pt Reef	52.1	29										1			1	1		
Gillis Shoal	53.2	30									1	1			1			
Gillis Shoal	53.1	31				1						1			1	1		
Malagawatch	54	32								1					1			

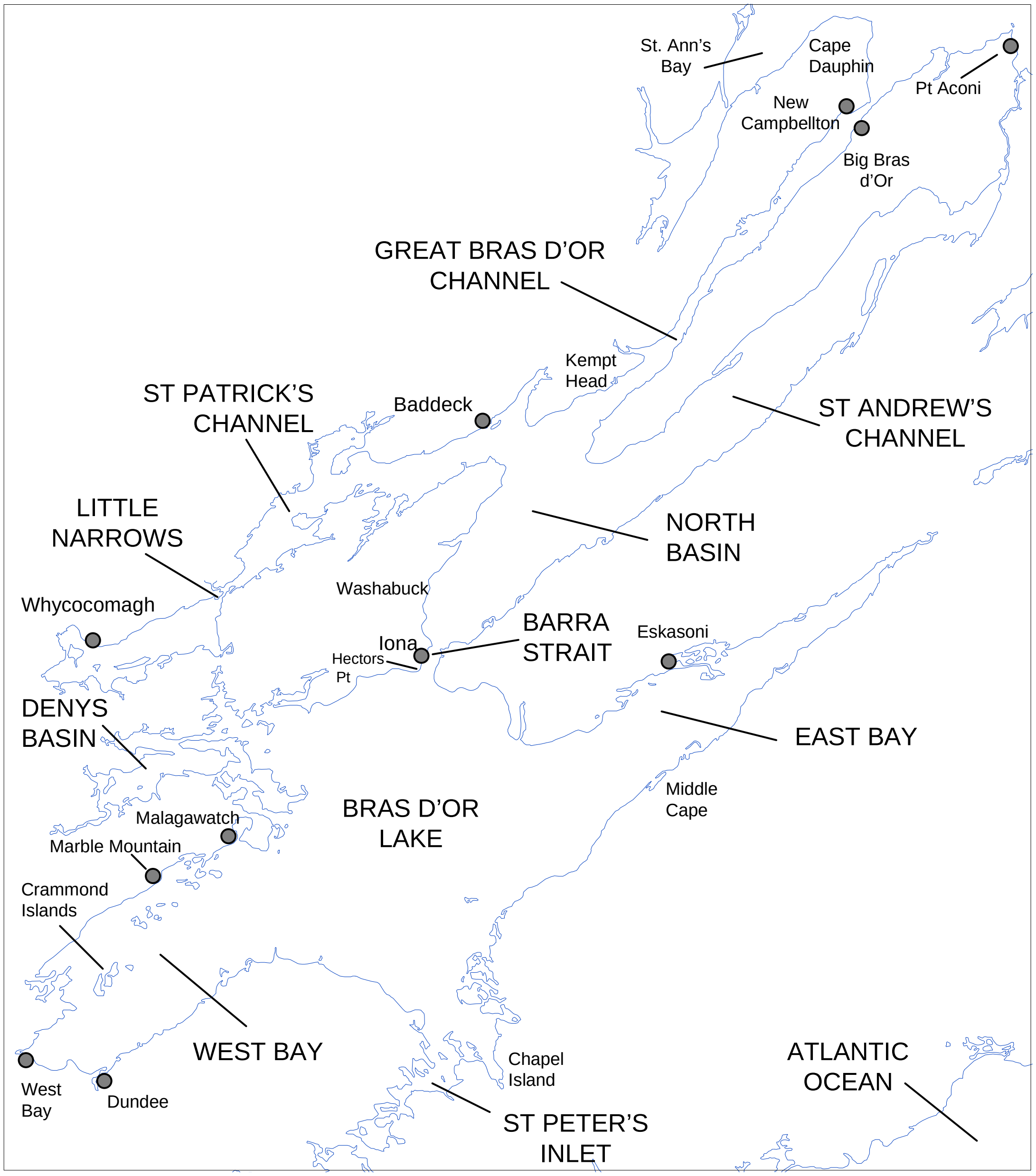

Fig. 1. Map of Bras d'Or Lakes and place names referred to in text.

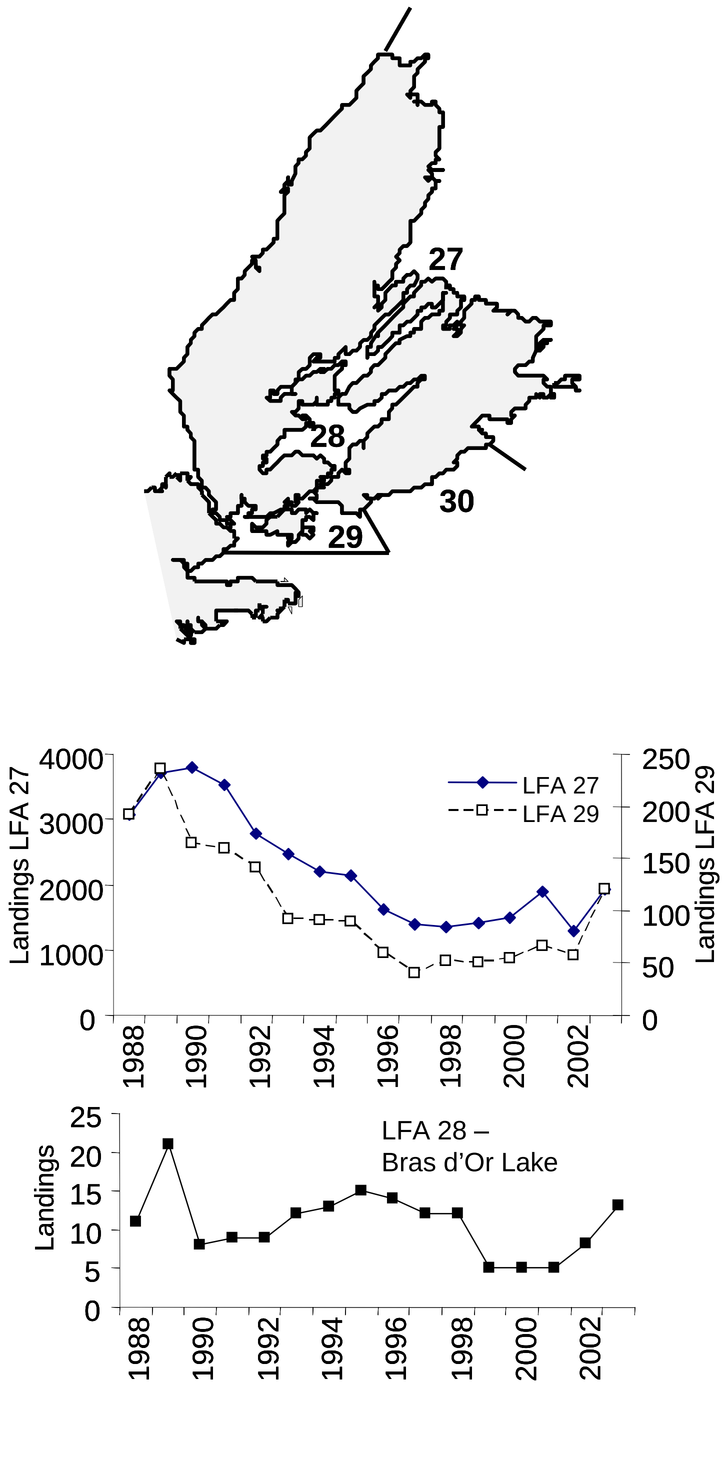

Fig. 2. Map showing Cape Breton Lobster Fishing Areas (LFAs) and graphs of reported lobster landings (tonnes) for LFAs 28, 29 and 27.

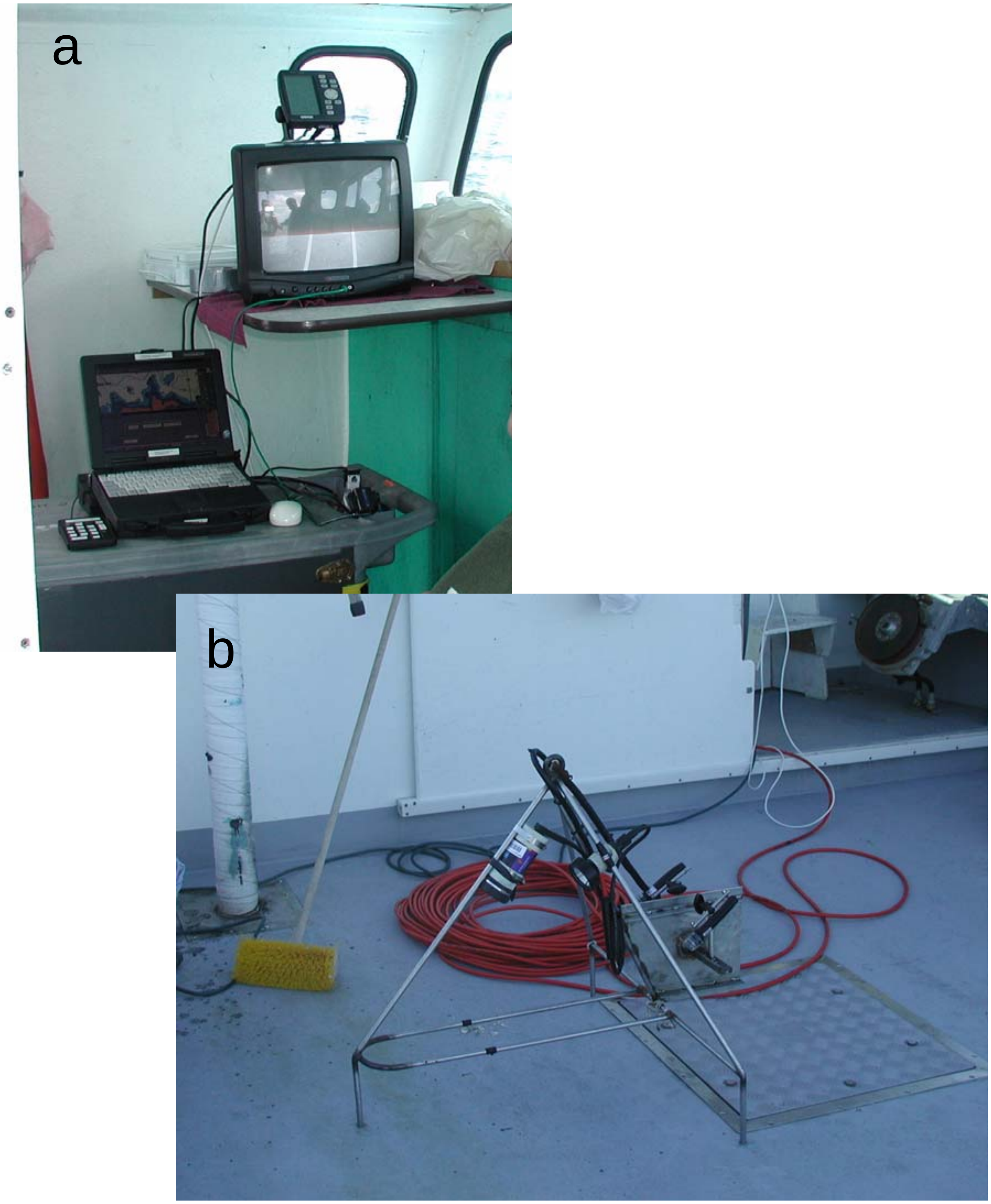

Fig. 3. Urchin system components as deployed on Pie'lalo. (a) Video monitor and computer with software for GIS (MapInfo) and creation and storage of habitat and event files. On top of monitor is GPS unit; to the left of the laptop is the keypad for recording habitat and events; to the right of the laptop is a Digital Handicam for recording the video on mini DV tapes. (b) Urchin tripod with camera, laser lights and auxiliary underwater light.

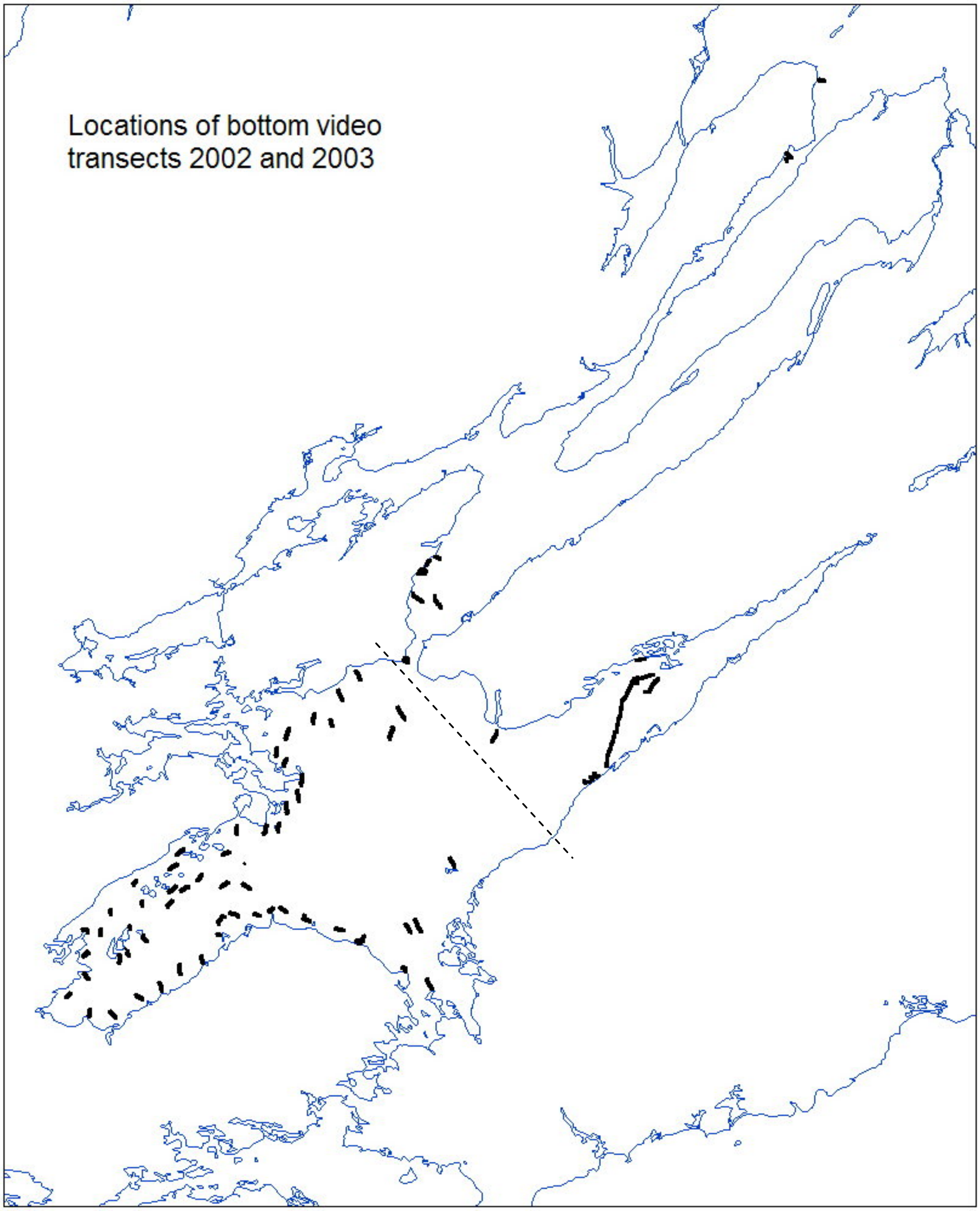

Fig. 4. Location of underwater video transects. Those completed in 2002 are north of the dashed line; those completed in 2003 are south of the line (mainly in West Bay). For area names see Fig. 1.

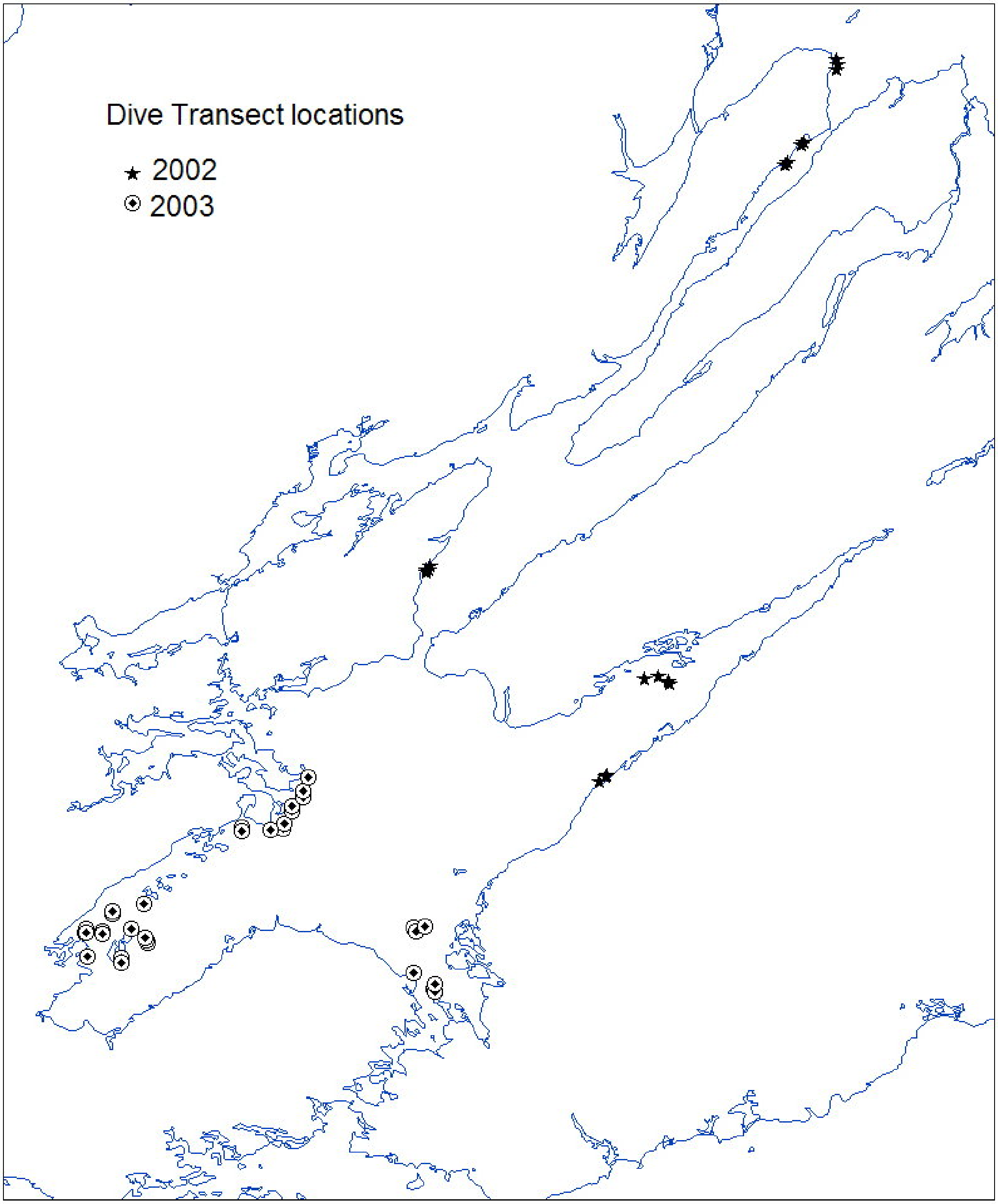

Fig. 5. Location of dive transects in 2002 and 2003. For area names see Fig. 1.

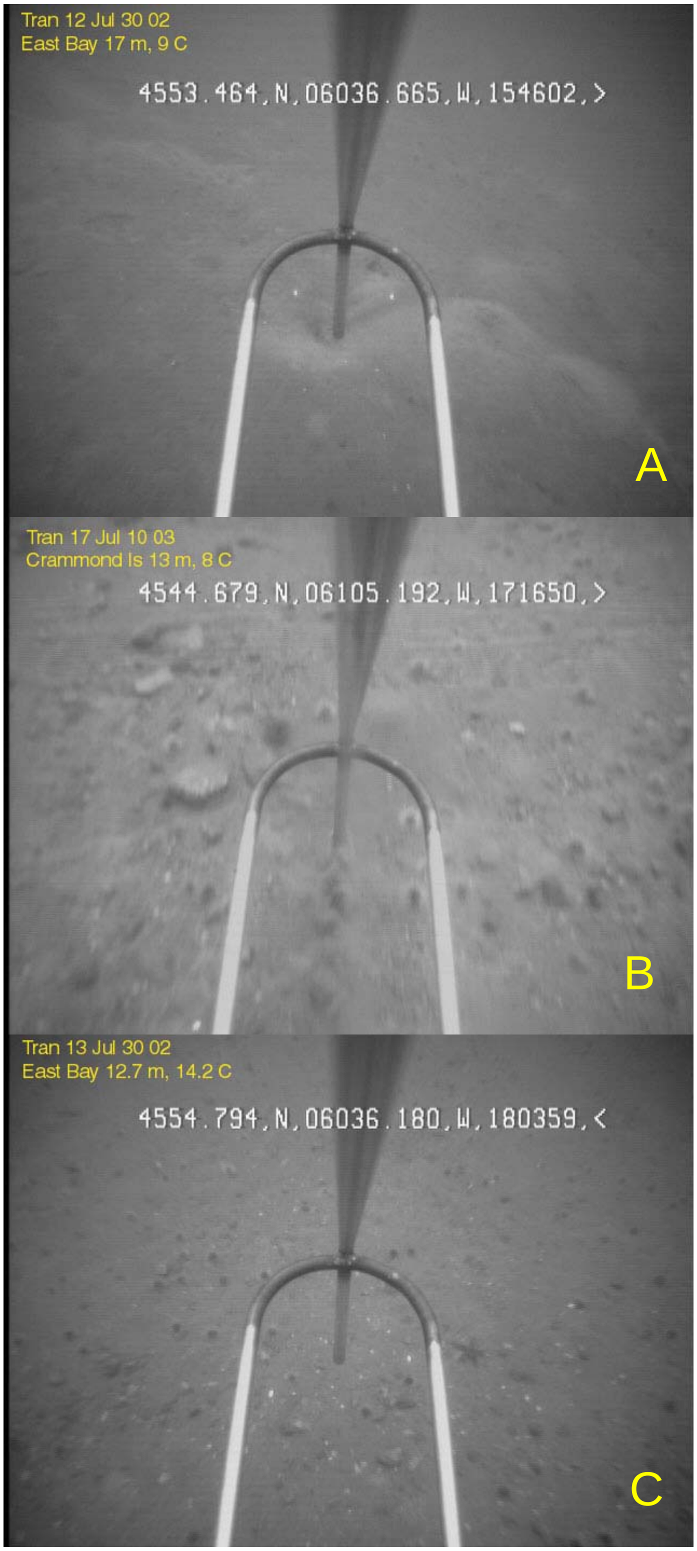

Fig. 6. Examples of low structure bottoms. A,B: East Bay, C: West Bay. Transect number, date, depth and bottom temperature provided in upper left.

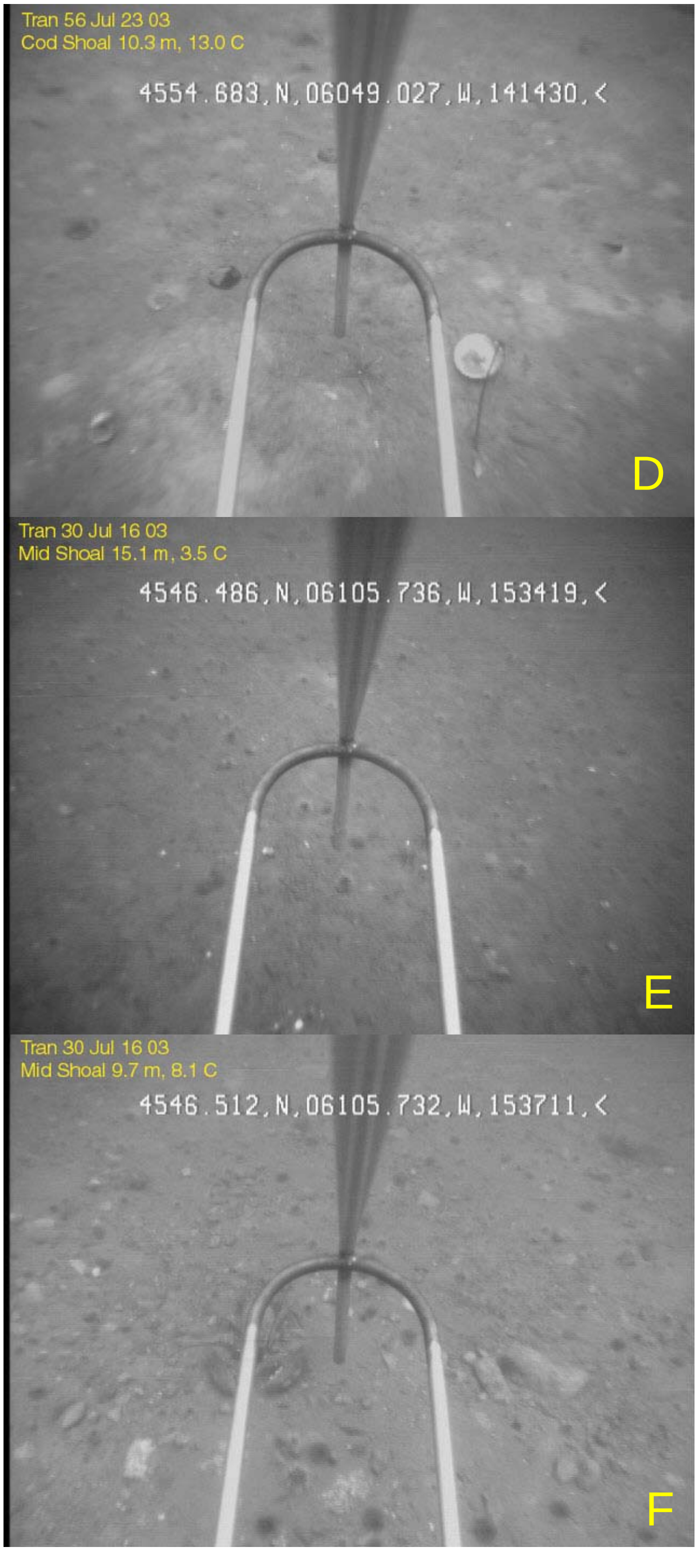

Fig. 6. Cont'd. Examples of low structure bottoms. , D: central Bras d'Or Lake
E: Mid Shoal, West Bay; F: Mid Shoal (note lobster).

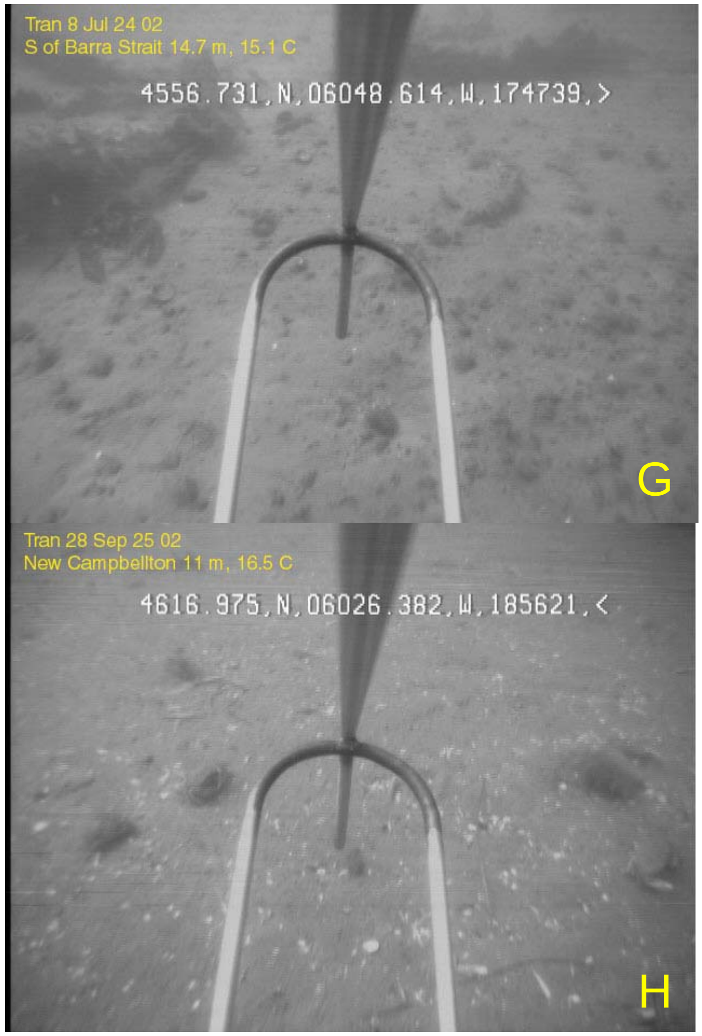

Fig. 6. Cont'd. Examples of low structure bottoms. G: South of Barra Strait (note lobster under drift kelp); H: Outer Great Bras d'Or Channel (note rock crabs).

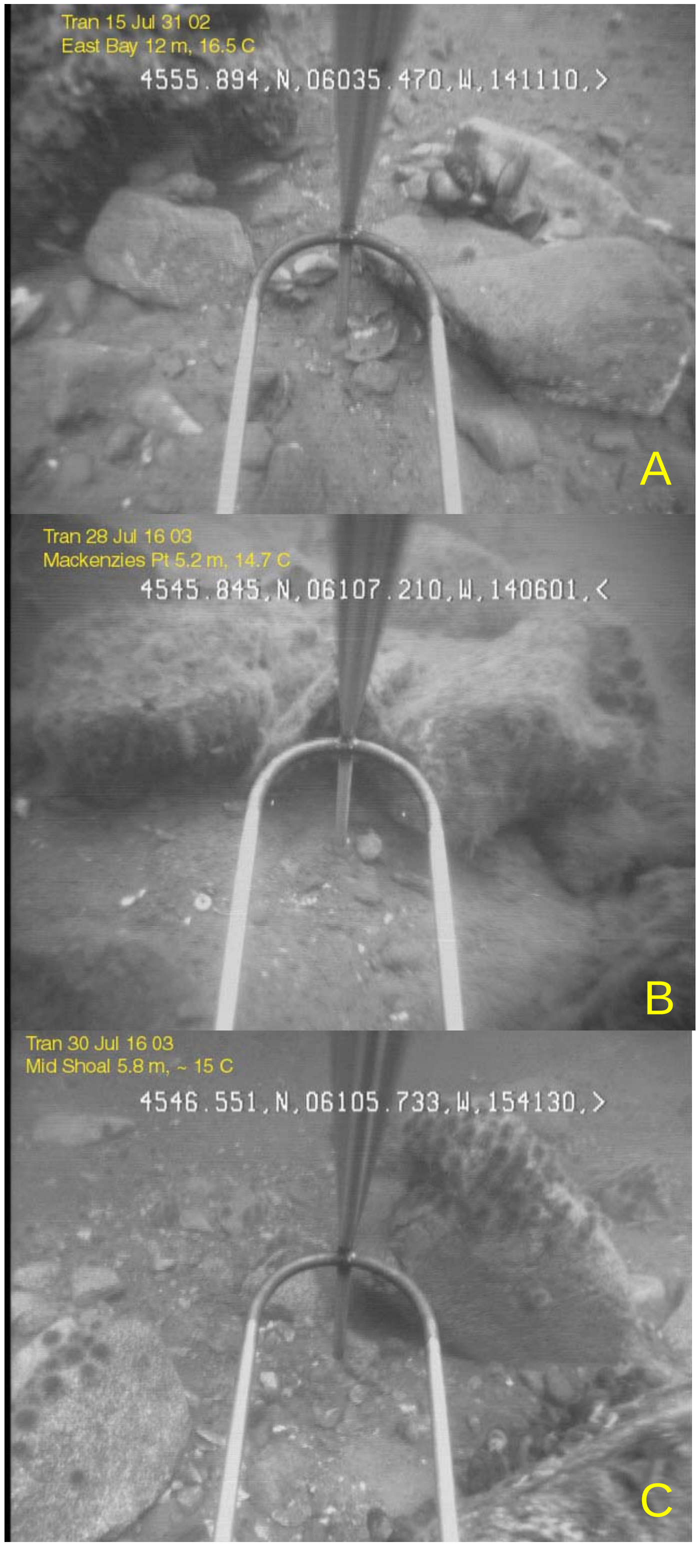

Fig. 7. Examples of moderate structure bottoms. A : East Bay, B-C: West Bay.

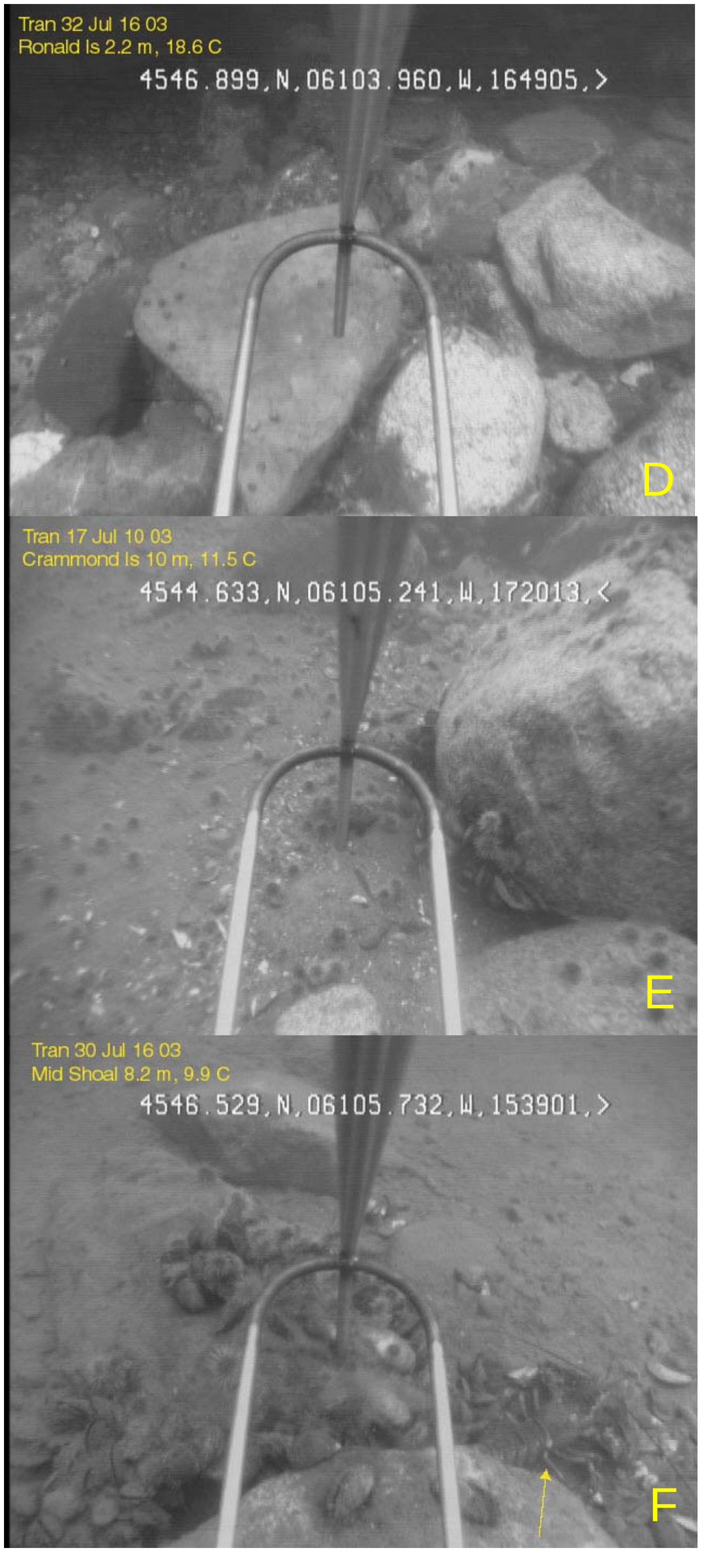

Fig. 7. Cont'd. Examples of moderate structure bottoms. All from West Bay. Note lobster emerging from shelter in F.

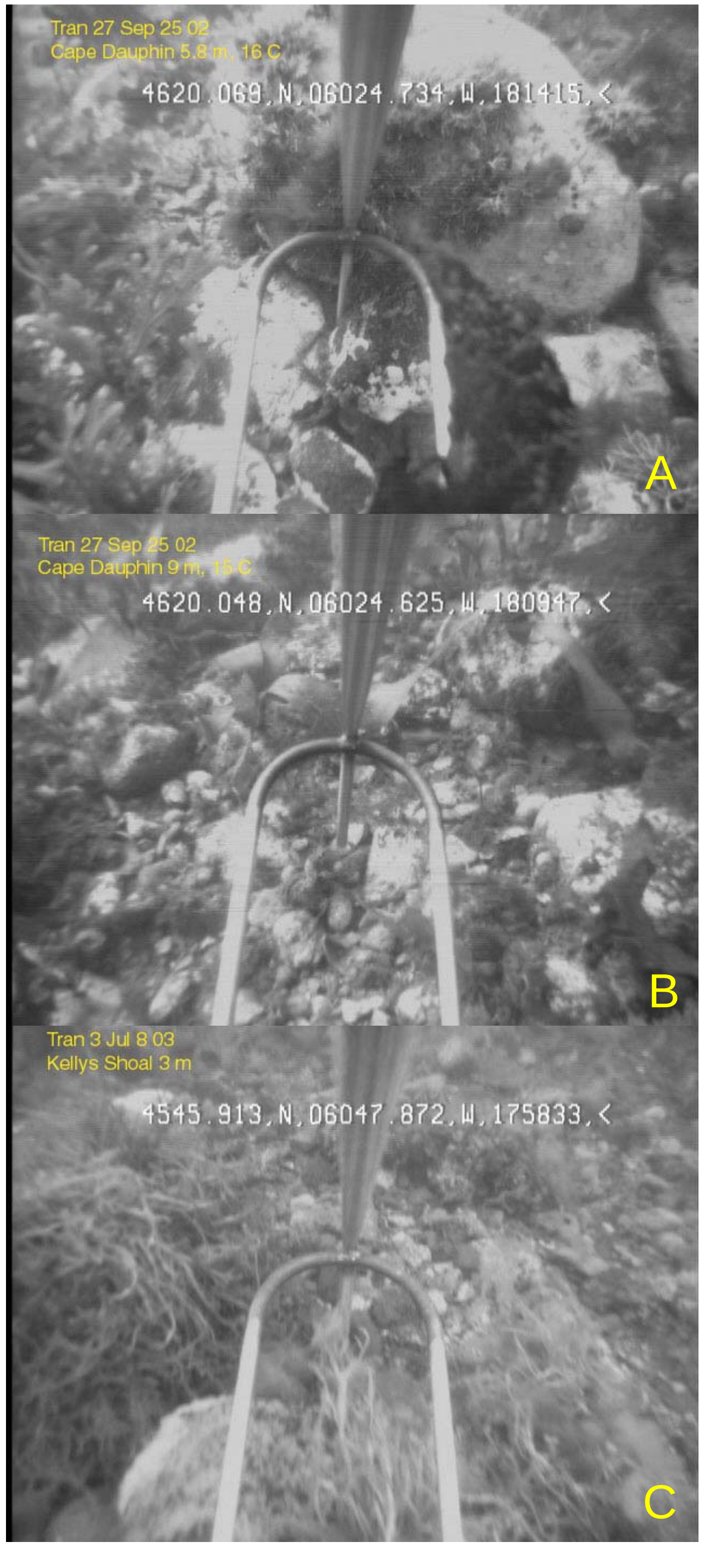

Fig. 8. Examples of high structure bottoms. A, B: off Cape Dauphin; C: Kellys Shoal.

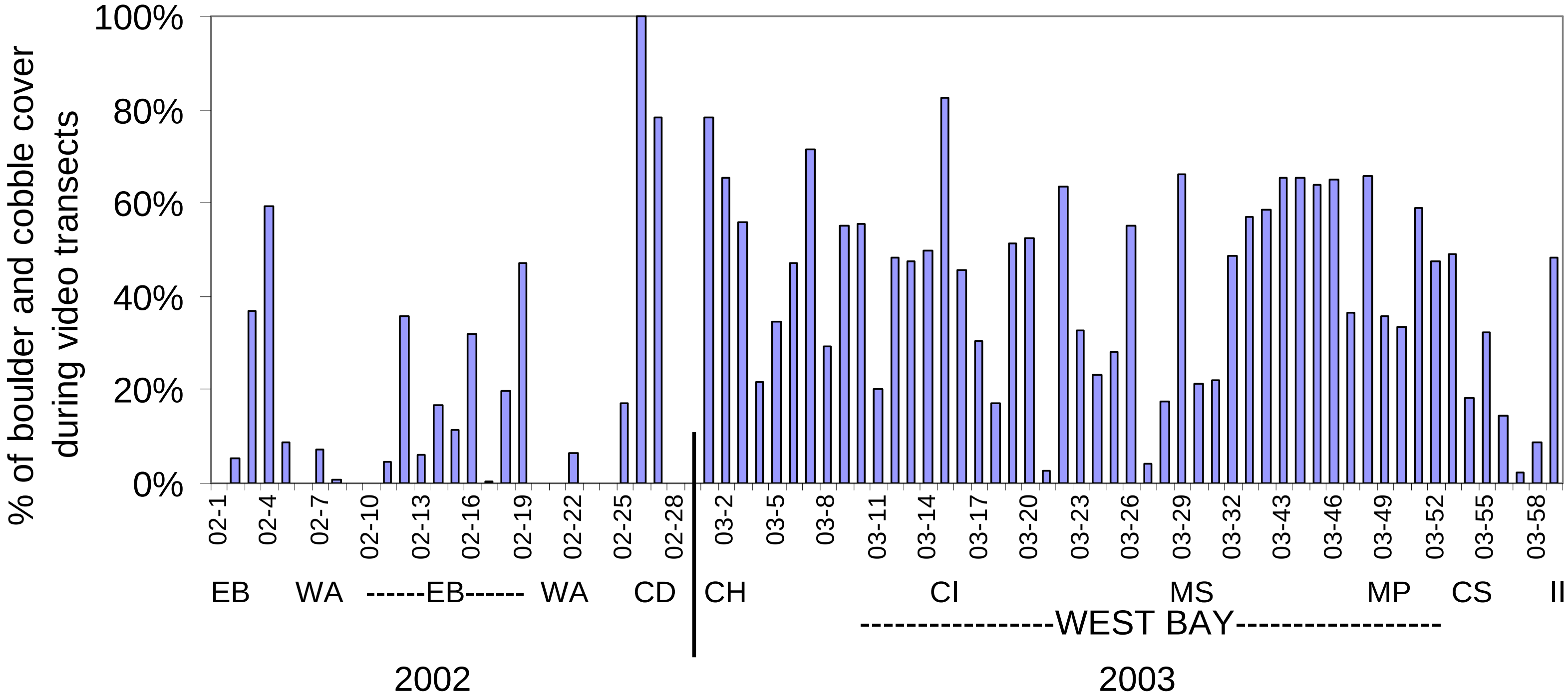

Fig. 9. Percentage cover of boulder and cobble for video transects conducted in 2002 (Consecutive numbers 02-1 to 02-29) and 2003 (03-1 to 03-59). EB = East Bay, WA = Washabuck, CD = Cape Dauphin, CH = Chapel Is., CI = Crammond Is., MS = Mid Shoal, MP = Militia Point, CS = Cod Shoal, II = Indian Island

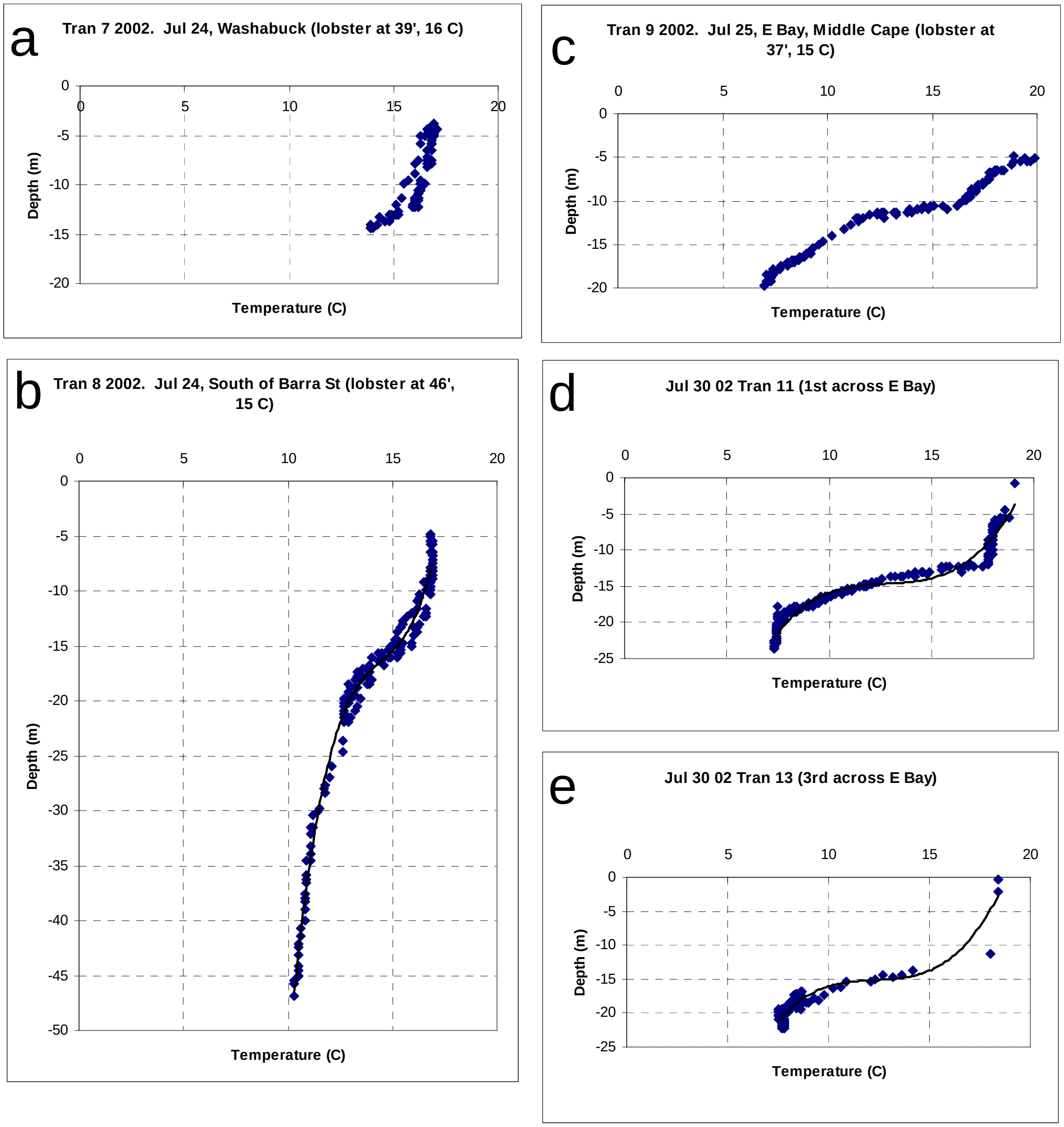

Fig. 10. Examples of temperature profiles from July 2002.

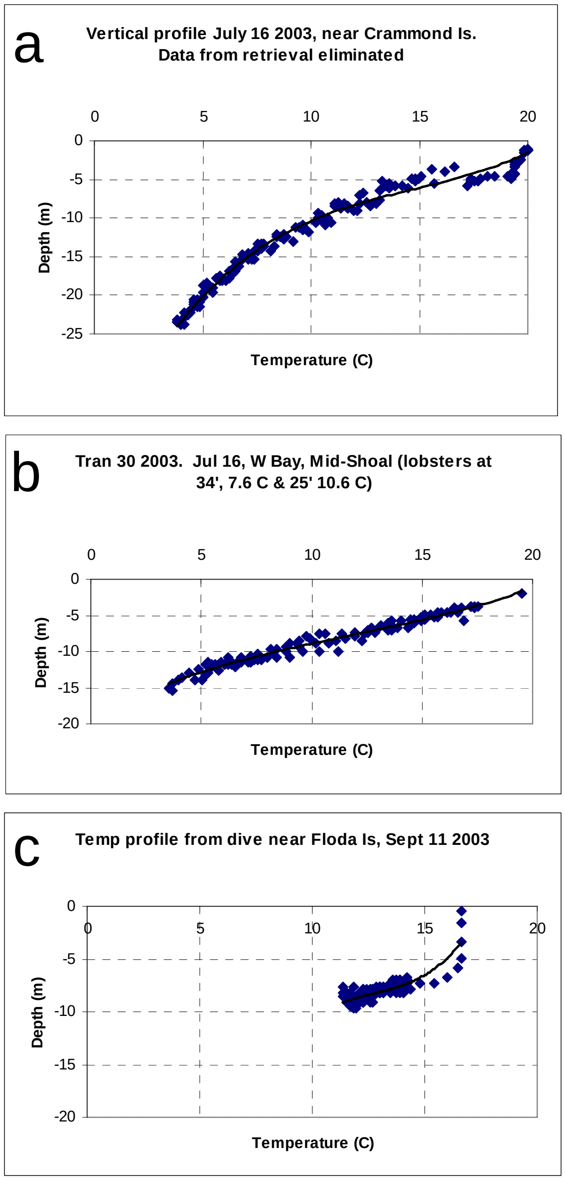

Fig. 11. Examples of temperature profiles from July and Sept 2003.

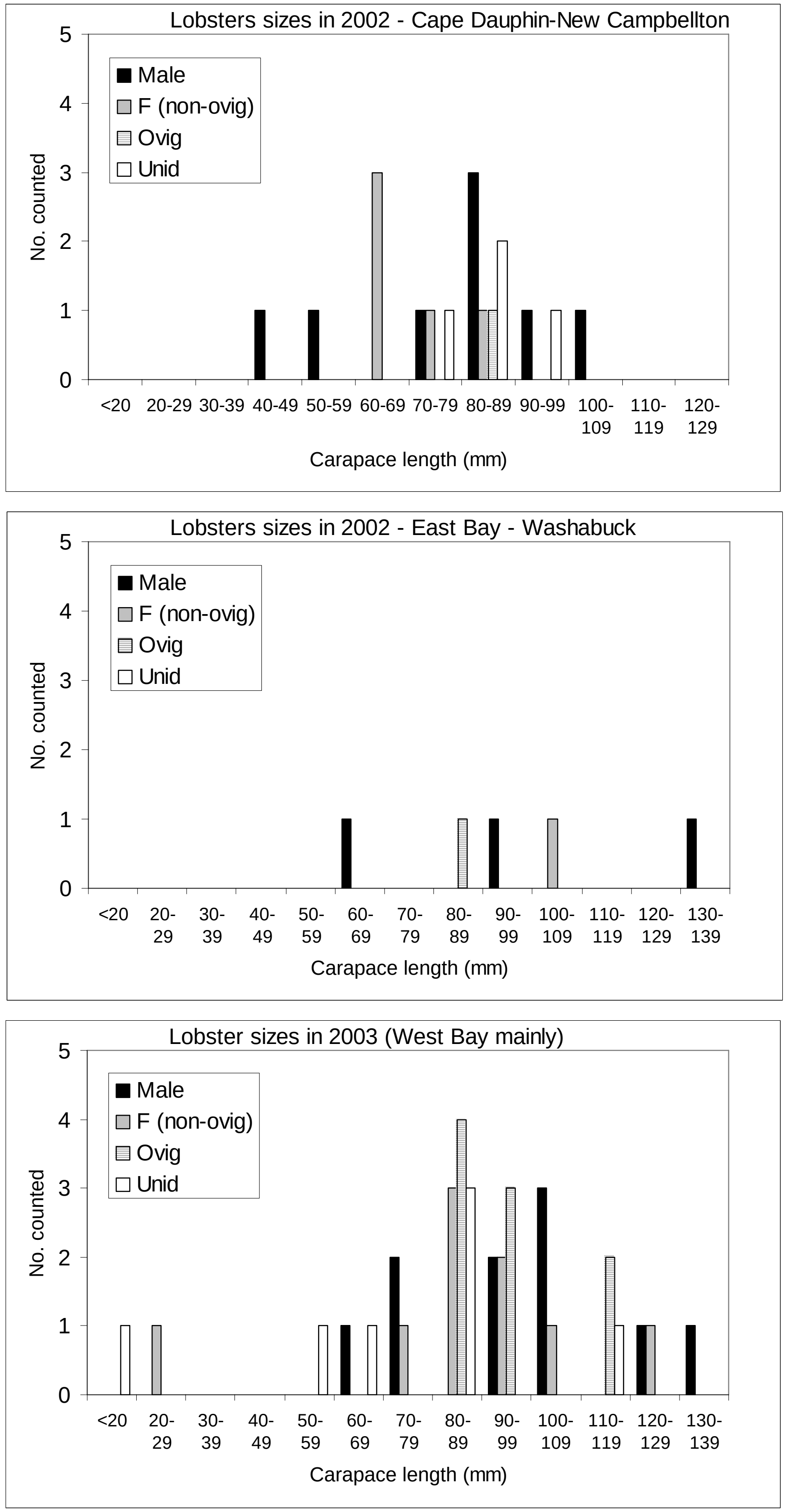

Fig. 12. Size frequency of lobsters measured during dive transects in 2002 and 2003.

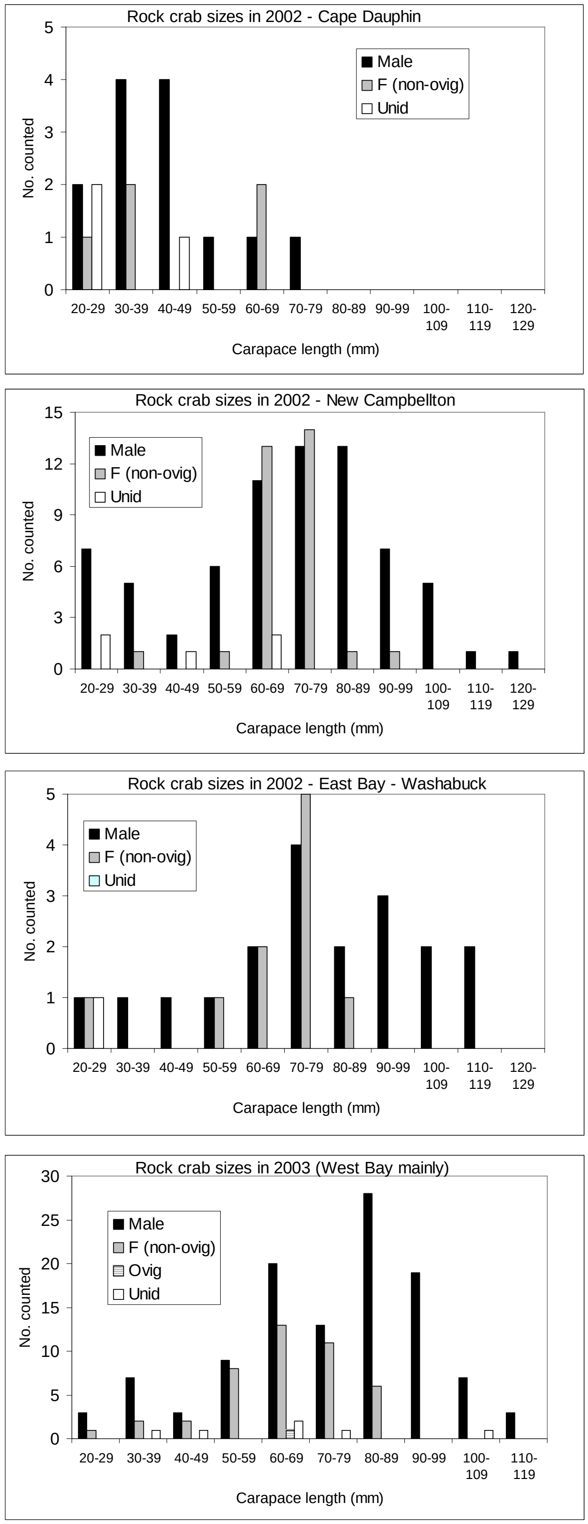

Fig. 13. Size frequency of rock crab measured during dive transects in 2002 and 2003.

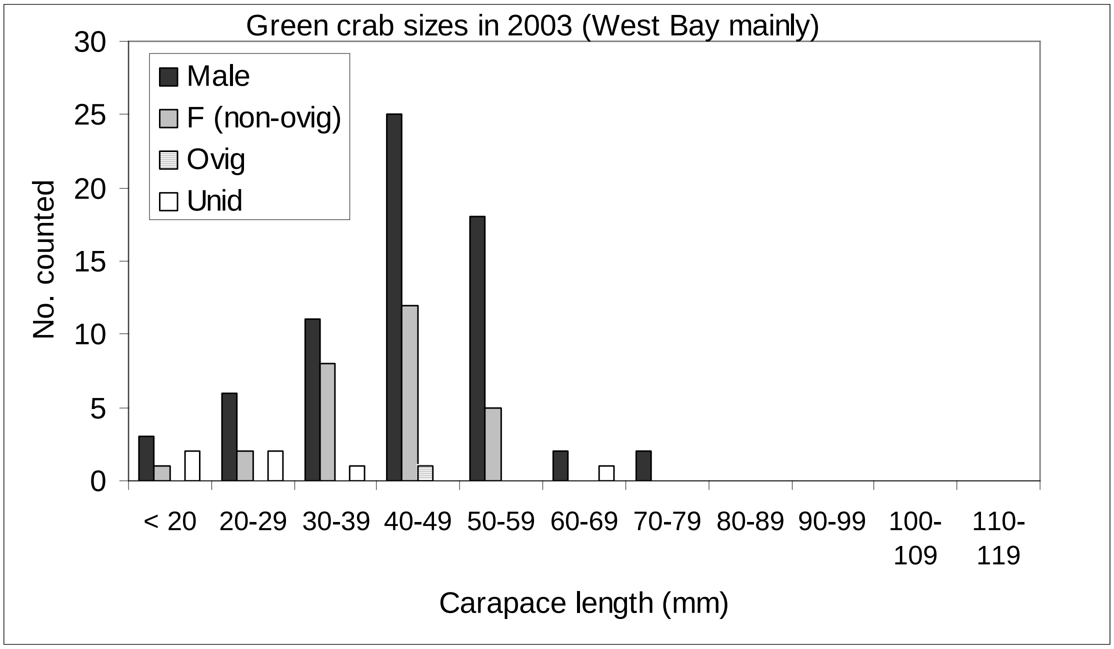

Fig. 14. Size frequency of green crab measured during dive transects in 2003.

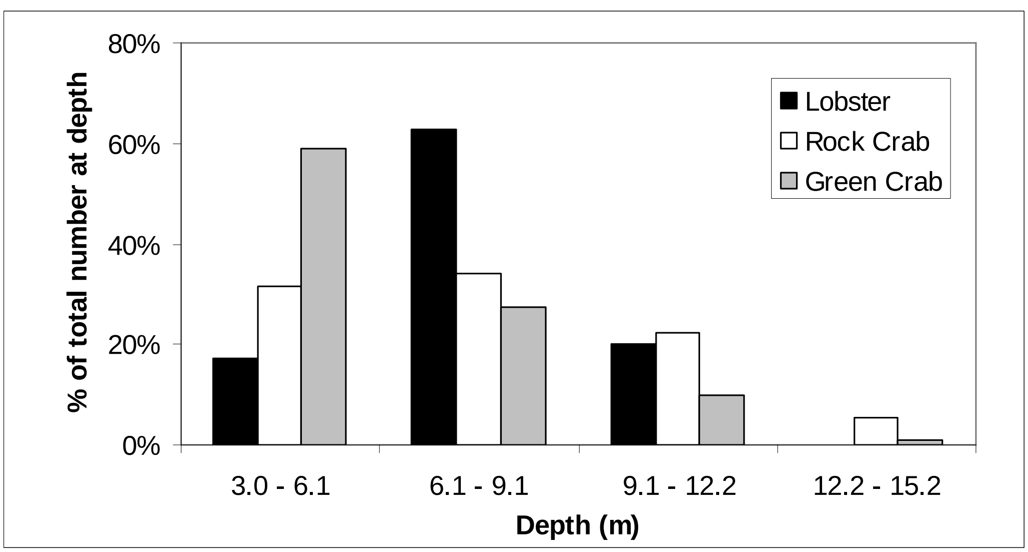

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Fig. 15. Distribution of lobsters and crabs with depth during dive transects in 2003. Displayed for each species is the percentage of the total count measured within each depth interval.

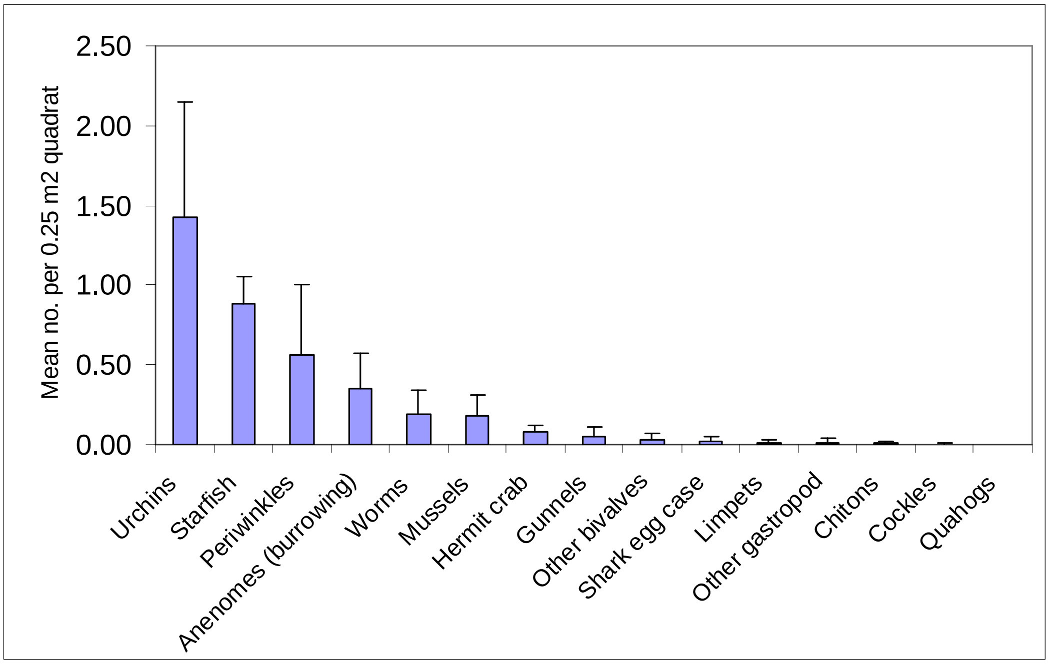

Fig. 16. Densities of 15 most abundant taxa counted during all 0.25 m^2 quadrats (n = 203) in 2003. Lines with vertical bars are standard errors.

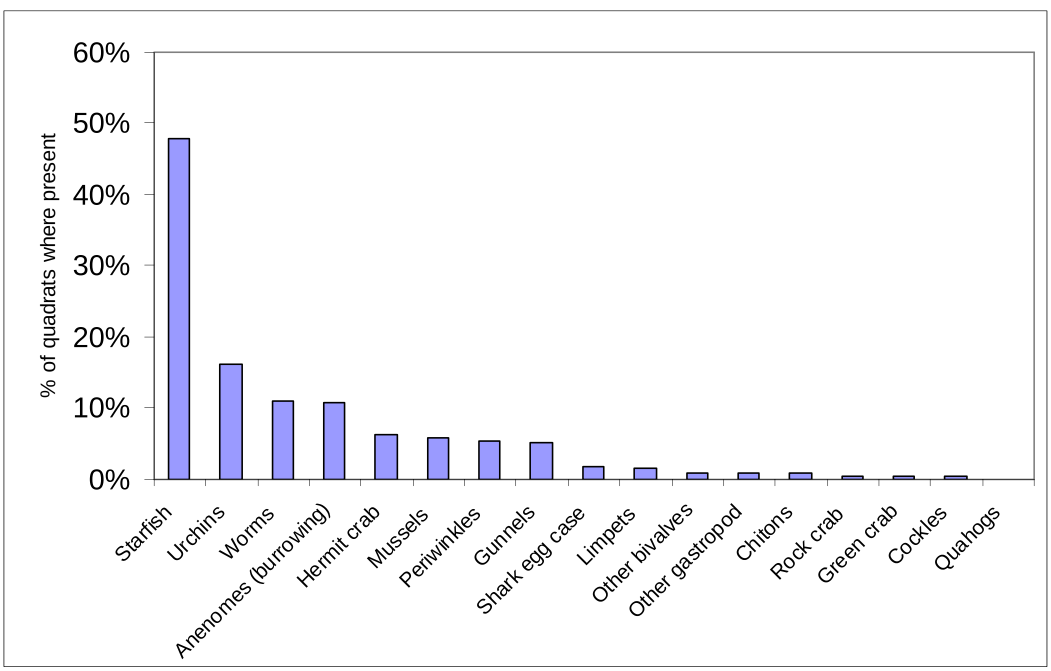

Fig. 17. Incidence of taxa encountered while diving. Shown is percent of quadrats where taxa were present.

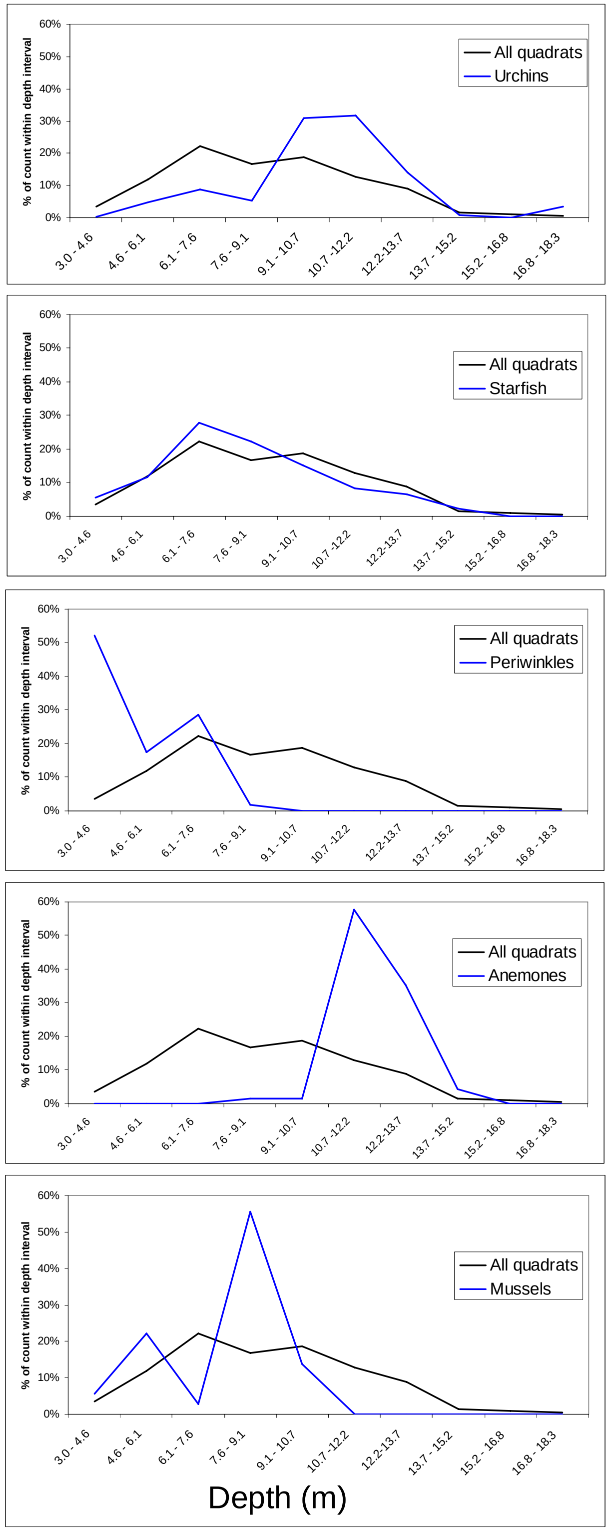

Fig. 18. Depth distribution of 5 most abundant taxa in quadrats. Shown for each taxon is the percentage by number within each depth interval (solid black line). For comparison with the depths that were "available" the percentage of all dive quadrats that were within each depth interval is also shown (dashed line).