COASTAL HABITAT OCCUPANCY BY LOBSTERS, *HOMARUS AMERICANUS*, IN RELATION TO DREDGE SPOIL DISPOSAL IN THE APPROACHES TO SAINT JOHN HARBOUR, NEW BRUNSWICK, CANADA

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ABSTRACT

Lawton, P., Singh, R.S., Strong, M.B., Burridge, L.E., and Gaudette, J. 2009. Coastal habitat occupancy by lobsters, *Homarus americanus*, in relation to dredge spoil disposal in the approaches to Saint John Harbour, New Brunswick, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2844: v + 60 p.

Geo-referenced video, trapping, and line transect diving surveys assessed coastal habitat occupancy by lobsters relative to long-term use of one of Atlantic Canada's major ocean disposal sites. A field experiment used traps set at different distances from a target disposal position to evaluate potential effects of exposure of lobsters to high near-bed sediment loads during disposal events. Visual inspection of lobsters following retrieval from traps, along with determination of glucose concentration (a proxy for stress), indicated a potential for mortality in lobsters in close proximity (less than approx. 100 m) to disposal events. Geo-referenced video enabled calculation of a disposal "footprint" around the target position, and revealed that lobsters quickly reoccupied disturbed sites. Chronologies of disposal events over the 2005 permit season showed that some locations were used at high frequency (sequences lasting over 10 days with consecutive events occurring at < 24 h intervals). Recommendations are made on adaptations to dredge spoil disposal activity to reduce the potential for lobster mortality, and for disposal site monitoring and management.

RÉSUMÉ

Lawton, P., Singh, R.S., Strong, M.B., Burridge, L.E., and Gaudette, J. 2009. Coastal habitat occupancy by lobsters, *Homarus americanus*, in relation to dredge spoil disposal in the approaches to Saint John Harbour, New Brunswick, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2844: v + 60 p.

La vidéo géo référencée, des cassiers et des sondages en plongée le long de ligne de transects ont évalué l'occupation d'habitat côtière par les homards quant à l'utilisation à long terme d'un des sites d'immersion en mer majeurs du Canada Atlantique. Des cassiers ont été mis à différentes distances d'un endroit d'immersion en mer cible pour évaluer les effets potentiels d'exposition de homards aux hautes charges de dépôt près du font pendant les événements d'immersion. L'inspection visuelle des homards après la récupération des cassiers, avec la détermination des concentrations de glucose (un indicateur de stress) a indiqué un potentiel de mortalité des homards tout près (moins qu'approximativement 100 m) des événements d'immersion. La vidéo géo référencée a permis le calcul de "l'empreinte" autour du l'endroit d'immersion cible et a révélé que les homards réoccupent rapidement les sites dérangés. Les chronologies d'événements d'immersion durant la saison de permis 2005 ont montré que quelques endroits ont été utilisés à haute fréquence (séquence pendant plus que 10 jours avec des événements consécutifs arrivant à des intervalles < 24 h). Des recommandations sont faites sur l'adaptation des activités de dépôt de matériaux de dragage pour réduire le potentiel de mortalité du homard, et sur le contrôle et la gestion des sites d'immersion.

INTRODUCTION

Saint John, located at the mouth of the Saint John River, is the largest port in the province of New Brunswick, Canada. Annual dredging of the Saint John River is required to maintain safe navigation, for which the Black Point Ocean Disposal Site (Figure 1) has been designated for dredge spoil disposal. In operation since 1958, Black Point has received over 25 million m^3 of dredge spoil material since the beginning of the disposal activity, making Black Point the largest ocean disposal site in Atlantic Canada (Envirosphere Consultants Ltd. 2003). Although initially selected as a dispersive site, spoil has accumulated resulting in the formation of a shoal (Figure. 2) which requires ongoing management. The responsible federal government agency regulating this activity, Environment Canada (EC), previously sponsored a series of studies under its Disposal at Sea Monitoring Program to evaluate the effects of long-term use of the Black Point Ocean Disposal Site. These studies were primarily focused on contaminants, geochemistry, seabed biological community description, geophysical survey, field measurements, and oceanographic modeling (A. MacDonald, EC, Dartmouth, Nova Scotia, personal communication). A report by Envirosphere Consultants Ltd. (2003) provides a comprehensive summary on prior environmental monitoring at the Black Point Ocean Disposal Site. See also Li et al. (2009) for a recent review of geophysical and hydrographic studies conducted at the site.

There has been much less attention to potential direct and indirect impacts of disposal activity on local marine resource species, such as the American lobster, *Homarus americanus*. Saint John Harbour and the Black Point area fall within Lobster Fishing Area (LFA) 36. One of the major marine fisheries in the region, LFA 36 has 176 full-time commercial fishers (DFO 2007). Fishing season landings have reached an historical high plateau since 2000, averaging 3701 t, with the 2005-06 seasonal landings of 3887 t representing an historical high since landings were first reported in 1892 (DFO 2007). Although the overall stock status is considered to be healthy, there remain concerns over the level of understanding of the ecological and environmental factors that contributed to the large increase in landings in LFA 36 and other Bay of Fundy LFA's since the mid-1990's, as well as uncertainty over the dynamics of the fishery itself, in terms of changes in fishing patterns and effective effort (DFO 2007).

Within LFA 36, local fishing patterns in various parts of the Bay of Fundy are influenced by regional coastal development pressures, such as aquaculture development (Chang et al. 2007), and ocean disposal activities (Lawton et al. 2005). Concerns over the potential impact of dredge spoil disposal activities on lobsters have been widespread among lobster fishermen in New England and the Canadian Maritimes, but few studies have looked at its impact on the resource. One study has shown that juvenile habitats can be vulnerable to sediment disposal activity (Elner and Hamet 1984) while two other studies did not find a significant impact of disposal on lobster abundance (O'Donnell et al. 2007, Valente et al. 2007). Overall, impact of disposal activities on lobster populations seems to be site specific.

In 2003, Fundy North Fishermen's Association (FNFA, Box 241, Lepreau, New Brunswick E5J 2T1) made representations to the Department of Fisheries and Oceans (DFO) and EC, requesting that additional scientific studies be undertaken. Specifically, FNFA requested an evaluation of the population size structure of lobsters occupying coastal habitats in the approaches to Saint John Harbour over summer months, and an assessment of the potential effects of exposure to dredge spoil material on lobster condition. After the fishing season closed on June 30, 2004, local fishermen from LFA 36 volunteered to set lobster traps in the approaches to Saint John Harbour. Fishermen also participated in conducting a trap-based holding experiment to determine the effects of proximity to dredge disposal events on lobster condition. These preliminary studies were reported in Lawton et al. (2005).

This report describes additional benthic video, trapping, and SCUBA diving-based surveys undertaken in 2005, funded by EC's Disposal at Sea Monitoring Program, that provide a more comprehensive description of benthic habitat conditions and habitat use by lobsters in relation to dredge spoil disposal activity and provides further recommendations on approaches to management of impacts on lobsters. To test for the influence of this disturbance, comparisons were made on population size structure, density, and habitat occupancy rates by lobsters between sites which had been subject to ocean disposal activity within the past two years, and sites which had not received spoil material for greater than four years (i.e. two disturbance "regimes", or experimental "treatments").

METHODS

Dredging activity in Saint John Harbour occurs during the summer and the fall, which corresponds to the closed fishing season for lobster in LFA 36. During the year of this study (2005), disposal activities commenced on August 4 and ended on November 11. Dredge spoil disposal has been undertaken annually since 1958 at Black Point (Figure 1). The Black Point Ocean Disposal Site is exposed to strong currents induced by the outflow of the Saint John River and the Bay of Fundy tides, with a tidal range in excess of 8 m. This site was selected as the disposal area because of its dispersive potential due to the strong currents. Nonetheless, over the years, there has been gradual accumulation of spoil material, resulting in the formation of a shoal area (Figure 2). Around the disposal site, water depths are between 15 to 30 m, while the depth over the long-term disposal site has been reduced to as little as 3-4 m (Li et al. 2009). Because of the shallow depth above the shoal, a new area, the 'recent disposal area' was established in 2003 to the northwest of the original area (Figure 1). The 'old disposal area' has not received spoil material since 2001.

HABITAT OCCUPANCY BY LOBSTERS IN SAINT JOHN HARBOUR APPROACHES

Research conducted in 2005 centered on both the recent and old disposal areas at the Black Point Ocean Site with some sampling also conducted at Mispec Point and Anthony's Cove based on the recommendations of the previous work (Lawton et al. 2005). Mispec Point delimits the eastern point of the Saint John Harbour approaches, and was used both as an additional site from which to document summer coastal habitat occupancy by lobsters, as well as a location from which to obtain lobsters for field experiments to be conducted in 2005. Anthony's Cove is situated further inside the harbour approaches to the northeast of Black Point Ocean Disposal Site, and is characterized by generally deeper bathymetry (Figure 1). Anthony's Cove had been selected as an alternative dump site for annual dredge spoil material following consultations with local stakeholders. As such, disposal activities at Anthony's Cove were much less intense than at Black Point and it was considered feasible to conduct a field experiment there (see Lawton et al. 2005 for additional details).

In July 2005, immediately following the close of the spring lobster fishing season on June 30, but before the commencement of disposal activities, the influence of previous years' disposal disturbance on population size structure, density, and habitat occupancy rates by lobsters was investigated by conducting benthic video, trapping, and SCUBA diving surveys. Lobster population characteristics were compared between two disturbance regimes at Black Point: 1) the 'old disposal area', which had not received spoil material for greater than four years and 2) the 'recent disposal area' which had been subject to ocean disposal activity within the past two years. In the shallowest portions of the disposal site SCUBA-based line transect survey approaches (Lawton et al. 2001) were feasible, whereas in deeper portions of the site only trapping and remote video survey approaches were used (Strong and Lawton 2004; Lawton et al. 2005). For field survey planning a series of eight 200 m x 200 m survey boxes (Figure 2) were identified in a geographic information system (GIS) workspace following a review of prior Natural Resources Canada (NRCan) multibeam seabed surveys (provided by R. Parrott, Geological Survey of Canada (Atlantic), NRCan, Dartmouth, Nova Scotia) and information on prior dredge disposal activity (S. Lewis, EC, Dartmouth, Nova Scotia, personal communication). Four boxes were in the old disposal area and four were in the recent disposal area. Remote video and trapping survey target positions were identified for all eight boxes. Due to depth and time considerations SCUBA diving surveys were only targeted for completion within survey boxes 2, 3, 5 and 6 (Figure 2).

Remote Video Surveys to Assess Lobster Distribution (Black Point)

This survey was conducted from July 4th to July 8th 2005, prior to the SCUBA diving and trapping surveys. A total of 23 transects were undertaken at the recent disposal area and 15 transects at the old disposal area (Figures 3 and 4; Appendix 2). The URCHIN remote camera system that was used had been recently developed by DFO (see Strong and Lawton 2004 for a detailed description) for coastal habitat inventory and consisted of a monochrome camera and a light attached to a stainless steel tripod. Powered from the surface via a 100-m cable, the system included a pair of underwater lasers for scaling the camera footprint. Depth and temperature were recorded using a Vemco TDR minilog attached directly on the tripod. Data on latitude and longitude were acquired via a Garmin GPS map receiver and antenna and a GBR 23 differential receiver on the surface vessel. Images from the camera along with the position information were recorded on mini-DV format digital videotapes. The URCHIN video system was used in a drift mode and the location of the vessel was tracked on a Panasonic Toughbook CF-27 computer using MapInfo software. The system was deployed using the DFO Research Vessel *Salar*.

The geo-referenced video footage was subsequently analyzed for a range of biotic and abiotic benthic habitat criteria by a single technical analyst, working from a customized spreadsheet data entry form adapted from the Northeast North America regional marine habitat classification scheme of Valentine et al. (2005; see also Appendix 1). Valentine et al. (2005) use the following distinctions between the various spatial extents at which marine habitat classification is required: micro-habitats (requiring 1 to 10's cm resolution), macro-habitats (structured over 1 to 10's m ranges), meso-habitats (10's m to several km), and mega-habitats (10's km, aligning with major physiographic and marine geological features). Although in this project the analysis is for the effects of a specific human use activity (ocean dredge spoil disposal) within a specific meso-habitat unit (approx 1 km by 1 km), geo-referenced video records, analyzed in conformance to a recognized marine habitat classification scheme, will ultimately be useful for contribution to regional mega-habitat classification.

In describing marine habitats, Valentine et al. (2005) use three levels of descriptive terms: seabed substrate dynamics (their class 2); seabed substrate type (their class 3), and degree of physical and biological structural complexity (classes 24 and 11). All three levels were adapted into the spreadsheet-based analysis approach (see Appendix 1 for details).

A Macro-habitat Scale Analysis determined habitat structure and transitions at 1 m to 10 m scales. This was the initial tape analysis approach - undertaken by reviewing specific sections of each video tape, either in slow forward, normal speed, or rewind-playback. Primary consideration was the analysis of seabed features and the location of transitions in macro-habitat type, not fauna and flora enumeration. While referring to the tape time stamp, a segment of tape was viewed to define where a significant transition occurred.

A subsequent Micro-habitat Scale Analysis determined seabed and biological features at sub-meter resolution. This was undertaken as a secondary analysis, once the macro-habitat scale results had been reviewed. Based on the definition of specific bottom types and disturbance condition assessments, as well as the field of view and image quality criteria, specific frames were identified to re-analyze to record micro-habitat features.

The data obtained from these analyses were entered into a spreadsheet with three tables: Habitat, Species, and Human Usage. Appendix 1 provides details on the actual records that were extracted from the tapes.

Trapping Surveys to Assess Lobster Distribution (Black Point, Mispec Point, Anthony's Cove)

To determine the spatial and size distribution of lobsters in the Saint John Harbour approaches, a combination of juvenile and commercial lobster traps were used rigged into trawls of five traps. Each trawl consisted of two commercial traps (one at each end) and three juvenile traps in the middle section. A 40 m line separated the traps from each other. Each end commercial trap had a buoy line (30 to 40 m) to the surface. Traps were baited with redfish racks, and 113 g to 436 g fresh herring per trap.

Juvenile traps were built by Wade's Wire Traps of Glennwood, Yarmouth County, Nova Scotia, according to specifications provided by the Fishermen and Scientist Research Society, Nova Scotia. Traps were 102 cm long x 53 cm wide x 36 cm high, constructed from Aquamesh GAW (galvanized after welding) wire mesh having squares of 2.5 cm x 2.5 cm. The entrance hoop was 12.7 cm in diameter. A ghost-fishing panel (designed to allow escapement of lobsters from traps that are lost) consisted of a piece of wire mesh held in place with biodegradable hog rings over a 10.16 cm x 15.24 cm hole. The corners were reinforced on the hauling end using 4 mesh x 5 mesh (3.81 cm x 3.81 cm) with extra bracing on sides and hauling end. The runners were made of hardwood and three cement ballasts (3.63 kg each) were used.

Commercial traps, supplied by local fishermen that participated in the survey, were an American design (comprising one "kitchen" and two side-by-side "parlour" areas) constructed of plastic-coated wire mesh. Traps were 122 cm long x 57 cm wide x 34 cm high with wire mesh squares of 3.8 cm x 3.8 cm, and an entrance hoop size of 17.8 cm. The center hood was a 12.7 cm ring.

The trapping survey was conducted at three locations around the approaches to Saint John Harbour. At Black Point Ocean Disposal site, the trapping survey took place between July 4 and 17, 2005, just before the beginning of the disposal activity at this site (which started August 4, 2005). Ten trawls (a total of 50 traps) were set within the old disposal area and the recent disposal area along a North-South bearing (Figure 5). After a one-day soak and haul, trawls were reset in the same location for a two-day soak and haul. Due to the overall availability of traps, access to the site from local wharves, and tidal factors, the trapping proceeded in a sequential manner through the different survey boxes. Sequencing of the trapping survey was also influenced by the requirement to also conduct remote video drift surveys and SCUBA diving-based line transects. In general the sequence adopted for each survey box was to first undertake remote video surveys, then diving-based assessments, and finally trap-sampling.

At Mispec Point, the trapping occurred during the period August 22 to 25, 2005 while disposal activity was happening at Back Point. Traps were set at depths similar to the survey conducted at Black Point. Eight strings were deployed parallel to the shore and one more offshore along a North-South bearing (Figure 6). Traps were first set for a one-day soak followed by a two-day soak. In addition to being used to provide more information on coastal habitat occupancy by lobsters in this region, the trapping at Mispec Point was used to provide a source of lobsters for the field experiment to be conducted at the Anthony’s Cove alternative disposal site.

At Anthony’s Cove, a final period of trapping was conducted between August 30 and September 3, 2005. This trapping survey also coincided with disposal activities that were still underway at the nearby Black Point Ocean Disposal Site. Nine trawls were set for a two-day soak followed by a one-day soak, near the 2005 alternative disposal site in Anthony’s Cove. Five additional trawls were also set for a two-day soak closer to the shore of Anthony’s Cove (also identified as Cranberry Point in this report; Figure 7). All trawls were set along a North-South bearing at depths ranging from 8 to 16 meters.

Because the trapping survey occurred during the closed fishing season, an out of season lobster fishing license was required. Fishing activities were restricted to daylight hours and high tide periods, due to restricted vessel access at Mispec wharf (several hours either side of high tide). All trapping was conducted onboard commercial lobster fishing vessels.

At-sea trap sampling data collection was undertaken by a contracted marine biologist (A. MacIntyre, Under the Sea, St. Andrews, New Brunswick) familiar with DFO protocols on quality assurance, and the use of standardized field data recording sheets. Information recorded by individual trap hauled included the size (carapace length, CL, to the nearest mm), sex category (male, female, egg-bearing (berried) female), and moult condition (hard-shelled, soft-shelled) of each lobster caught. Completed field data sheets were forwarded to DFO’s Science Branch, Biological Station, St. Andrews, New Brunswick, where the catch information was entered into an Oracle relational database (Crustacean Research Information System, CRIS) using a unique trip identifier. A wide range of trip reporting options are available through CRIS, including the representation of catches in terms of estimated weight. Estimated weights (in g) are calculated in CRIS for individual lobsters using wet weight to CL (mm) relationships for different sex categories. Although individual lobster weights were calculated in g within CRIS, trap catches are presented in terms of pounds of lobster per trap haul (pounds/TH), for ease of interpretation by stakeholders.

Mark-Recapture Studies to Assess Lobster Movement (Black Point)

During the July 2005 trap sampling at the Black Point disposal site a mark-recapture study was undertaken to assess short-term movement of lobsters within the vicinity of the survey boxes. All lobsters caught from traps hauled from one of the survey boxes sampled during each day's trapping activity were banded by placing a rubber band over one of the claws (so as not to impair claw use), before releasing the lobster to the water. In the event of recapture of a previously tagged lobster, an additional band was to be placed upon the claw. Additional bands were applied if lobsters were subsequently recaptured. This provided a simple means to identify both single and multiple recaptures of individual lobsters, although as the bands were not numbered, the movement analysis was restricted to a general estimate of recapture rates within the traps sampled.

Line Transect Surveys by SCUBA Divers to Assess Lobster Distribution (Black Point)

The SCUBA diving survey was conducted at the Black Point Ocean Disposal Site from July 6 to 13, 2005. For the first transect in the old disposal area a 150 m transect was used. The transect line was marked every meter with twine, and every 5 m with a numbered tag for underwater orientation of the divers and for recording the location of lobsters and habitat features. One end had an anchor with a buoy line to the surface; the other end had a weight and a buoy line to the surface. The transect line was deployed from the surface by the support vessel, a commercial lobster fishing vessel (*Bay Breeze*) using the GPS system on the boat to locate the target positions for the start point and transect heading. Due to the working depth and the time required to search for lobsters, divers were unable to complete this first transect and all subsequent dive transects were restricted to 50 m in length. Divers searched an area one meter on both sides of the transect line by upturning boulders and cobbles, investigating crevices in hard bottom areas and probing burrows in soft sediments. For lobsters that could be captured on bottom the following information was recorded on underwater slates: CL (to the nearest mm), sex category, moult condition, and the distance along the transect line where caught. Divers also recorded general substrate categories.

In addition to completing line transect surveys for lobsters, SCUBA divers also obtained underwater video footage at the Black Point Ocean Disposal Site. During an exploratory dive on July 5, 2005, underwater video of one of the trapping trawls was recorded. Diver-held video of benthic habitat conditions was also acquired on July 13, 2005, at three separate pre-identified locations in survey boxes 3, 5 and 6 (Figure 9).

LOBSTER RESPONSE TO DREDGE SPOIL DISPOSAL EVENTS

Field Experiment Setting (Anthony's Cove)

To determine the impact on lobsters of exposure to increased sediment load associated with disposal activities, a field experiment was undertaken that involved placing lobsters in holding traps set at specific distances from a target disposal point. Anthony's Cove was selected as the site for the field experiment due to the limited disposal activity at this alternate disposal site which facilitated coordination with the Saint John Harbour Authority and its contractor for dredge spoil disposal in 2005. A target position was identified where disposal events using the dredging company scows could be specified to occur over a specific two-day period (August 27-28, 2005; Figure 10). A control area, where there was to be no dredge spoil deposited, was identified south-east of the disposal target (about 700-800 m away). This control area was at a similar water depth (Figure 10).

Lobsters to be used in this holding experiment were obtained on August 25 and 26, 2005, from traps which had been set for one day soaks in an area near Mispec Point (Figure 6). To obtain sufficient numbers of animals, those lobsters caught on August 25 were submerged in plastic crates until the following day; their claws were banded to reduce damage from aggressive interactions within the crates. On August 26 one fishing boat was used to haul, select and band the claws of newly-caught lobsters and then transfer these additional lobsters to a second fishing boat that had retrieved those lobsters captured the previous day. Lobsters were selected for use in the holding experiment from the combined catch of the two days of fishing. All were in hard-shell condition, had both claws intact, and exhibited no obvious external shell injury prior to placement in the holding experiment traps. There was no sex-based selection; however, lobsters were carefully examined for moult condition. Lobsters that had recently moulted and those close to moult (with an observable pre-moult split mark in the dorsal carapace) were not used. Lobsters were divided into two size groups (70-79 mm CL; 80-99 mm CL) and both claws were banded to prevent lobsters from injuring one another during the holding experiment. Each lobster was then finally checked for several physical characteristics (Appendix 3) and banded on the upper part of the claw with a numbered plastic cable tie. Eight lobsters (four from each size category) were placed in juvenile lobster traps similar to the ones used in the trapping surveys previously described. As the experimental design required a total of six different sets of traps (3 replicates per treatment/control) this resulted in (8 x 3) x 6 = 144 lobsters being used in this experiment.

The traps were tied in trawls of three with a 40 m line separating each trap. A separate end commercial trap was attached to the string of three juvenile traps by a 120 m line. This non-fishing (closed entrance) commercial trap also had a buoyed line of 40 m and was used to ensure that the retrieval of the trap trawls could be undertaken from a point away from the target disposal point. Traps trawls were deployed on August 26 at pre-determined locations in the treatment and control areas (see Figure 10). In the treatment area, four trawls were set such that the juvenile traps with lobsters in them were targeted to be at three radial (40, 80, 120 m) distances from the disposal target in a web-design (four axes, three distances from target per axis). This resulted in four sets of three traps, each being the same distance from the target in the treatment area. In the control area, two strings of traps were deployed parallel to each other (Figure 10).

After the disposal treatment had occurred (34 events of dredge spoil disposal activity at the disposal target on August 27 and 28), traps were hauled. As each holding trap was hauled, it was inspected to determine if there were traces of dredge-spoil material associated with the trap structure. As soon as possible after landing on deck, a blood sample was extracted from each lobster. Blood samples were kept on ice until transported to the laboratory where samples were frozen until analyzed using a biochemical test for stress (glucose in lobster haemolymph, see below for description of method). After being sampled for blood each lobster was then carefully examined for gross physical condition and activity, gross morphological indication of exposure to high turbidity (e.g. through inspection of the gill cavity under the ventral margin of the cephalothorax). Lobsters were also checked for their ability to freely move their antennae, claws, walking legs, and abdomen when these were manually stimulated. See Appendix 4 for the data form used to record this information.

Glucose Concentration Determination in Lobsters

Glucose in lobster haemolymph was used as a stress indicator, as hyperglycemia (increased concentrations of glucose) has been observed as a response to various kinds of stress in American lobsters (Telford 1968). Lobster haemolymph samples were obtained with 3 ml plastic disposable syringes (Becton and Dickson) equipped with 21 gauge needles. The syringes were heparinized with N-ethylmaleimade (0.02M in 3% NaCl) just before sampling. The needle was inserted just under the ventral membrane of the first or second abdominal segment, lateral and parallel to the ventral nerve cord. Haemolymph from the ventral abdominal sinus was drawn into the syringe and immediately expressed into 5 ml nalgene centrifuge tubes, capped and placed on ice. The clots were broken up by homogenizing the haemolymph samples on ice for 15 - 20 seconds on a polytron homogenizer. The tubes were centrifuged for 10 min at 2500 x g at 4°C in a Sorval RC 28S centrifuge. The resulting supernatant (plasma) was decanted by Pasteur pipette into 1.5 ml micro-centrifuge tubes. Plasma samples were frozen at -80°C until analysis.

Plasma glucose was determined using a commercial kit (Sigma-Aldrich Canada, Oakville, ON). The procedure is based on hexokinase phosphorylation and glucose-6-phosphate oxidation. Absorbance was measured at 340 nm at 37°C using a Cary 300 Bio Spectro-photometer, according to the kit instructions. Sample size in the cuvette was 0.01 ml and 1.0 ml of the Glucose (HK) reagent was added. Glucose standard (100 mg/dl) was purchased from Sigma Diagnostics and dilutions were made to create a standard curve of absorbance vs concentration from 0 to 100 mg/dl. Standards and samples were analyzed in duplicate. The concentration of plasma glucose was determined by linear regression analysis from the standard curve according to the following formula:

$$\text{Glucose concentration (mg/dl)} = [(A-B) - C]/ D$$

where A = absorbance of the sample; B = absorbance of water; C = y intercept from the standard curve; and D = slope of the standard curve.

The glucose (HK) procedure is linear from 1 mg/dl to 750mg/dl. The sensitivity of the assay is reported to be 1.0 mg/dl (Sigma-Aldrich Canada, Oakville, ON).

Environmental Factors

Prior to the disposal activity conducted by commercial scows on August 27, 2005, a Conductivity-Temperature-Depth Profiler (CTD; Seabird 25) was deployed in several areas of the treatment and control area to measure salinity, temperature, oxygen and turbidity. Monitoring was conducted during ebbing tide, at slack-water, and about one hour after low tide (low tide at 12:51 Atlantic Daylight Time). Each cast was replicated. A minimum of two casts were planned in two pre-designated sampling areas (areas A and B) on either side of the target disposal point in the treatment area, and a further two at the control area (area C; see Figure 11 for target locations for CTD casts). The principal environmental factor of interest was turbidity. The Seapoint turbidity meter on the CTD measures turbidity by detecting light scattering from suspended particles within 5 cm of the sensor window, measured in units called Formazine Turbidity Units (FTUs).

Pre- and Post-Disposal Event Remote Video Survey

A dedicated remote video survey was conducted in Anthony's Cove using the same methods as for the video survey at the Black Point Ocean Disposal Site (also see Appendix 1). The goal of this second survey was to evaluate the use of video-based techniques to estimate the area of influence of specific ocean disposal events. Pre- and post-disposal substrate conditions were recorded in the general area of the alternate disposal site at Anthony's Cove. Nine remote transects were completed prior to the disposal activity on August 23 and 24, 2005, while a further eight post-disposal transects were conducted on August, 30, 2005.

CHRONOLOGY OF DREDGE SPOIL DISPOSAL OVER THE 2005 PERMIT SEASON

Records of dredge spoil disposal activity in the approaches to Saint John Harbour over the 2005 permit season (i.e. both for Black Point Ocean Disposal Site and the alternate disposal site at Anthony's Cove) were provided by Environment Canada (S. Lewis, EC, Dartmouth, Nova Scotia, personal communication). The total number of disposal events reported, total amount of dredge spoil deposited, along with specific locations and times when individual disposal loads were dumped were reviewed. From dumping reports with complete information, detailed chronologies were prepared on the usage of specific dumping positions within the permitted disposal areas. This included the total number of times the position was used over the permit season, and the time interval that elapsed between successive loads being deposited.

RESULTS

HABITAT OCCUPANCY BY LOBSTERS IN SAINT JOHN HARBOUR APPROACHES

Remote Video Surveys to Assess Lobster Distribution (Black Point)

A total of 40 URCHIN video transects were completed during July 2005 at Black Point, representing an estimated total distance covered on bottom of 9.8 km (Appendix 2). Individual transects ranged from 29 to 614 m due to the nature of the survey technique (drift transects). A total of 32 lobsters were observed on the videos, distributed across both the recent and old disposal areas (Figure 12). Due to low visibility conditions on bottom on some remote video sets and the relatively narrow path width of the video (approx. 0.5 to 1.0 m) these lobster observations are considered minimum estimates of habitat occupancy.

The macro-habitat scale analysis of the remote videos taken at the Black Point disposal site indicated that the principal seabed texture was mud and sand in the recent disposal area, with a more varied range of seabed textures (also including mud and sand) being observed in the old disposal area, including some observations of cobble and boulder accumulations within the shallowest portions of that area. In addition to these materials, other seabed physical structures (classification class 24; Appendix 1) contributed to a higher degree of benthic structural complexity at the old disposal area. A predominantly clay seabed had been furrowed (armoured) by current action to create a series of fairly high relief features (0.5 to 1.0 m), along with multiple small crevices and cave-like overhangs, presumably due to ongoing scouring (Figure 13A). Additional descriptions were obtained by SCUBA divers of this distinctive habitat, which likely represents a consequence of the long-term deposition of dredge spoil material in the old disposal area and the shallow depths of the shoal at the present time. The remote videos taken in the recent disposal area encountered few signs of infauna and the sediment surface was mostly flat or gently undulating (Figure 13B). Isolated accumulations of more consolidated clay-based material were encountered there and interpreted to be remaining from disposal activity conducted as late as 2004 (the video survey was conducted prior to the start of 2005 disposal activity).

Detailed interpretations of the benthic habitat at Black Point from the macro-habitat and also from the micro-habitat analysis are not presented in this report, except for the integrated assessment of the effects of ongoing human usage (classification class 19, Appendix 1). This descriptor was based on an interpretation by the analyst of the nature of the seabed condition as disturbed, undisturbed, recovering, or unknown, derived from observations on seabed texture, physical and biological structural elements, and the presence of benthic fauna and epifauna. In general the classification of human usage (Figure 12) corresponded with the distinction of the Black Point site into a recent disposal area and an old disposal area. The principal region classified as disturbed was the deeper portions of the recent disposal area to the northwest of the shoal. The shallower portions of the recent disposal area were classified as recovering, which was also attributed to the majority of the video transects conducted in the old disposal area.

Trapping Surveys to Assess Lobster Distribution (Black Point, Mispec Point, Anthony's Cove)

A total of 6048 lobsters were captured and measured for biological variables at Black Point during the eight trapping days with 500-1049 being measured on each sampling day (Table 1). About 54% of lobsters measured were captured in the juvenile traps while 46% were captured in the commercial traps. Juvenile traps made up 60% of the traps deployed while 40% were commercial traps. As indicated in Table 1 and Figure 14 (A and B), trips with two-day soaks consistently retained higher numbers of lobsters than those deployed for one-day soaks. More males than females (in pounds per trap hauled; pounds/TH) were retained in the two-day soaks than in the one-day soaks (Figure 14A and B).

The results of the trapping activities conducted at Mispec Point and Anthony's Cove are presented in Figure 14 (C). It is noteworthy that the nearshore trapping at Anthony's Cove recorded the highest pounds/TH of male lobsters when compared to the other two-day soaks that were conducted around the same time (August-September 2005). Higher pound/TH of males, females and berried lobsters were recorded at Anthony's Cove than at Mispec Point. These later trapping activities (Figure 14C) also recorded higher pounds/TH of berried lobsters than the earlier trapping at the Black Point ocean disposal area (Figure 14A and B).

The average lobster catch rates at the Black Point disposal site were a little higher in the recent disposal area compared to the old disposal area; however, there was no difference in the sex ratios, which was close to 0.5 in both areas (Figure 15). In terms of size class distribution of lobsters caught in traps set in the old and the recent disposal sites the overall size range encountered in traps was similar, with the distinction that more pre-recruits were caught on average at the recent disposal area (Figure 16).

Catch rates for juvenile (< 62.5mm CL), pre-recruit (62.5-82.5 mm CL) and commercial size (>82.5 mm CL) lobster categories showed marked differences between sampling areas (Figure 17A). Differences were more pronounced for juvenile lobsters, with catch rates at Anthony's Cove, Cranberry Point and Mispec Point about a fifth of what they were at Black Point. For the pre-recruit size category, catch rates were almost three times higher at Black Point, and for commercial-sized lobsters just less than double the catch rate than in the other locations. Overall, catches were dominated by pre-recruit lobsters (Figure 17B).

Mark-Recapture Studies to Assess Lobster Movement (Black Point)

From the eight hauling days over the period July 6 to 17th 2005 at Black Point, a total of 6048 lobster were caught and of that total 1209 (~20%) were tagged with bands (Table 2). There were 43 recaptures (~4%) of lobsters during the trapping period. Of the 43 recaptures, 35 (~81%) were single recaptures, 5 (~12%) were recaptured twice, 2 (~5%) were recaptured three times, and one lobster was recaptured four times.

Line Transect Surveys by SCUBA Divers to Assess Lobster Distribution (Black Point)

Due to the lack of prior *in situ* observation of benthic conditions at the Black Point ocean disposal site, general habitat descriptions recorded by divers are reported for each of the nine line transects that were successfully completed (Figure 8). Bottom conditions were generally not conducive to detailed assessment (depths at time of sampling ranged from 42 – 63 ft, currents were often high, and visibility was low, particularly on mud-dominated transects).

Transect 1, completed on July 6, 2005 within survey box 5, used a 150 m transect line (Table 3). The dive began over hard sand-gravel-cobble bottom. The cobble was packed into the substrate, and as a result the cobble could not provide hiding places for lobsters. After the 40 m mark, the bottom changed to larger cobbles with some boulders that provided better shelter for juvenile lobsters (10 to 15 mm). Based on the number of rocks that were turned over by the divers to search for lobsters, the lobster density was interpreted to be low, compared to densities commonly encountered in similar searches of shallow-water cobble-boulder habitats in SW New Brunswick. Divers found seven juvenile lobsters along the 110 m of good searchable bottom of the transect.

Transect 2 completed on July 7, 2005, also in survey box 5, began over large cobble-small boulder substrate. The silt layer over these rocks was easily disturbed and thus made searching difficult. Many of the boulders were imbedded in the bottom and therefore the availability of crevice spaces for lobsters was low. Seven lobsters were found, most between 30 to 60 mm CL. One lobster of 11 mm CL was captured. Hand-capture of a lobster of this size, which would not be captured in trap-sampling, or observed from remote video surveys (due to its cryptic habit) is significant in confirming that post-larval settlement occurs at the Black Point site - this lobster would be from the 2004 year-class. Additional observations of recently-settled lobsters were obtained on other dive transects.

Dive transect 3, completed on July 7, 2005 in survey box 6, covered a unique bottom type consisting of large clay mounds, up to one meter in diameter, that closely resembled boulders. In the final 25 m the clay became more ledge-like with a few caves that were 15 to 20 cm in diameter. One 93 mm CL lobster was located in one of these caves. Two small (<12 mm CL) lobsters were observed along this transect, but could not be hand-captured.

On July 8, 2005, dive transects 4 and 5 were completed in survey box 6. Transect 4 covered an area that was almost completely hard packed clay with lots of relief and structure (small caves, burrows, and channels for lobsters to hide in). Fifteen lobsters were observed, mostly between 40 to 70 mm CL. Transect 5 covered an area that resembled hard ledge but was actually hard packed clay. This transect had even more relief and structure than the previous transect. There were numerous channels up to 75 cm deep with lots of caves (burrows) for lobster to use as shelters. Most lobsters of the 21 observed were in the 30 to 60 mm CL range and were hidden in caves, burrows and along the channels. One large male lobster was observed in a large depression.

Transects 6 and 7 were completed on July 11, 2005 within survey box 3. The substrate on transect 6 was mostly comprised of a sandy-mud fraction with small amounts of gravel mixed in. The final 10 m was mostly a flat clay-mud mixture. A few large clay mounds in excess of 2 m in diameter were noted. One excavated lobster burrow was observed but no lobster was present. Only one 67 mm CL lobster was captured on transect 6 and was transiting through the area. Transect 7 was recorded as uneventful. The substrate consisted of very soft, flat, mud-sand mixture with small amounts of gravel. There were small amounts of cobble (less than 10%) after the 35 m mark. The bottom was soft enough to observe what appeared to be lobster tracks all along the transect; however, no lobsters were encountered during the dive.

On July 12, 2005, transect 8 in survey box 2 covered an area of hard packed mud with approximately 15 cm high ridges, resembling sand dunes. One lobster was recorded along the transect, but no other suitable lobster shelter was observed. Transect 9 was conducted over a very soft mud bottom with no lobsters observed; however, several sets of what appeared to be lobster tracks were across the surface of the mud. After the 50 m transect was completed divers completed an additional 10 minutes of swimming on a southerly course in excess of 150 m. During this portion of the dive, only three lobsters were observed (each of approx. 50 mm CL).

Each line transect was subdivided into 5 m sections (representing a 10 m^2 search area), thus a total of 110 sections were searched by divers along the nine transects. The highest density of lobsters (as number per 10 m^2) was recorded in survey box 6 (Figure 18). Of the 55 lobsters encountered and measured by divers, 96% were observed from survey boxes 5 and 6, located in the old disposal area. As indicated in Figure 18 there were 10 recently-settled lobsters (under 20 mm CL) caught by divers in boxes 5 and 6. Most of the lobsters caught by divers were below the legal size (the minimum legal size is 82.5 mm CL) with only four caught that were over 81 mm CL.

Due to the lack of prior *in situ* observation of benthic conditions at the Black Point ocean disposal site, and the difficulty of conducting SCUBA-based observations there, general descriptions recorded by divers are reported for each of the four diver-held videos that were acquired (see Figure 9 for locations).

The video on July 5, 2005, of a trap trawl recently set in the old disposal area covered bottom consisting of a hard packed sand-gravel mixture with a small amount of silt. Most traps were sitting upright on the bottom with approximately 40 m separation between traps. The trawl line arced about 5 m between the traps. The traps had been in place for less than 45 minutes prior to the video. There were in excess of 15 rock crabs along the trawl line, but none near the traps.

Trap 1 showed a lobster approaching the trap with one lobster already in the kitchen portion of the trap.
Trap 2 showed one lobster circling the trap.
Trap 3 showed one lobster in the parlour of the trap.
Trap 4 was upside down and was righted by the diver.
Trap 5 showed 2 lobsters circling the trap.

Three video dives were conducted on July 13, 2005. Video dive 1 in the old disposal area (survey box 5) occurred over a cobble-boulder bottom with a few consolidated clay clumps mixed in. A meter stick with 10 cm taped increments was used to provide a reference the size of seabed features. The meter stick was also inserted into clay and the clay was compressed between fingers to demonstrate the consistency. This video contains footage showing good potential lobster habitat with numerous stacked boulders, although careful searching did not encounter any. Video dive 2 in survey box 6 encountered a similar bottom type to that encountered in video dive 1, although in this case several small lobsters were observed under boulders and cobbles. There were also clay furrows present in this area. The third video dive was in survey box 3 and covered an area that was mostly flat with soft clay; no lobsters were seen.

LOBSTER RESPONSE TO DREDGE SPOIL DISPOSAL EVENTS

Field Experiment Setting (Anthony's Cove)

Traps deployed nearest the disposal point at Anthony's Cove (Trap 1 in each treatment trawl) were between 36 to 49 m from the disposal target (Table 4A). On retrieval, traps that were targeted to be 120 m away (Trap 3 in each trawl) were estimated to be between 117 to 138 m from the disposal target (Table 4B). The location of the middle trap (Trap 2) in each trawl was assumed to be half way between Trap 1 and Trap 3. Figure 20 shows the final locations of all traps in relation to the target disposal point. During the recovery period, Trawl 3 was not located and was assumed to be lost. On recovery T1-3 and 2 (Trawl 1, traps 3 and 2) did not show signs of sediment in them. T1-1 had some mud on the trap on recovery. The lines between the traps in T2 had mud on them and mud was visible on lobsters in T2-2. T2-1 appeared to have been dumped on directly and the trap showed signs of damage. Four of the lobsters in this trap (T2-1) were dead and the other four were non-responsive. T4 also showed signs of the disposal activities with mud appearing in the trap and on lobsters in T4-3. T4-2 appeared to be less impacted and lobsters did not have any mud on them. T4-1 of this trawl had lobster with mud on their carapaces and on their claws.

Glucose Concentration Determination in Lobsters

There were differences in average size among replicates within the size groups (70-79 and 80-89 mm CL) of lobsters used in the control and treatment traps for Task 3. These size distributions were achieved by random distribution (except for maintaining the two size groups).

Glucose concentrations in haemolymph were not consistent among sampling sites (Figure 22). The mean glucose concentration is presented as a mean for all control lobsters (C`s). Concentrations of glucose measured in lobsters from trap line 1 are not significantly different from each other. While lobsters from traps labeled T1-1 (i.e. Trawl 1, trap 1) and T1-3 have glucose concentrations that are the same as those at the reference site, the average glucose concentration at T1-2 is significantly lower than that measured in lobsters from the reference site. Lobsters from T2-1 and T2-2 on trap line 2 have similar glucose concentrations and the same as lobsters from the control site. Lobsters from T2-3, however, have higher glucose concentrations than any other lobsters in this study. These animals were in poor condition when they were sampled. In fact, only four of eight lobsters were alive. Lobsters from traps T4-1 and T4-2 also had elevated concentrations of glucose in their haemolymph although not as high as T2-3. Lobsters from the third trap on the T4 line (T4-3) had glucose concentrations equal to the controls.

Environmental Factors

Multiple CTD casts (a total of 25; Figures 23 and 24) were conducted on August 26, 2005 at the treatment and control sites. The casts were made from the surface to near-bottom while the research vessel drifted (Figure 23). There was also *ad hoc* monitoring of two dredge disposal events. Two casts were conducted at the disposal target position immediately after two disposal events (conducted prior to low tide).

From plots of turbidity measurements for the depths (in meters) as recorded by the CTD (Figure 24; note different scales for turbidity values on different casts) it is evident that turbidity was highest at depths closest to the bottom in area A (Figure 11; exceeding 60 Formazine Turbidity Units [FTU] on some casts) and along the scow course (exceeding 200 FTU) after one disposal event. In contrast, measurements of turbidity at the control location did not exceed 6.5 FTU in any of the 6 casts conducted there at different stages of the tide. Comparisons between sampling areas are best considered in terms of the relative magnitude of differences, as opposed to the absolute values of FTU for any one location. These turbidity measurements are consistent with visual observations from the *Salar* during CTD casts where it appears that sediment in the upper part of the water column was quickly carried away from the disposal area by the strong currents. Suspended sediment close to the seabed was presumably being augmented by the recently dumped material, or the current was not as strong close to the seabed leading to locally higher suspended sediment loads than near surface.

Pre- and Post-Disposal Event Remote Video Survey

A total of 9 video transects were completed on August 23 and 24, 2005, prior to the scheduled disposal events (August 27 and 28, 2005), and a further 8 video transects were completed on August 30, 2005, two days after the experiment. Completed transects ranged between 151 and 605 m (Figures 25 and 26; Appendix 2 provides more details on the start and end positions).

The remote videos recorded at Anthony's Cove were analyzed by using the same method as described above for the Black Point ocean disposal area and in Appendix 1, resulting in observations on the habitat, species, and human usage. In particular the spatial distribution of "fresh" clay mounds (Figure 27A) was used to draw a polygon around the disposal target area which was interpreted to be the seabed "footprint" of the disposal activity (recorded as human usage – clay mound; Appendix 1). The area of the polygon was 35,120 m² (Figure 29). Lobsters were recorded in the video transects both before and two days after the disposal activity (Figure 27B; Figure 28).

The directed dredge spoil disposal events for the field experiment were part of regular 2005 permit season operations, and thus the time, position and amount of dredge spoil disposal events were reported to EC by the commercial company hired to conduct harbour dredging and disposal in 2005. Most of the dredge spoil was dumped along the scow course shown in Figure 10; however, the data shows a spread of the disposal points within the field experiment area (Figure 29). As noted in the next section of the report, there were some problems with truncation of position information in the commercial logs, such that disposal locations appear at regularly spaced positions.

CHRONOLOGY OF DREDGE SPOIL DISPOSAL AT BLACK POINT IN 2005

Disposal activities commenced on August 4, 2005 and ended on November 11, 2005. Information on the location, amount deposited, and time of individual disposal events was provided by Environment Canada (S. Lewis, EC, Dartmouth, Nova Scotia, personal communication). As of January 19, 2006, the records provided indicated that there were 1301 disposal events during 2005 with a total of 149,215 m^3 of dredge spoil deposited at the Black Point ocean disposal site and at the alternate disposal site in Anthony's Cove. However, a separate Saint John Port Authority report to EC (S. Lewis, EC, Dartmouth, Nova Scotia, personal communication) indicated that the total material disposed was 165,660 m^3. This suggests that possibly 143 disposal events (based on average loads and 16,445 m^3 of dredge spoil not included in the January 19, 2006 report) are not included in the following analyses. Additionally, positions recorded by the automated project tracking system of the commercial operator were truncated, such that reported positions appear to be regularly-spaced (see Table 5 and Figures 30 and 31), as opposed to actual positions (it was reported that the navigation systems on the scows were operational at full precision – the truncation occurred in an automated project reporting system).

The available data indicates that two specific dumping positions at the Black Point Ocean Disposal Site received most of the dredge spoil material (one had 162 disposal events and the other received material from 831 events; Figure 32). Most of the other dumping positions, however, received one to nine disposal events, while ten dumping positions received between 15 - 35 events. Accepting that disposal point positions were truncated, leading to an inflation in the number of events reported at specific positions, the monitoring documentation does allow for an examination of detailed chronologies of dredge spoil disposal as the time the loads were released was reported. In order to compare disposal chronologies with aspects of lobster behaviour, an analysis was conducted on the frequency and overall length of time that discrete sequences of disposal events were carried out, using an interval of 24 h between disposal events as the breakpoint between sequences (i.e. a series of disposal events, each separated by < 24 h would be considered a discrete sequence).

Disposal activity at dumping positions for which there were more than 10 disposal events over the permit season had rates of dumping that ranged up to one per hour during periods when more than one scow was operating between the dredging location within the harbour and the disposal site (Table 5). The most intensively used disposal point at Black Point received 831 dredge spoil loads over the season (115 m^3 per load, except for two partial loads) distributed as 12 discrete sequences with intervals between loads within sequences ranging from one to three hours). The highest number of consecutive events reported for this disposal point was 163 loads deposited over a period of 194 h (8 days; Table 5). Similarly, for the disposal point with the second highest number of events (162 loads over the permit season) all except for four dredge spoil loads were delivered within 24h of each other. The longest duration sequence for this reported location lasted 153 h, with 34 loads delivered. The next level of usage was 35 loads over the permit season, which occurred at three disposal points. For these three positions 51 – 77% of the disposal activity occurred as consecutive loads delivered at intervals < 24h.

DISCUSSION

HABITAT OCCUPANCY BY LOBSTERS AND DREDGE SPOIL DISPOSAL

Lobster Distribution in Relation to Seabed Characteristics

Habitat suitability for lobsters typically relies on the presence of shelters, particularly for earlier benthic life-history phases (Lawton and Lavalli 1995). Video and diving surveys conducted at Black Point in this study, and prior remote video surveys in the approaches to Saint John Harbour (Parrott and Strong 2003) indicate that lobsters may occupy and excavate burrows in predominantly depositional environments, although typically at low densities. Thus, a portion of the lobster population immigrating in late spring into the area from deeper water in the Bay of Fundy may take up residency in depositional areas, perhaps for a considerable portion of the summer months, and may also occupy burrows in these areas for moulting activity. The remote video transects conducted as part of the field experiment on effects of dredge spoil disposal on lobsters indicate that Anthony's Cove, a predominantly depositional habitat which has experienced less disturbance than Black Point (due to its being only an alternative disposal site) is used during summer months by lobsters. Lobsters were present both before and after (Figure 27B; Figure 28) experimental disposal activities).

However, while the major substrate type in the recent disposal area at Black Point consisted of mud and sand, there was little evidence of epifaunal and infaunal colonization, nor for extensive occupation of this habitat by lobsters. The most common evidence for lobster presence in these areas came from linear tracks resulting from the penetration of lobster walking legs into the sediment surface during movement across the habitat (Figure 28). A total of 12 lobsters were observed in the remote video taken in the recent disposal area in 2005 (Figure 12).

In contrast, the old disposal area was characterized by a greater range of substrate types, including cobbles and boulders, upon which epifaunal communities were well-established, as well as a complex topography in some parts that appeared to have been formed by cumulative scouring (armouring) of predominantly clay-based sediment (Figure 27A). The higher frequency of shelters resulting from these structured habitats resulted in higher numbers of lobster being observed by divers in the old disposal area than were seen in the shallow portions of the recent disposal area that could be accessed by diving. Most of the lobsters caught by divers were below the legal size limit and the presence of settlers from the 2003 and 2004 year class (10 in total, nominally those lobsters < 21 mm CL; Figure 19) confirms that the old disposal area is an active settlement habitat, and indicates that the area is used year-round (as the early benthic life history phases of lobsters do not move extensively; Lawton and Lavalli 1995). Long-term disposal of dredge spoil at Black Point, by creating a relatively extensive shallow-water structure in a previously deeper-water area, may have improved the habitat suitability for juvenile lobsters. Although it is considered that initial lobster settlement is much lower in sedimentary environments than complex hard-bottom areas, there is also an indication that settlement is higher in shallow-water habitats than in deeper areas (Wilson 1999). Long-term disposal activity has created a shallow bank with minimum water depths of approximately 5 m below mean low water (Figure. 2). As reviewed by Envirosphere Consultants Ltd. (2003), this buildup is thought to be due, in large part, to the disposal of gravel, rock and boulders originating from areas of seabed in Saint John harbour not previously dredged, as well as silt/clay from current dredging. Over the years, periodic slumping has occurred, creating a slump area which extends several kilometers south and southeast of the disposal site (Figure. 2). In 2000, analysis of bathymetric and geophysical data suggested a main spoil pile area of 0.8 km^2 and a slump area that extends 1.5 km to the south, approximately 1.5 km wide (Envirosphere Consultants Ltd. 2003).

The development, composition and persistence of shallow-water seasonal lobster assemblages has not been extensively studied (historical studies reviewed by Lawton and Lavalli 1995), and has typically relied upon trapping-based assessment of distribution and movement (see Bowlby et al. 2007; Bowlby et al. 2008 for recent reviews). The use of juvenile-directed traps in the 2005 study helped to better document the distribution of juvenile lobsters, providing corroboration that these coastal habitats provide a lobster nursery area function. Lobsters less than 50 mm CL were caught on each day of trapping in each of the three trap-sampled locations. The smallest lobster retained in the traps was 26 mm CL.

Based on the trapping survey, size class distribution was similar in both the old and recent disposal areas with the exception that more pre-recruit lobsters were caught in the recent disposal area (Figure 16). Overall, the amount of lobster caught was higher in the recent disposal area than on the old disposal area (Figure 15). This result differed from the diving survey results that showed lobster abundance was higher in the old disposal area. The discrepancy between the two surveys is likely due to trapping artifacts. Entry of lobsters into traps depends on many factors such as currents and bottom habitats. It is possible that more lobsters were caught in the recent disposal area because trapping was more effective there than in the old disposal area. In a highly complex bottom such as the old disposal area, there is a greater likelihood of some traps ending upside down on the bottom, and thus less effective (the video survey along a trawl that had recently been set in the old disposal area encountered this effect). Additionally, bottom complexity increases turbulence on bottom in high current conditions, which would break down the bait plume and reduce the area of attraction of a trap. Thus, the difference in the amount of lobsters caught between the two disposal areas may be primarily related to a difference in fishing efficiency. The effectiveness of lobster trapping as a means of determining actual population size structure and densities of lobsters is complex, as the entry of lobsters into traps depends on size, sex, moult status, intra- and interspecific interactions, and physical factors such as water temperature, currents and bottom habitat (see Miller 1990; Smith and Tremblay 2003; Tremblay and Smith 2001; Lawton et al. 2005).

The tagging approach used in the 2005 study was not able to resolve individual lobster movement patterns; however, the generally low rates of recapture during the trapping survey are consistent with prior results from several summer trap-based tagging studies on Bay of Fundy lobsters (Robichaud and Lawton 1997; Lawton et al. 2005). Lobsters are likely making daily and longer-term movements across various parts of the approaches to Saint John Harbour. Resolution of individual lobster movements using acoustic telemetry approaches (e.g. Bowlby et al. 2007; Bowlby et al. 2008) may help to better understand daily movement patterns, although there would presumably be significant logistic problems with integrating such approaches in close proximity to commercial ocean disposal activities.

Lobster Response to Dredge Spoil Disposal Events

In 2004 a preliminary experiment was conducted at Black Point by Lawton et al. (2005) involving the placement of lobsters in traps adjacent to dredge spoil disposal activity to assess biological effects on lobsters. Due to problems in arranging for disposal loads to be placed at specific target positions, the traps were considered to have been placed too far away from the actual dredge spoil disposal activity in 2004 for lobsters to be exposed to high near-bed sediment loads. In 2005 a web-based design was adopted for trap placement to provide for replicate traps set at three relatively short distances (40, 80, and 120 m) from a single target disposal point. Additionally, benthic habitat conditions were assessed both prior to and after the spoil disposal events occurred in order to assess the seabed “footprint” of the disposal activity during the trial. For this second experiment there was evidence for some of the lobsters having been exposed to high near-bed sediment loads based on physical and physiological criteria assessed for lobsters on removal from the traps. Analysis of footage from the remote video survey indicated that dredge spoil material had spread outwards from the disposal target up to the locations where the second traps had been located.

The concentration of glucose of lobsters in the holding traps was found to be generally higher than values reported by other authors for the American lobster (Mercaldo-Allen, 1991). Lobsters sampled in the laboratory at the St. Andrews Biological Station (SABS) routinely have higher glucose concentrations than reported in the literature as well (Burridge, unpublished results). It is possible, therefore, that laboratory holding conditions are somewhat stressful for lobsters or that the levels measured in the laboratory are representative of this “population” of lobsters. Further study will be required to determine if either of these possibilities explains the results. Regardless of what is considered normal for lobsters from the Bay of Fundy, the values measured in these experimental treatment lobsters and lobsters at the control site are significantly higher than levels reported in the literature or measured in lobsters at SABS. The mean concentration of glucose in haemolymph sampled from lobsters in this experiment was always greater than 50 mg/dL (Figure 22). It would appear from these data that lobsters near the dump sites are affected either by their holding or as a result of their location. The fact that there are differences among the glucose levels in lobsters from the various locations suggests that holding conditions are not the sole reason for elevated glucose.

On retrieval traps were within acceptable distances from their original target positions and the final layout was still similar to the original planned layout (Tables 4A and 4B). Given the fact that there were at least two of the inner most traps with dredge spoil in them, it is assumed that at least some of the disposal activity occurred over them. When dredge spoil does cover lobsters in a trap to the extent that they cannot climb to the top of the mound, it is likely that they will not survive. This is evident from one trap that took a direct hit and was covered by a disposal event where 50% of the lobsters were dead and the others were non-responsive.

The CTD casts conducted during the trap-based holding experiment at Anthony's Cove indicate that during disposal events sediment in the upper part of the water column is quickly carried away from the disposal location by the current. Sediment in the lower part of the water column, however, can be very high (Figure 24) and this may indicate slower current or "prolonged" sediment release from the recently-deposited dredge spoil material. Similar observations were made in the general area during 2004 disposal activities by SCUBA divers (Lawton et al. 2005). The short-term fate of dredged material disposal in open water has been subject to considerable monitoring and modeling, and is generally assumed to be separated into three phases: convective descent, dynamic collapse, and passive transport-dispersion (Palermo et al. 1998). Convective descent comprises the initial fall of the disposal cloud from a surface vessel, while dynamic collapse refers to the period following either impact with the bottom or arrival at a neutral buoyancy where descent is retarded and horizontal spreading dominates (subsequent passive transport bring determined more by ambient currents and turbulence than by dynamics of the disposal operation; Palermo et al.1998). Based on this model, smothering of the traps likely took place during the dynamic collapse phases of the disposal events. This has implications for lobsters since they are always on the sediment surface and if they are in the sediment plume in the vicinity of a disposal event they may be impacted by the suspended material. Other parts of this study indicate that lobsters are found in the Anthony's Cove area during the dumping activities. For adult lobsters, suspended sediment can clog the gills and inhibit oxygen exchange. Also, given the current regime and exposure of the area, it can be expected that dumped material would be re-suspended by storm events and by currents. Additional studies are needed to better understand the spatial and temporal range of suspended sediment in the harbour and to further evaluate its impact on lobster behavior.

Dredge Spoil Disposal Chronologies

The frequency of dredge spoil disposal at a specific location is likely to influence the exposure of lobsters. If there is sufficient time between events (say > 24 h) then, given the high mobility of lobsters in the area, there is a chance that additional lobsters may either be transiting over the recent dredge spoil or trying to find shelters in it or conduct foraging activity. In such cases, this may increase the chance of lobsters being smothered by a new disposal event at the same location. Conversely, for locations where dredge spoil activity continues over a period of time with high frequencies of events, the location may generate sustained elevated levels of near-bottom turbidity which may lead to avoidance of the disturbed area by lobsters. The position at Black Point that had the highest number of disposal events also had them all within one to three hours of each individual event. This is the highest disposal intensity recorded at Black Point and indicates that there is less chance for lobsters to make or take up any sort of shelter in the newly disposed dredge spoil. Similarly, the site with the second highest number of disposal events had 96% occurring within one to 11 hours of the previous event. These short time intervals could preclude lobsters from forming shelters in the dredge spoil. Although Wahle et al. (2004) did not observe that lobsters were attracted from the immediate surroundings to the disposal site they studied; this question remains relevant for the Black Point Ocean Disposal Site. If lobsters are attracted to the disposal site, then mortality can potentially be fairly high since lobsters in the general area seem to be very mobile.

FUTURE MONITORING, MANAGEMENT OPTIONS, AND RESEARCH NEEDS

Coastal habitat occupancy by lobsters in relation to dredge spoil disposal operations in the approaches to Saint John Harbour is now better understood, based on this study and that of Lawton et al. (2005), yet significant uncertainties remain. The 2004 and 2005 field studies used a range of technical approaches to assess impacts of dredge disposal on lobster and lobster habitat. Fully quantitative conclusions have proven difficult to achieve and thus management decision-making needs to proceed accordingly. Some reasons for this uncertainty are specific to the local environment at Black Point, others are more general limitations in the scientific approaches which can be applied, and/or cost considerations relative to information content and explanatory power to determine cause and effect relationships.

Environmental conditions at the Black Point disposal area (high bottom currents, short slack tide periods, and generally deep bottom depths) limit the extent and sophistication of *in situ* experiments, particularly those which include the use of divers, or diver-held video. Trapping approaches proved practicable, but attempts to evaluate condition or stress indicators in lobsters in proximity to dredge spoil disposal using traps are confounded by the probability that the trapping and pre-experiment holding of lobsters itself also constitutes a stressful condition. Nonetheless there were some significant elevations in glucose identified in some experimental traps impacted by dredge spoil.

Although there are limitations with video as an assessment tool, experience with the URCHIN video system during three years of operation at Black Point indicates considerable promise in using video as a biological effects monitoring tool. Detailed geo-referenced assessments of bottom conditions were obtained in recent and old disposal areas, and additionally during pre- and post-disposal periods for the field experiment. Using specific evidence of anthropogenic disturbance (observation of clay mounds on the bottom) it was possible to determine a seabed “footprint” from disposal activity. In its current design, the URCHIN system was able to be deployed in all areas of the disposal site, although strength and small spatial-scale variability in bottom tidal currents made for some difficult deployments.

Integration of scientific sampling protocols with a commercial undertaking such as ocean disposal of dredge spoil proved difficult, due to different perceptions on operational requirements and complicated communication and review channels. It was unfortunate that the vessel tracking system in use in 2005 did not generate high precision positions to enable a full suite of GIS evaluations of the distribution and frequency of disposal events, and thus estimates of the size, distribution and accumulation of disposal activity in specific geographic areas.

Over the long-term, annual disposal of dredge spoil at Black Point (particularly historical activities in the old disposal area) has resulted in a substantial alteration of the pre-existing benthic habitat. The principal changes are reflected in the contemporary bathymetry and bottom topography, and bottom conditions as video-documented in this study. The new biological studies in 2005 provide the first evaluation of the current habitat suitability of recently disturbed areas and previously disturbed areas for lobster production. There appear to be both beneficial and harmful aspects to the change in habitat conditions.

Historical activity around the primary disposal point at Black Point has created a relatively extensive shallow-water structure with considerable topographic complexity in a previously deeper-water area; however, it has not been receiving dredge spoil for several years. Trapping, diving, and remote video surveys all confirm that this area now provides good habitat conditions for juvenile lobsters, and in particular the diving-based assessments confirm that active benthic settlement from pelagic larval stages occurs at Black Point. In the longer-term, disposal activity, although altering habitat, may have improved conditions for juvenile and pre-recruit lobsters. This evaluation of a beneficial aspect for juvenile lobster production does not incorporate an assessment of loss of prior habitat function for adult lobster (and possibly juvenile lobsters) and other benthic invertebrates or groundfish that may have used the pre-existing deeper water environment as seasonal or year-round habitat.

Within the shorter-term (1 – 3 yr) continued annual disposal activity, such as in the recent disposal area at Black Point, alters benthic conditions relative to lobster habitat occupancy, and thus constitutes an ongoing disruption of that habitat. The distinction with this being that the habitat that is being disturbed (now existing) is in an already altered condition due to prior spoil disposal activity. From remote video surveys conducted prior to the start of annual disposal activity, and from comparison of pre- and post-experiment benthic video at Anthony's Cove (as well as trapping information on catch rates and recaptures) we have identified that lobsters are utilizing the recent disposal areas (e.g. lobster tracks evidencing movement over the bottom), but that the bottom feature classification (disturbed or recovering) and lack of topographic complexity are such that sheltering behaviour is likely substantially reduced relative to undisturbed (e.g. not used within 4 years) sites. Intermittent dredge spoil disposal (events at a location separated by 24 h or greater) and semi-continuous disposals (consecutive events separated by less than 24 h and as frequent as hourly) are expected to further disrupt lobster habitat occupancy, either by inducing movement away from the area, or movement into the area, and consequent exposure to risk of smothering (trapping experiment results and distribution of clay mounds identified around test disposal site).

Based on the observation of lobster traps being damaged by dredge spoil and the moribund condition of lobsters placed in some traps at distances of 40, 80 and 120 m from the disposal target, it is concluded that dredge disposal activity could potentially lead to lobster mortality over distance of perhaps up to 100 m. Although lobsters in the trapping experiment were not able to move away from their point location, the impact of consolidated material on-bottom (identified as clay mounds) suggests that unconfined juvenile and adult lobsters would be similarly affected. Additionally, although the current benthic video observations do not have sufficient resolution to confirm the presence of early benthic stages of lobsters (1 – 3 yr from settlement) in the currently used sites, available knowledge of their life history features indicates a cryptic shelter-restricted habit, such that deposition of a significant amount of consolidated material on-bottom is presumed to lead to direct mortality. Estimates of the total number of lobsters which might be killed during an annual disposal period could be made, using the current estimates of lobster abundance, a probability function for movement, timing of disposals, area of influence, etc, but would be highly conjectural.

An unresolved aspect of lobster behaviour is the determination of avoidance vs attraction of lobsters to areas of bottom disturbance. One potential mitigation approach (sustained activity at a series of point locations) is predicated on an assumption that sustained disturbance at one location is likely to lead to avoidance behaviour by lobsters rather than attraction. An alternative disposal strategy (multiple single or intermittent disposal events) is not recommended due to an assumption that each new initial disposal event in a given location will have maximum effect on the lobsters on bottom, and that periods between disposal events greater than 12 h may provide enough time for lobsters to migrate into or across new deposits, either to search for food or to seek shelter. Using a combination of remote video and acoustic tracking approaches it would be possible to develop field experiments which could allow for discrimination between the different hypotheses concerning lobster attraction vs avoidance, and effects of frequency of disturbance on lobster habitat occupancy. Bowlby et al. (2007), in a recent lobster movement study in the Northumberland Strait, Canada, discuss integrated approaches to study lobster movement based on combinations of passive and active acoustic tracking, along with recaptures by commercial fishing activity, over a range of spatial and temporal scales that would be similar to those required to analyze heterogeneity of movement in relation to dredge spoil disposal.

The Black Point ocean disposal site was originally selected to take advantage of potential dispersive features (Envirosphere Consultants Ltd. 2003), but over the intervening years there has been an accumulation of material at the site, such that new areas are now being used, which presumably may have a similar potential to generate long-term change in bottom conditions through sediment accumulation. Accepting the need for additional geophysical evaluation, current analysis of the impacts of disposal on lobster habitat suitability suggests new spatial management approaches to dredge spoil disposal could be developed in consultation with ocean managers and stakeholders:

1. The bottom characteristics of the old disposal area at Black Point, in particular the lobster habitat function that have been disclosed from the recent monitoring studies, suggest that this part of the site should now be left dormant, with continued dredge spoil disposal directed to adjacent areas that have been in recent use, but which are still relatively deep.
2. Should these adjacent disposal areas at Black Point continue to accrete material towards a bottom depth which is close to a navigational concern, they could also be “capped” with specific material, or subject to a geophysical evaluation to determine that the area is sufficiently armoured through local seabed dynamics such that there remains complex bottom topography. This would provide for additional settlement grounds and suitable juvenile and adult habitat for lobsters.
3. Subsequent disposal activity could then be targeted at other locations within the Saint John Harbour approaches that have greater natural depths. Disposal area polygons could be drawn, within which a small number of locations could be used in a semi-continuous intensive fashion. Should these locations also function as accretive as opposed to dispersive locations, then they too could ultimately be capped and assessed for their habitat function as a shallow shoal area.

4. Overall bathymetry and nature of the seabed in the approaches to Saint John Harbour would need to be reviewed in developing a long-term spatial management plan in order to identify a small number of geographical locations which might be amenable to use as short- to mid-term disposal locations. Simulations could be undertaken to evaluate the potential longevity of specific disposal locations within the harbour approaches and identify possible technical approaches (materials, timing) to armour disposal sites following their use.
5. Achieving a long-term spatial management plan would need to consider additional biological monitoring approaches to evaluate natural benthic community composition within the harbour approaches and ensure an eventual return in ecological services from the management plan, specifically in relation to habitat suitability for lobsters, but also potentially for other ecological features.
6. Dredge spoil disposal in the approaches to Saint John Harbour is only one of a number of habitat disruptions which are either underway or projected to occur in the future from coastal industrial development and placement of significant marine infrastructure. Approaches to mitigating impacts from these various developments should be coordinated across specific projects in order to ensure that the greatest compensation effects can be realized.

SUMMARY

1. Black Point Ocean Disposal Site and the Saint John Harbour approaches are used by lobsters during summer months, although catch rates vary between trapping locations. Benthic video and SCUBA diver observations show some lobsters may undertake directed movement over the seabed during daytime, potentially as part of long-distance movement.
2. SCUBA-based collections of lobsters from the 2004 settlement year confirmed that the old disposal area (not in use since 2001) at Black Point functions as a lobster settlement habitat. This had been interpreted from catches of juvenile lobsters in traps in 2004 and 2005 studies, but the capture of recently-settled lobsters reported in this study confirms this assessment.
3. Habitat suitability at the recent disposal area (used as recently as 2004) at Black Point was judged poor in 2005 due to the seabed composition (mud and sand; gently undulating topography; remaining evidence from prior year disposal events [clay mounds]), and little evidence of epifaunal and infaunal colonization).
4. Once ocean disposal activity was underway (many loads of material delivered per day; no requirement to deliver loads to precise locations) it was not possible to continue trapping adjacent to Black Point. Trapping conducted at other locations in the Saint John Harbor approaches, several kilometers distant, were useful in understanding general patterns of coastal habitat occupancy, but it remains unclear if lobsters emigrate from disposal areas, or move in towards them (an experimental design could be developed to evaluate this issue).
5. The field experiment conducted in 2005 to evaluate effects on lobsters of close proximity to high near-bed sediment loads from dredge spoil disposal illustrated the complexity and challenge of incorporating biological effects monitoring into commercial dredging operations. The need to collect lobsters by trapping for the experiment potentially resulted in generally high stress levels in the test lobsters, reducing the sensitivity of the experiment. Low position resolution of the commercial disposal logs prevented full analysis of the “footprint” from the series of disposal events.
6. Based on chronologies of dredge spoil disposal at specific locations and lobster behaviour patterns, it is proposed that maintaining short intervals between a series of successive disposal events at a single location may reduce the potential for lobster mortality by maintaining a localized area of high near-bed turbidity and habitat disruption.
7. Additional studies are needed to better understand the impact of sediment dumping on lobster behavior, such as migration and foraging. Juvenile lobsters are potentially at greater-risk due to their smaller size and less extensive movement potential.
8. Future ocean disposal monitoring would benefit from using marine habitat classification approaches, such as Valentine et al. (2005) that include criteria related to human usage. This report is believed to be the first application of this classification approach to biological effects monitoring at the meso-habitat scale. The approach could be expanded, particularly as an integrated approach with repetitive acoustic seabed mapping.
9. An outstanding research issue with regard to lobster behavior and the dumping of dredge materials on the sea bottom is whether or not lobsters are attracted or repelled by the increased suspended sediments and noise associated with this activity.
10. Geo-referenced video should continue to be acquired to assist in improving understanding of long-term changes that may be occurring at major ocean dredge spoil disposal locations such as Black Point in the approaches to Saint John Harbour.

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TABLES 1 TO 5

Table 1. Lobster trapping survey at the Black Point Disposal Site. Number of lobsters caught in juvenile and commercial traps on each hauling day. Fifty traps were hauled on each trip (30 Juvenile Traps and 20 Commercial Traps). Trapping was conducted off the lobster fishing vessel *Final Justice*, captained by Roger Hunter. Reference is provided to the unique trip identifier (Trip No.) in the DFO lobster catch sampling database.

Date Sampled	Soak days	Juvenile Traps	Commercial Traps	Total number of lobsters	Trip No.
06-Jul-05	1	277	223	500	7057
08-Jul-05	2	474	281	755	7058
09-Jul-05	1	257	298	555	7059
11-Jul-05	2	441	497	938	7060
12-Jul-05	1	364	241	605	7061
14-Jul-05	2	556	351	907	7062
15-Jul-05	1	365	374	739	7063
17-Jul-05	2	545	504	1049	7064
Totals	**12**	**3279**	**2769**	**6048**	

Table 2. Number of lobsters tagged and recaptured by date and area (boxes) at the Black Point ocean disposal site, July 2005.

Lobster tagged and recaptured by date and area

Area (box)	**06-Jul-05**			**07**	**08-Jul-05**			**09-Jul-05**			**10**	**11-Jul-05**			**12-Jul-05**			**13**	**14-Jul-05**			**15-Jul-05**			**16**	**17-Jul-05**		
	C	**T**	**R**		**C**	**T**	**R**	**C**	**T**	**R**		**C**	**T**	**R**	**C**	**T**	**R**		**C**	**T**	**R**	**C**	**T**	**R**		**C**	**T**	**R**
8	255	0	0		430	0	11																					
7	245	207	0		325	0	7																					
4								301	295	1		456	0	1														
1				No hauls				254	0	0	No t hauls	482	0	0				No hauls							No t hauls			
6															354	354	1		493	0	12							
5															251	12	2		414	0	4							
2																						336	336	1		519	0	0
3																						403	5	2		530	0	1
Totals	500	207	0		755	0	18	555	295	1		938	0	1	605	366	3		907	0	16	739	341	3		1049	0	1

	C	**T**	**R**
Totals for all dates:	**6048**	**1209**	**43**

Note: C = captured, T = tagged, R = recaptured

Details on the 43 recaptures:				
Number of times	**1**	**2**	**3**	**4**
Recaptures	**35**	**5**	**2**	**1**

Table 3. Line transect surveys by SCUBA divers, July 2005.

Date	Transect Number	Location	Transect Length (m)	Max depth (ft)	Min depth (ft)	Dive Time (min)	Number of Lobsters
06/07/2005	1	Box 5	150	56	52	58	7
07/07/2005	2	Box 5	50	44	42	42	7
07/07/2005	3	Box 6	50	49	47	30	3
08/07/2005	4	Box 6	50	52	48	40	15
08/07/2005	5	Box 6	50	62	55	30	21
11/07/2005	6	Box 3	50	56	51	15	1
11/07/2005	7	Box 3	50	62	60	15	0
12/07/2005	8	Box 2	50	62	61	12	1
12/07/2005	9	Box 2	50	63	62	30	0

Table 4 Position offsets for traps from target positions for field experiment. Trawl deployment (A) and retrieval (B) position offsets for the end trap in each trawl relative to the target position for each trawl and to the Disposal Event target position,

(A) Offset (m) of End Trap on Deployment		
Trawl	**From target location**	**From disposal target**
1	5	38
2	7	39
3	5	36
4	9	49

(B) Offset (m) of Trap 3 of each trawl:		
Trawl	**From target location**	**From disposal target**
1	8	117
2	16	122
3	Lost	Lost
4	26	138

Table 5. Chronology of disposal events at Black Point during 2005 permit season. For geographical positions where more than 10 disposal events were recorded over the 2005 permit season, individual events were classified as either representing part of discrete sequences (each event separated by less than 24 h) or as single events, where there was > 24 h between that event and the ones preceding and following it. Total events (N) refer to all events recorded at a specified position.

Reported Location				Total Events (N)	Events within Discrete Sequences (<24h interval)		Single Events (>24h interval)
Lat_DMS	Long_DMS	Latitude	Longitude		Elapsed Time (h)	Events	
451237	660103	45.2102778	66.0175000	30	2	2	13
					47	4	
					24	3	
					2	2	
					11	3	
					18	3	
451237	660107	45.210278	66.018611	35	24	4	8
					12	2	
					10	2	
					36	3	
					9	3	
					15	2	
					35	3	
					2	2	
					98	6	
451237	660111	45.210278	66.019722	16	12	2	9
					11	2	
					25	3	
451241	660107	45.211389	66.018611	831	148	74	0
					69	32	
					139	80	
					50	36	
					194	163	
					151	132	
					36	21	
					242	136	
					32	15	
					49	17	
					40	18	
					211	107	
451245	660103	45.212500	66.017500	15	1	2	6
					12	2	
					8	2	
					27	3	

Table 5. Chronology of disposal events at Black Point during 2005 permit season (Continued).

Reported Location				Total Events (N)	Events within Discrete Sequences (<24h interval)		Single Events (>24h interval)
Lat_DMS	Long_DMS	Latitude	Longitude		Elapsed Time (h)	Events	
451241	660103	45.211389	66.017500	162	7	2	4
					16	2	
					6	2	
					52	7	
					153	34	
					3	2	
					5	2	
					18	4	
					34	3	
					13	3	
					85	15	
					111	13	
					33	4	
					185	26	
					4	3	
					47	8	
					22	4	
					21	3	
					40	10	
					36	5	
					13	2	
					22	2	
451241	660111	45.211389	66.019722	35	3	2	17
					10	2	
					15	3	
					23	3	
					36	4	
					11	2	
					2	2	
451245	660107	45.212500	66.018611	35	24	7	13
					124	9	
					44	4	
					2	2	
451326	660130	45.223889	66.025000	19	4	2	0
					64	17	
451333	660145	45.2258333	66.0291667	18	34	18	0

FIGURES 1 TO 32

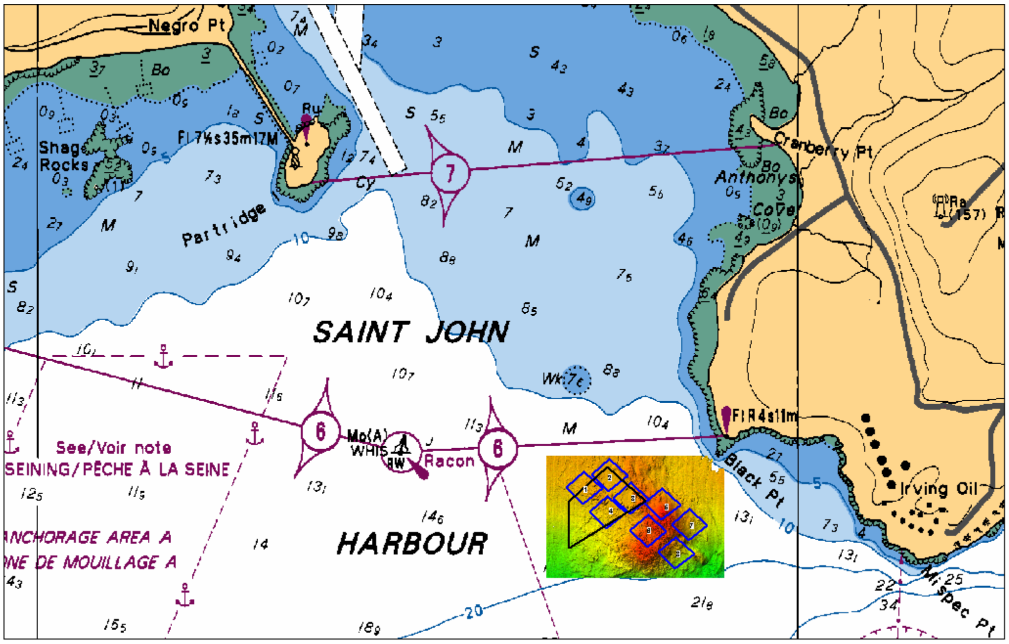


Figure 1. Geographical features in the approaches to Saint John Harbour. Permit boundary for 2005 dredge spoil disposal at the Black Point Ocean Disposal Site (black polygon), and the eight designated study boxes are indicated.

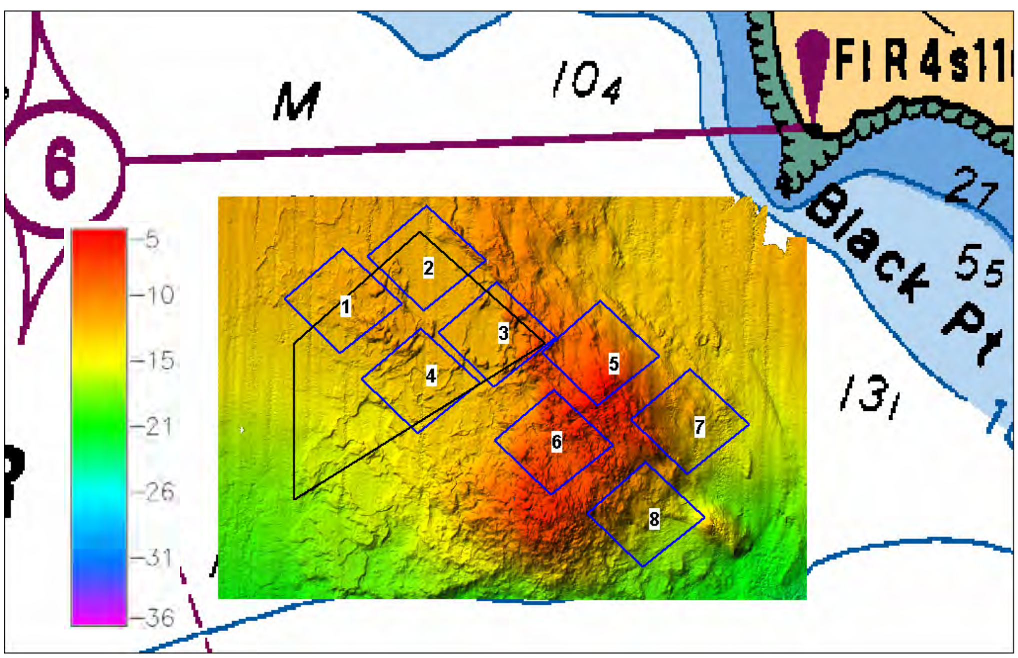


Figure 2. Close-up of the Black Point ocean disposal site. Disposal permit boundary (black polygon) and the eight designated study boxes (blue polygons) are shown. Depth shading indicated in meters. Multibeam image courtesy of R. Parrott, Geological Survey of Canada (Atlantic), Dartmouth, Nova Scotia.

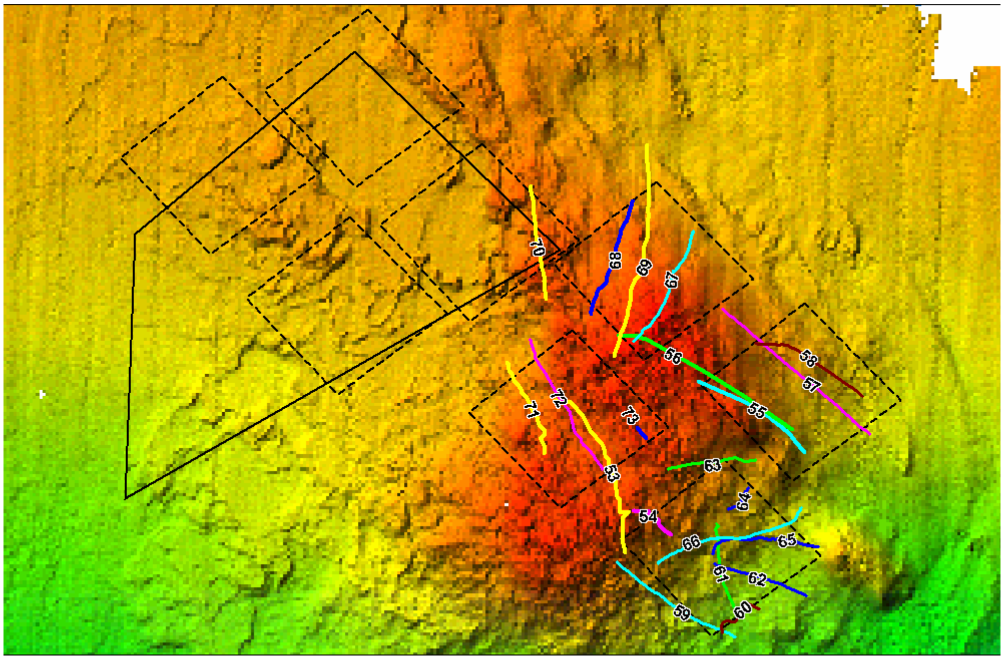


Figure 3. Remote video transects on July 4th and 5th, 2005 at Black Point. The set number for each transect is indicated (see also Appendix 2). Boxes bounded by broken lines are the eight designated study boxes identified in Figure 2.

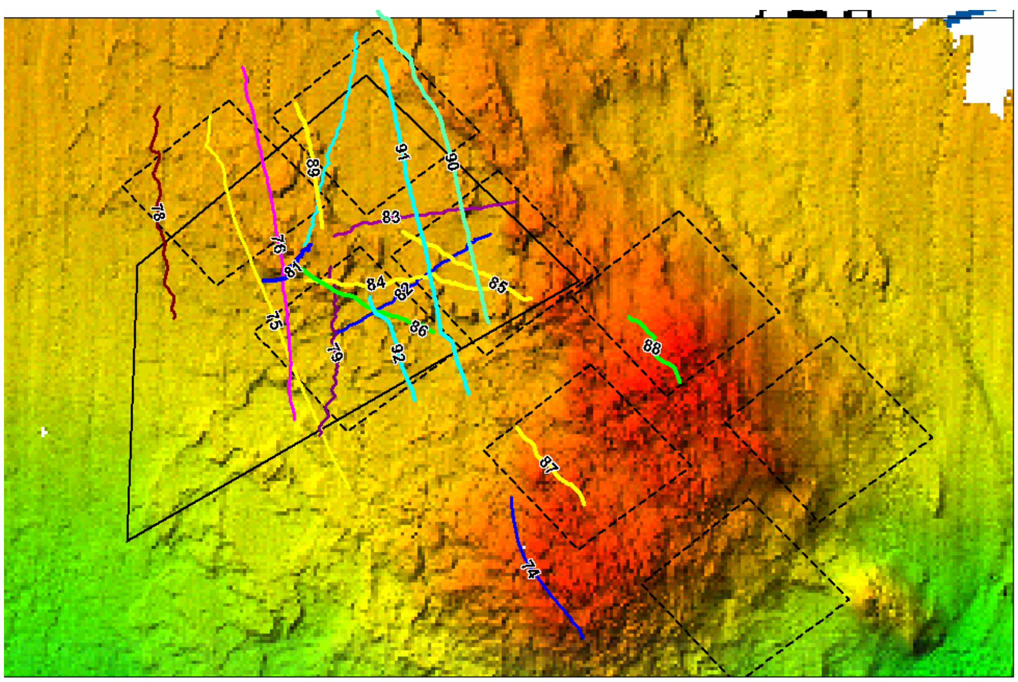


Figure 4. Remote video transects on July 7th and 8th, 2005 at Black Point. The set number for each transect is indicated (see also Appendix 2). Boxes bounded by broken lines are the eight designated study boxes identified in Figure 2.

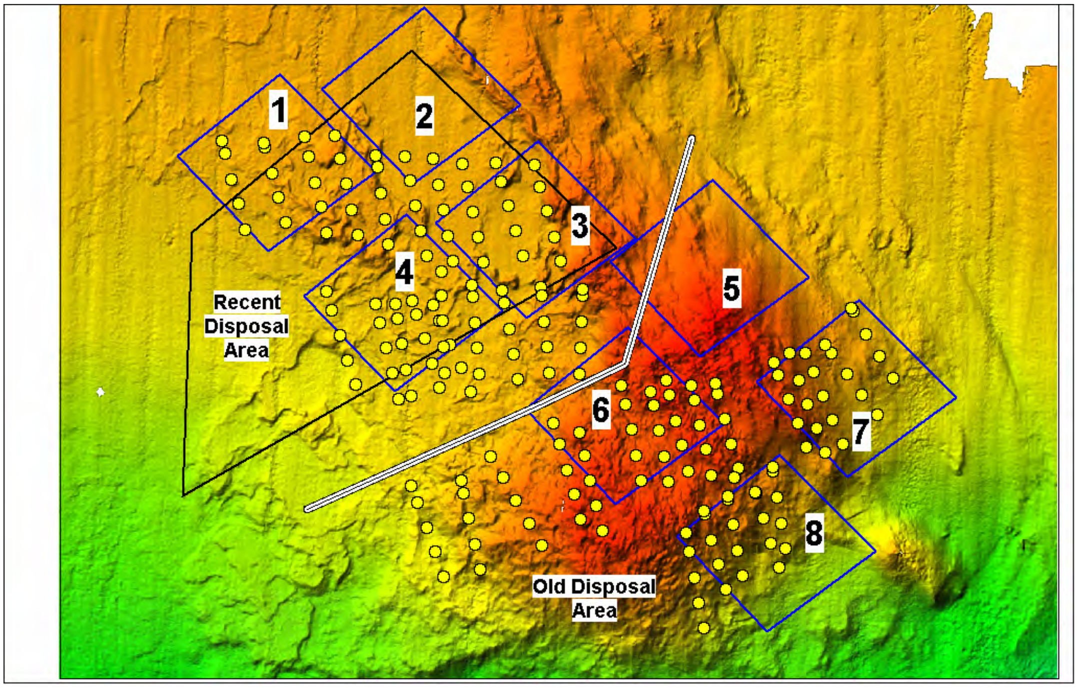


Figure 5. Lobster trapping positions at the Black Point ocean disposal site. Two groups of trapping data (separated by the line indicated above) were analyzed for comparisons of lobster catches between the recent disposal area and the old disposal area.

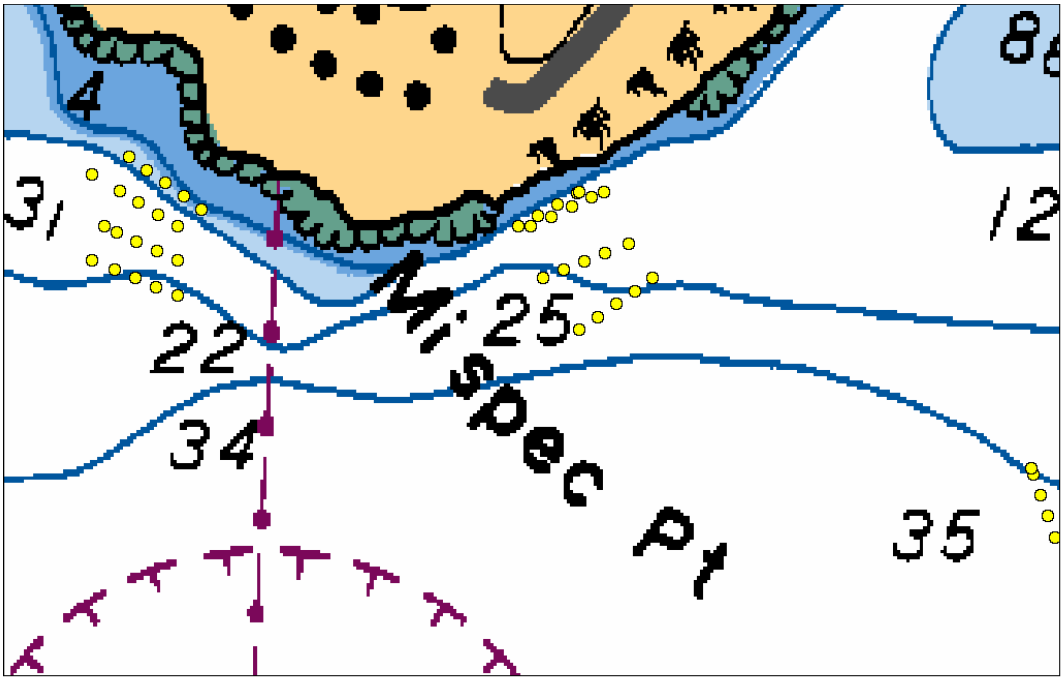


Figure 6. Lobster trapping positions at Mispec Point. Traps were set for a one-day soak followed by a two-day soak. Some traps were reset at the same position.

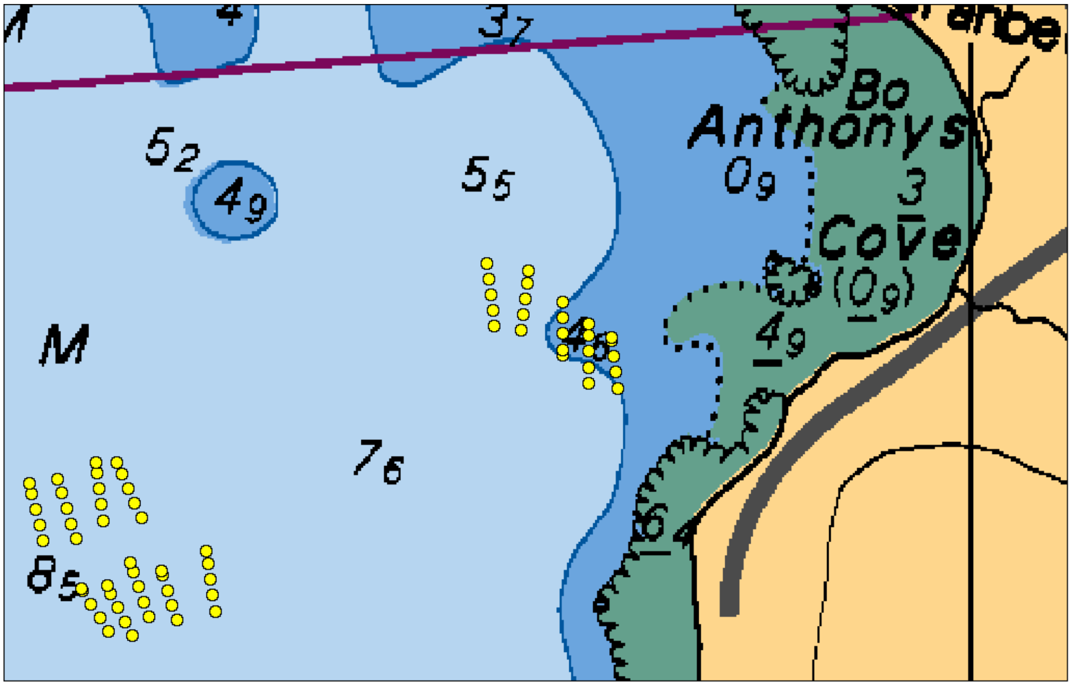


Figure 7. Lobster trapping positions in Anthony's Cove. In the area nearest to the shore (called Cranberry Point in this report), traps were set for one two-day soak only. The outer set of traps near the 2005 alternative disposal permit area were set for a one-day soak then a two-day soak. Some traps were reset at the same position.

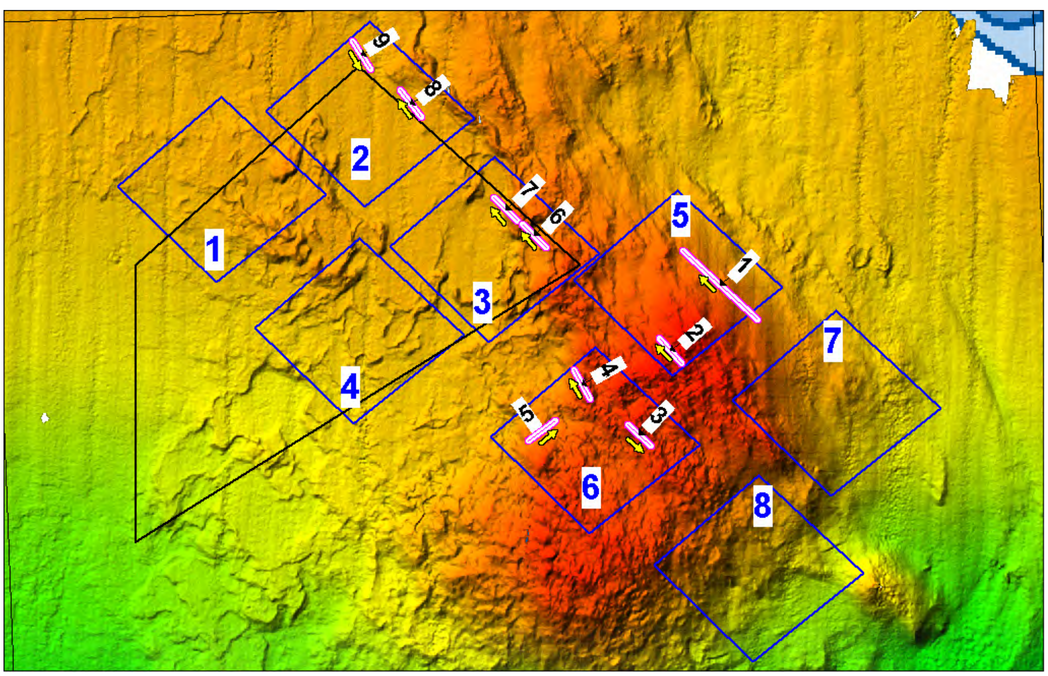


Figure 8. Line transects by SCUBA divers at Black Point during July 2005. The arrow next to each line indicates the direction of survey. See Table 3 for details.

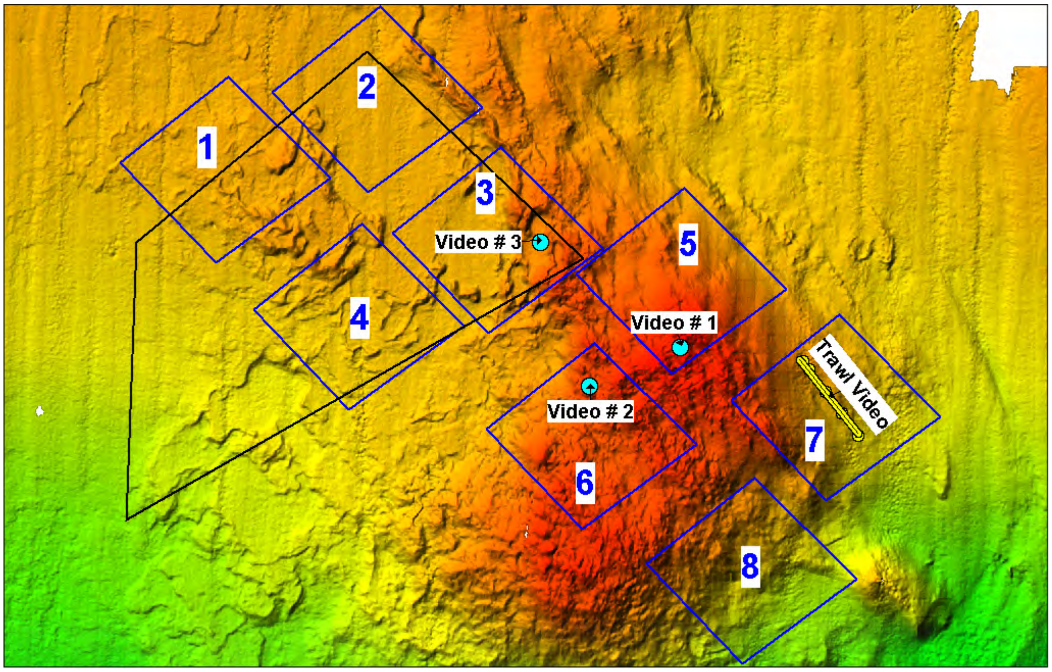


Figure 9. Underwater video collected at Black Point by SCUBA divers during July 2005.

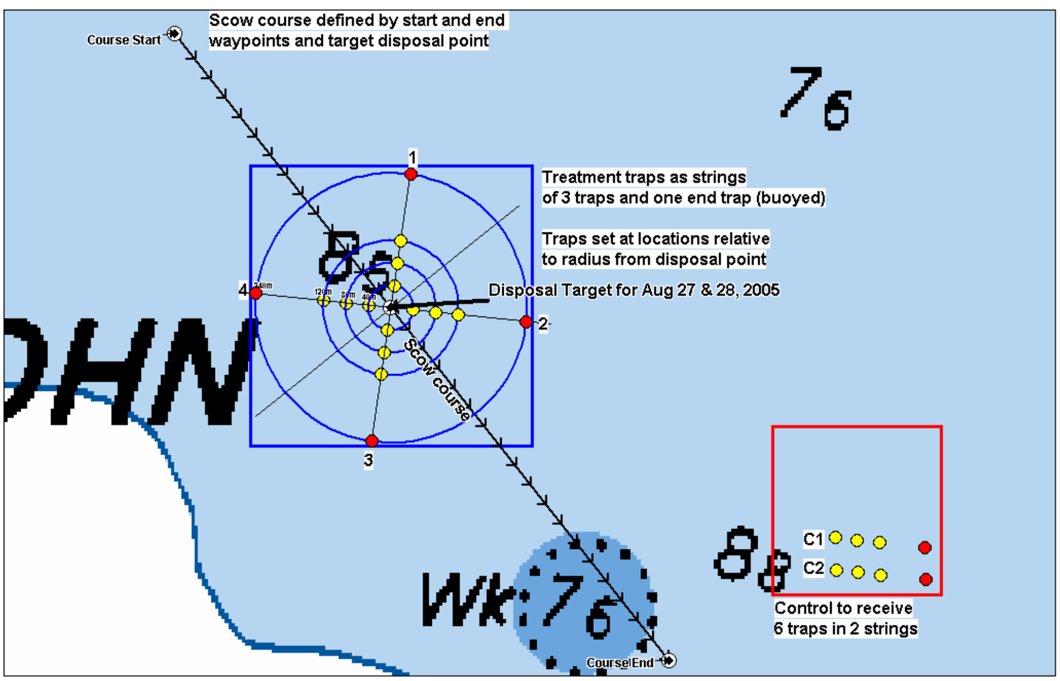


Figure 10. Layout of treatment traps and control traps in relation to a target disposal point at Anthony's Cove. Treatment traps were to be deployed at 40 m, 80 m, and 120 m from the target disposal point. Scows were to follow the path indicated and release dredge spoil at the target point.

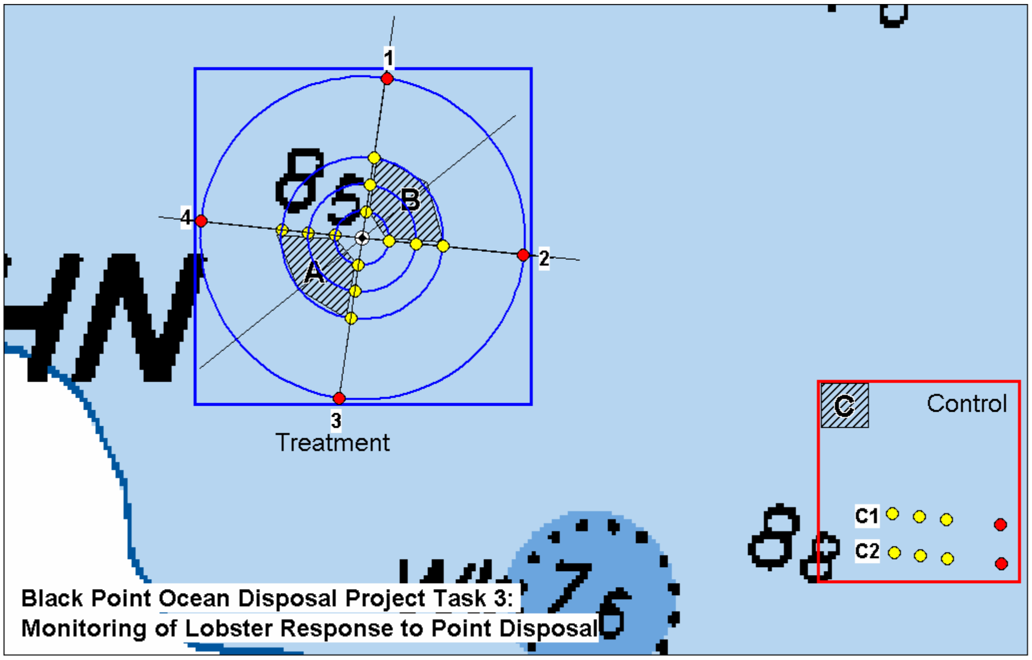


Figure 11. Designated areas (A, B, and C) for CTD casts during disposal activity at Anthony's Cove on August 27, 2005. Additional casts were undertaken directly over the target disposal location immediately after two dredge disposal events.

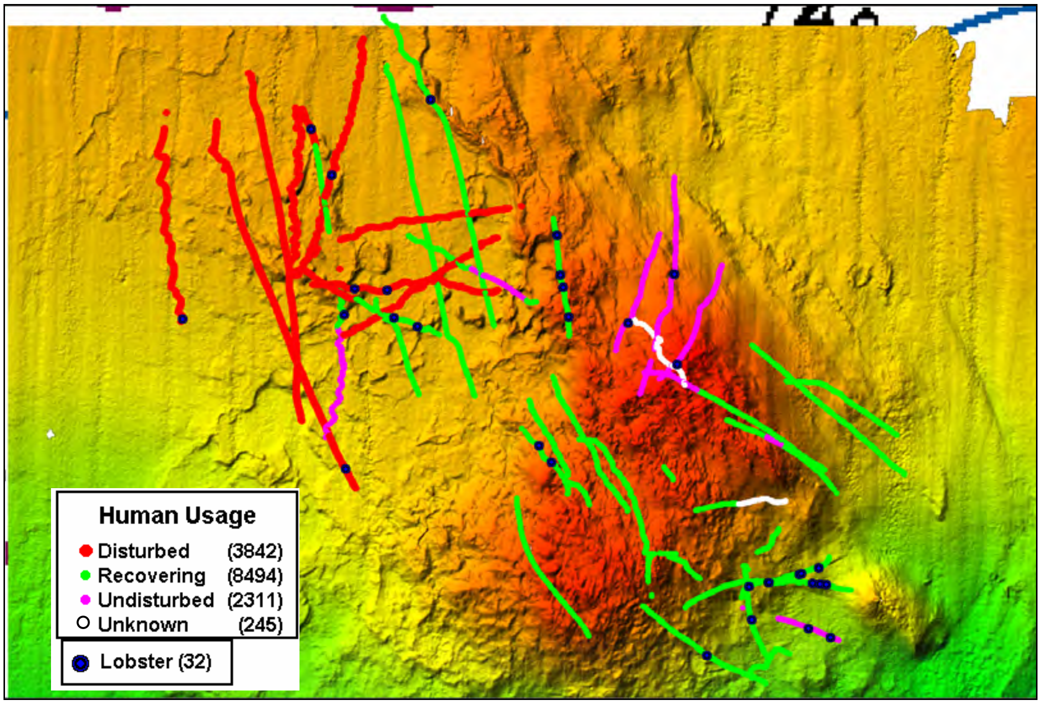


Figure 12. Video-based classification of the seabed at the Black Point ocean disposal site. Interpreted effects of human usage (see Appendix 1 for classification scheme). Also indicated are the positions along video transects where lobsters were observed. Numbers in brackets in the legend refer to the number of geo-referenced observations.

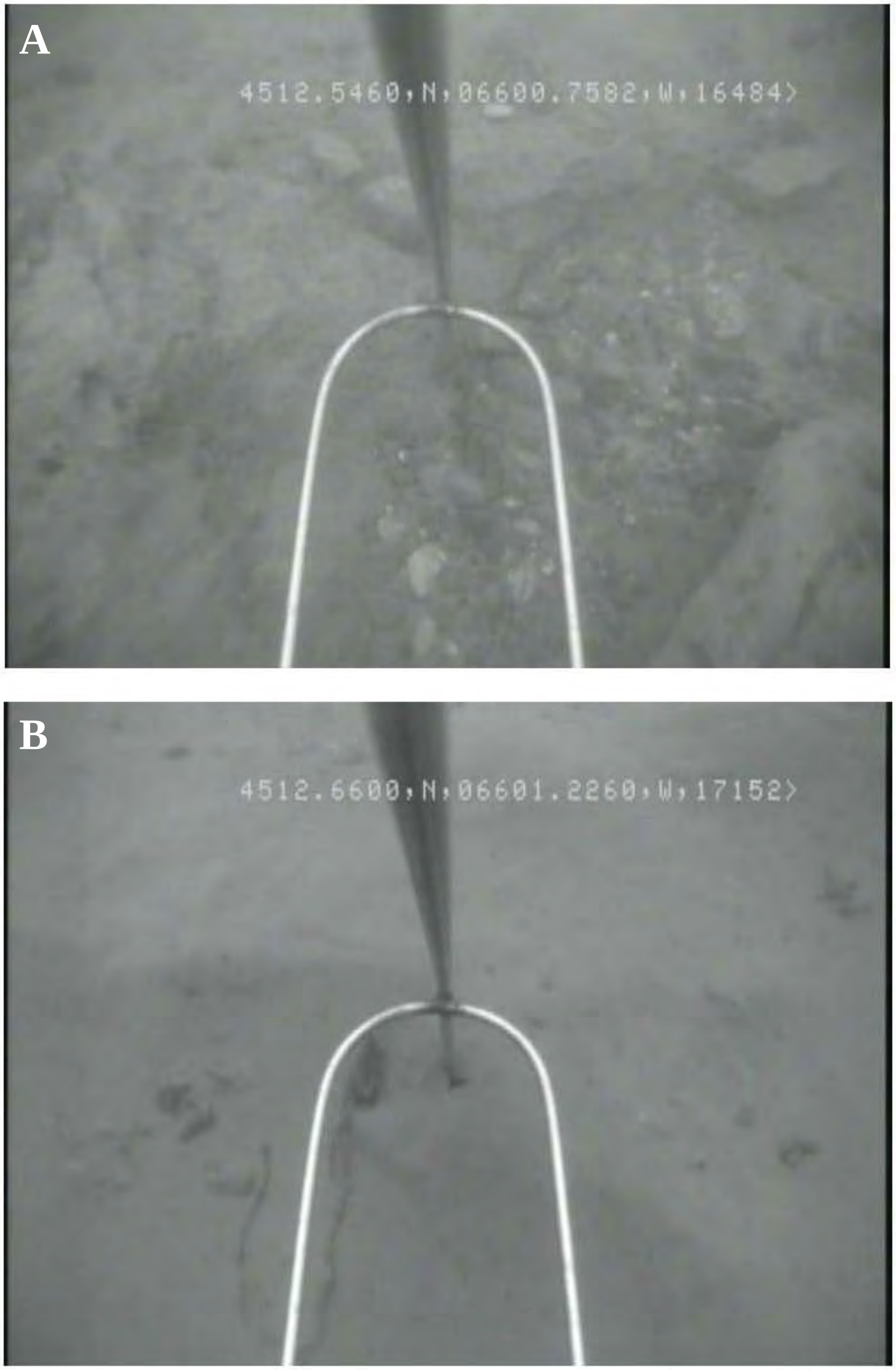


Figure 13. Image captures from URCHIN video surveys of the seabed at the Black Point ocean disposal site. (A) Old disposal area. Image collected on Set 56 on July 4, 2005. Note the high physical structural complexity of the seabed. (B) Recent disposal area. Image collected on Set 84 on July 7, 2005. Note the low physical structural complexity of the seabed. Refer to Appendix 2 for other details on each Survey Set.

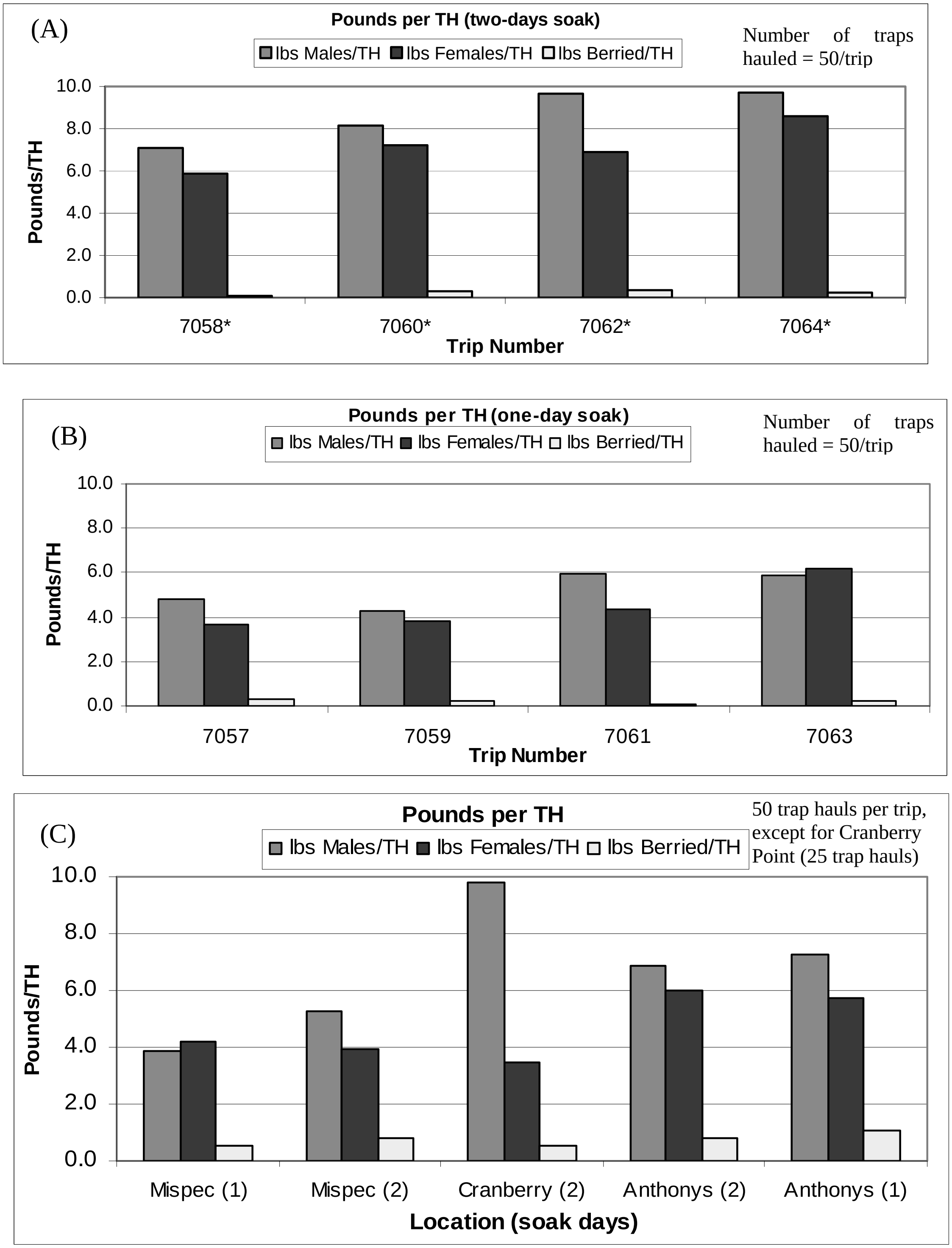


Figure 14. Catch by weight of males, females and berried lobsters per trap hauled (Pounds/TH). (A) Black Point on two-day soaks, July 2005 (* trip numbers from catch sampling database); (B) Black Point on one-day soaks, July 2005; and (C) Mispec Point, Cranberry Point and Anthony's Cove during August and September 2005 on one-day soaks and two-day soaks (indicated by the numbers in brackets).

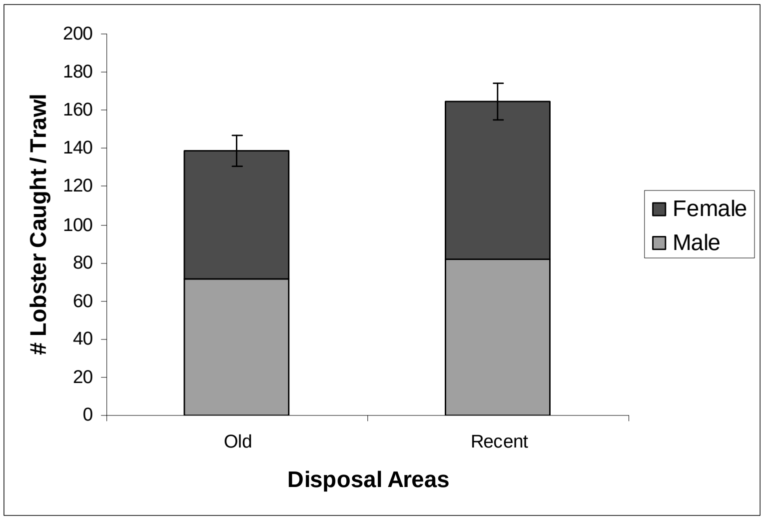


Figure 15. Average catch rates of male and female lobsters (Number per trawl ±SE) from old (n = 20 trawls) and recent disposal areas (n = 20 trawls) at Black Point.

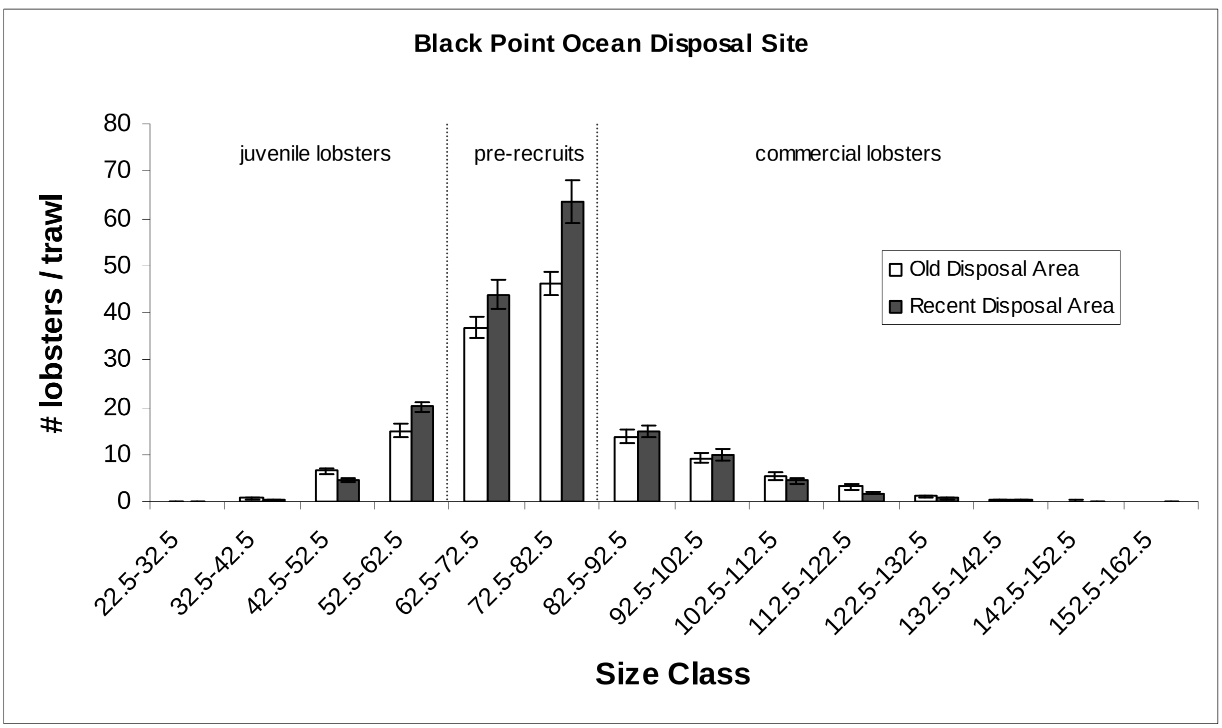


Figure 16. Average catch rates of lobsters (±SE) at Black Point based on size class. Data for different trap depths and soak days were pooled for the old (n = 20 trawls) and recent (n = 20 trawls) disposal areas.

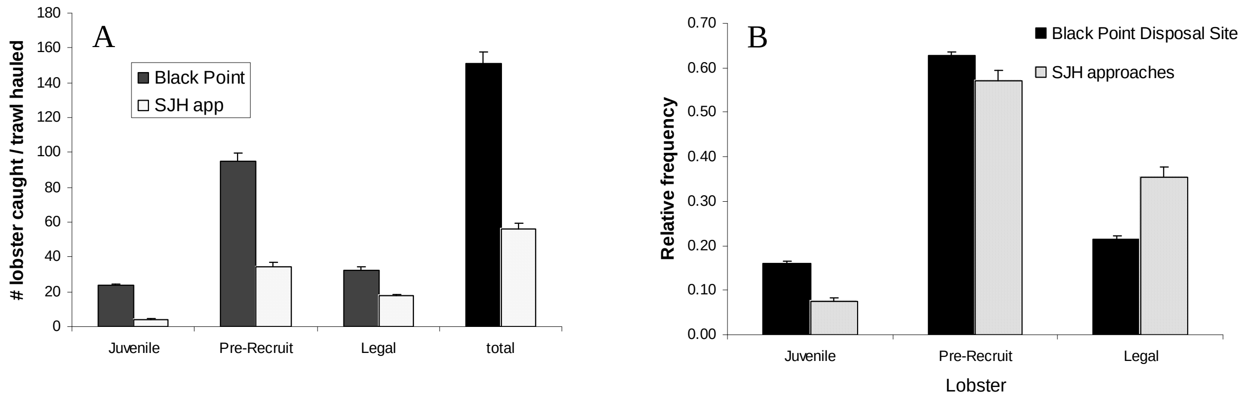


Figure 17. Average catch rates of lobsters by general size categories and relative frequency of capture. (A) Average catch rates (±SE) of lobsters from Black Point (old and recent disposal areas combined; n= 40 trawls) and Saint John Harbour approaches (Anthony's Cove, Cranberry and Mispec Point combined; n=41 trawls), and (B) Relative frequency of each size category for Black Point and Saint John Harbour approaches. Trapping in July 2005 at Black Point prior to disposal activity; trapping in Saint John Harbour approaches in August 2005 while disposal activity was underway.

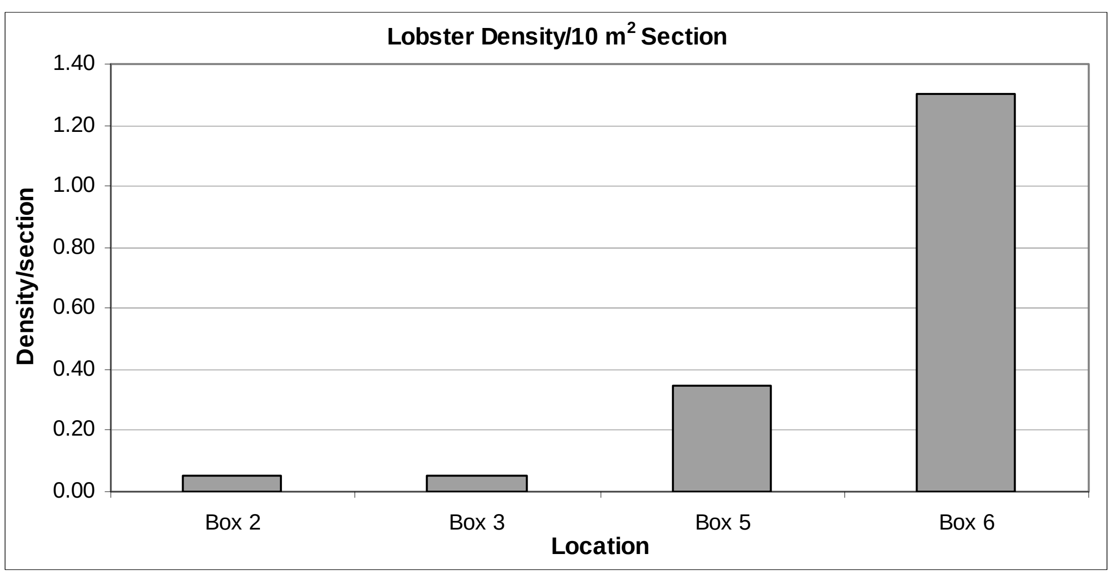


Figure 18. Lobster density per 10 m² section of line transects searched by SCUBA divers at the Black Point. Location of survey boxes indicated in Figure 2. Total number of sections = 110; total number of lobsters = 55.

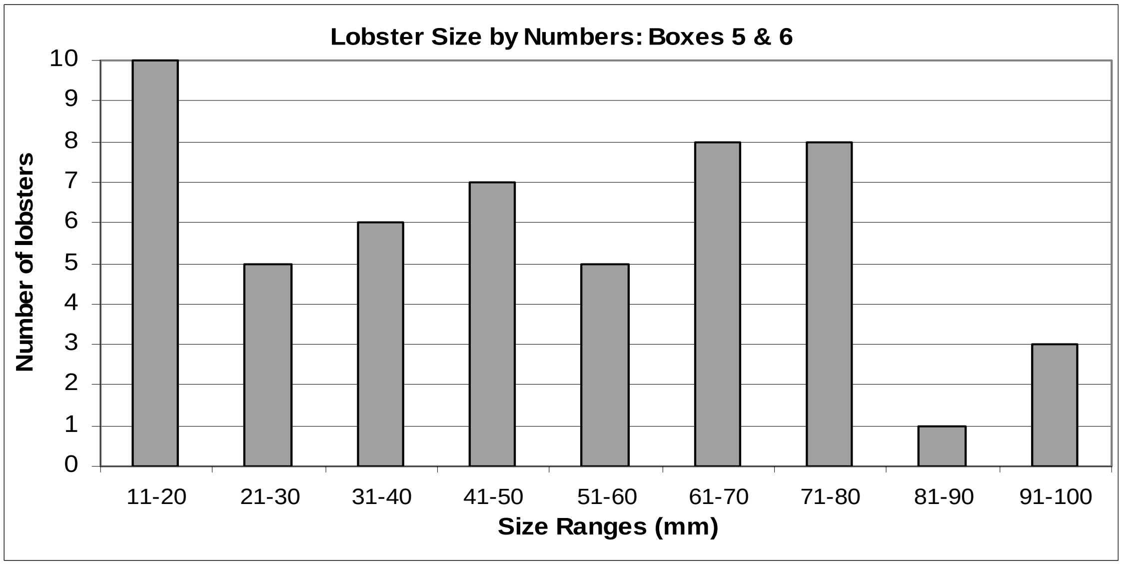


Figure 19. Size distribution of lobsters as recorded by SCUBA divers at Black Point. The total number of lobsters caught in line transects conducted in survey boxes 5 and 6 was 53. Only two lobsters were recorded in Boxes 2 and 3 with sizes between 51-70 mm CL.

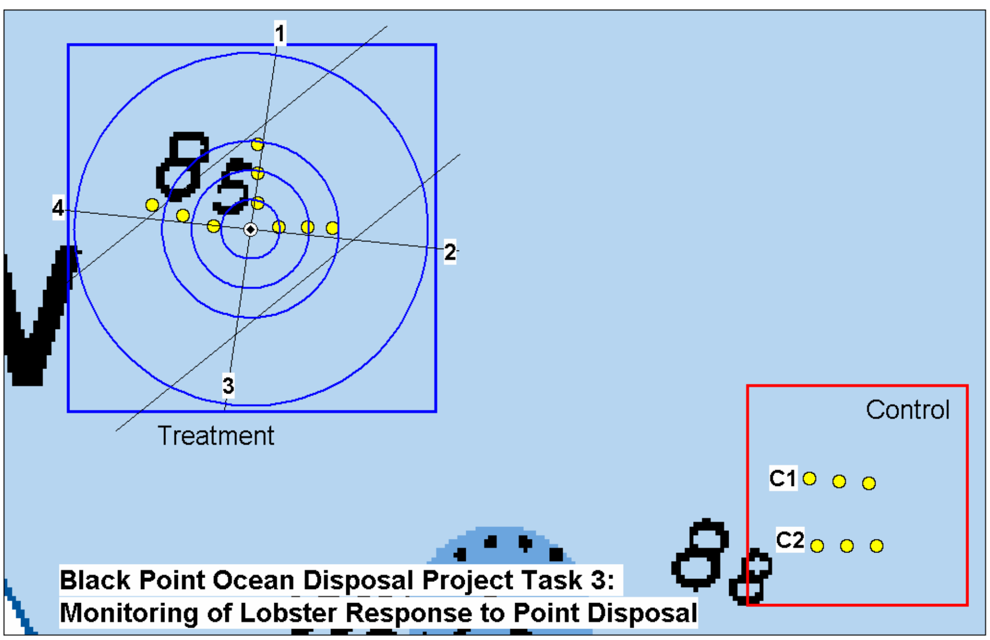
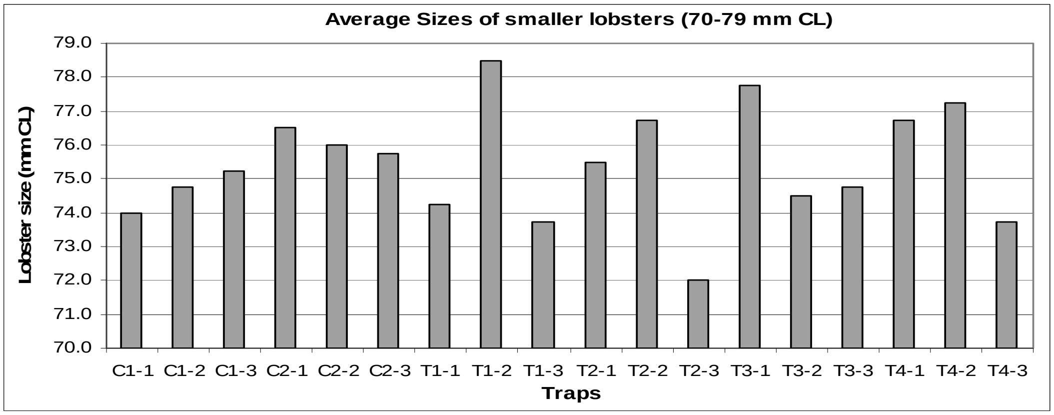


Figure 20. Actual deployment positions of treatment and control traps in relation to the target disposal point at Anthony's Cove. Note that trawl 3 was lost.



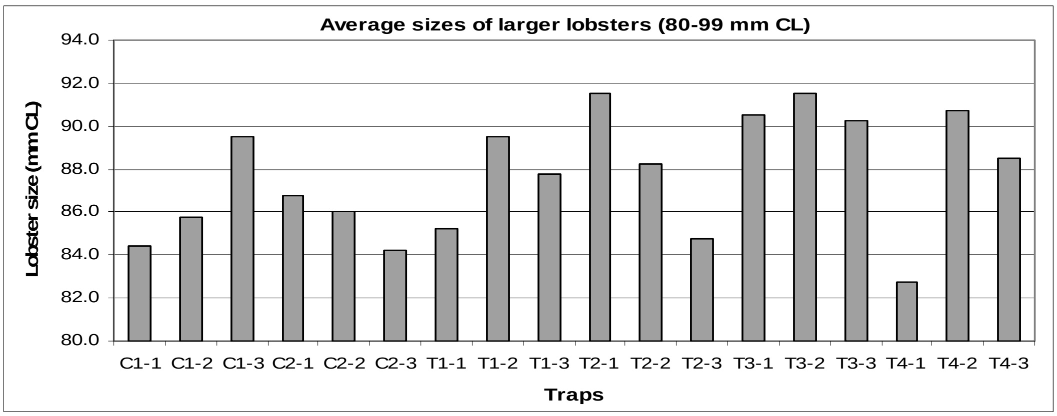


Figure 21. Size distribution for two size groups of lobsters used in the control and treatment traps for Task 3 in Anthony's Cove. C1-1 = Control 1-Trap 1, C1-2 = Control 1-Trap2, T1-1 = Trawl 1 –Trap 1, T1-2 = Trawl 1-Trap 2, etc.

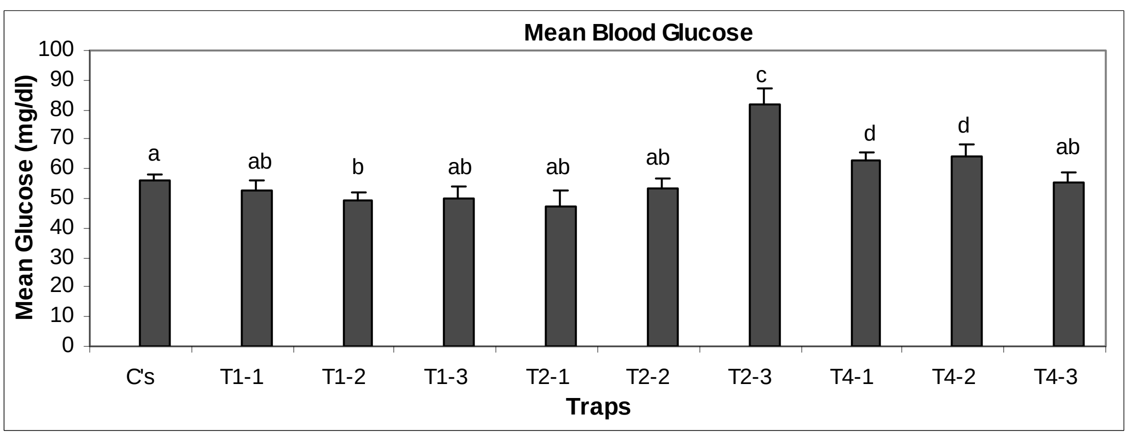


Figure 22. Mean concentration of glucose (mg/dl) in haemolymph sampled from lobsters held in traps near the Anthony's Cove alternative disposal site. There were six traps with 8 lobsters each at the control sites and the mean glucose concentration is presented as a mean for all control lobsters (C`s). The treatment traps had eight lobsters each. T1-1 = Trawl 1, Trap 1; T1-2 = Trawl 1,Trap 2, etc. Samples with the same letter are not significantly different from each other.

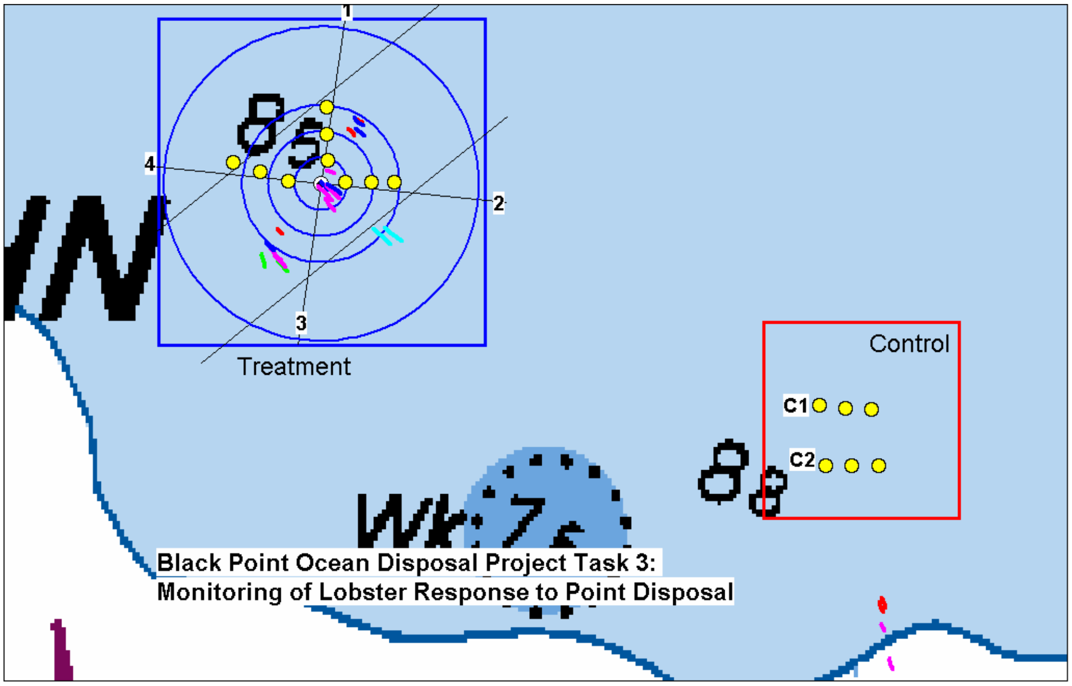


Figure 23. Location of the start and end points of the CTD drift sampling at Anthony's Cove. Each short coloured line indicates the position of a cast. Note casts to the south of the control area.

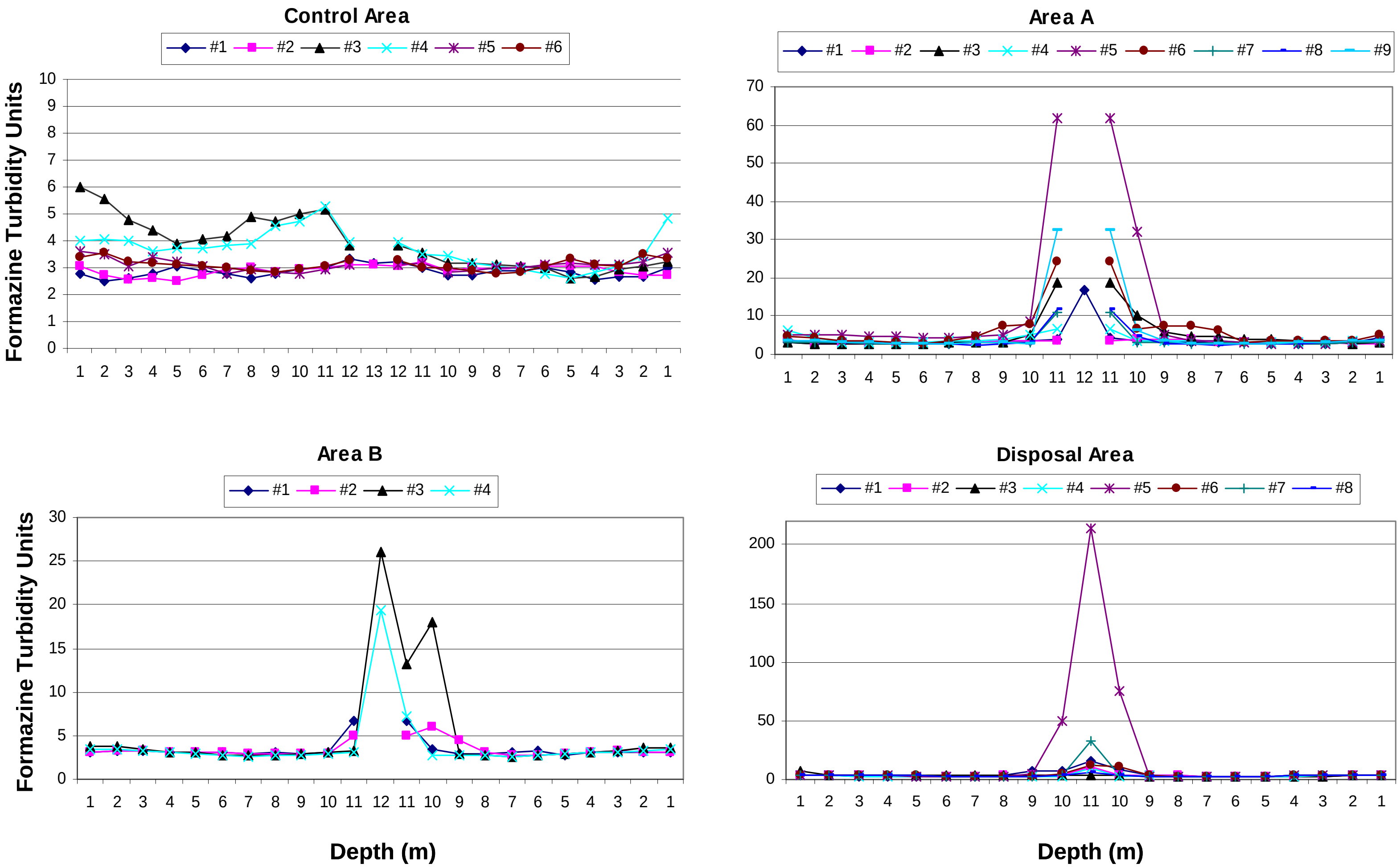


Figure 24. Turbidity profiles by depth at Anthony's Cove. Individual casts from the surface to near bottom then back to surface: Control Area C (6 casts); Area A (9 casts); Area B (4 casts); and for events at the Disposal Area (6 casts). Sampling locations A, B and C shown in Figure 11; drift lines during casts shown in Figure 23. Depth in m (as recorded by the CTD). Turbidity measured in Formazine Turbidity Units (FTU's). Note that different vertical scales have been used in each panel based on the observed FTU's.

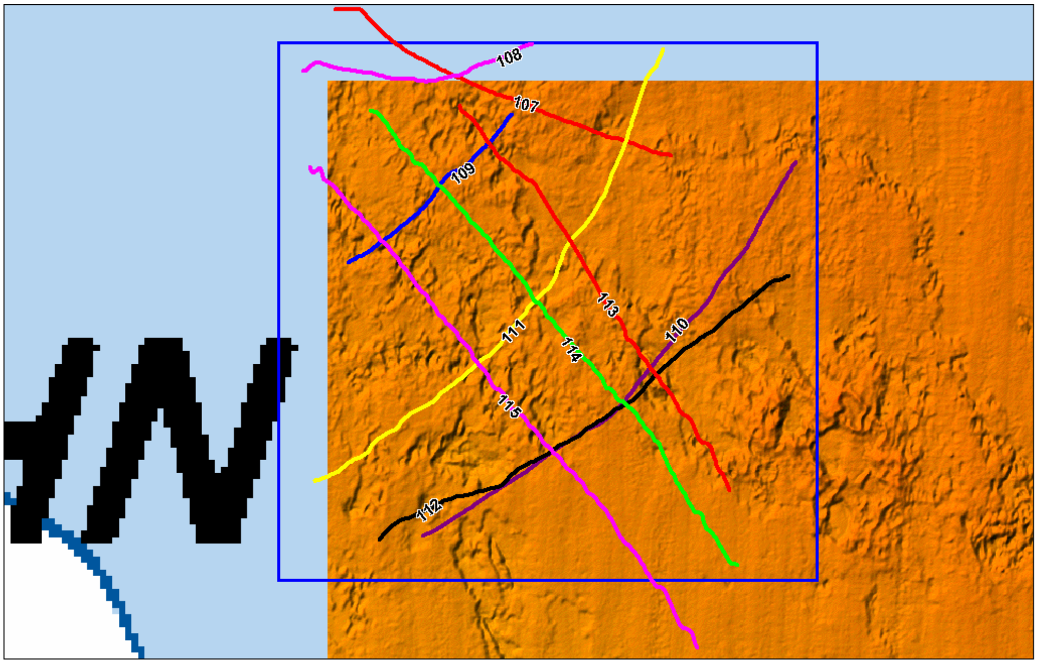


Figure 25. Remote video transects conducted prior to trap placement and dredge spoil disposal events at Anthony's Cove. The set number for each transect is indicated (see also Appendix 2).

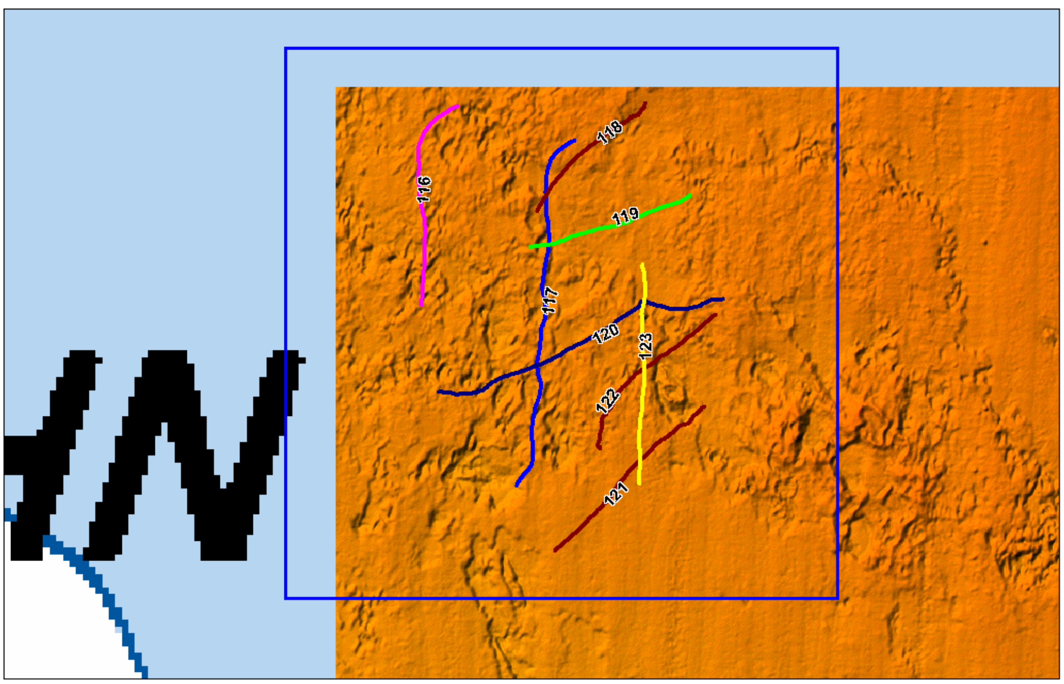


Figure 26. Remote video transects conducted after dredge spoil disposal events and retrieval of traps at Anthony's Cove. The set number for each transect is indicated (see also Appendix 2).

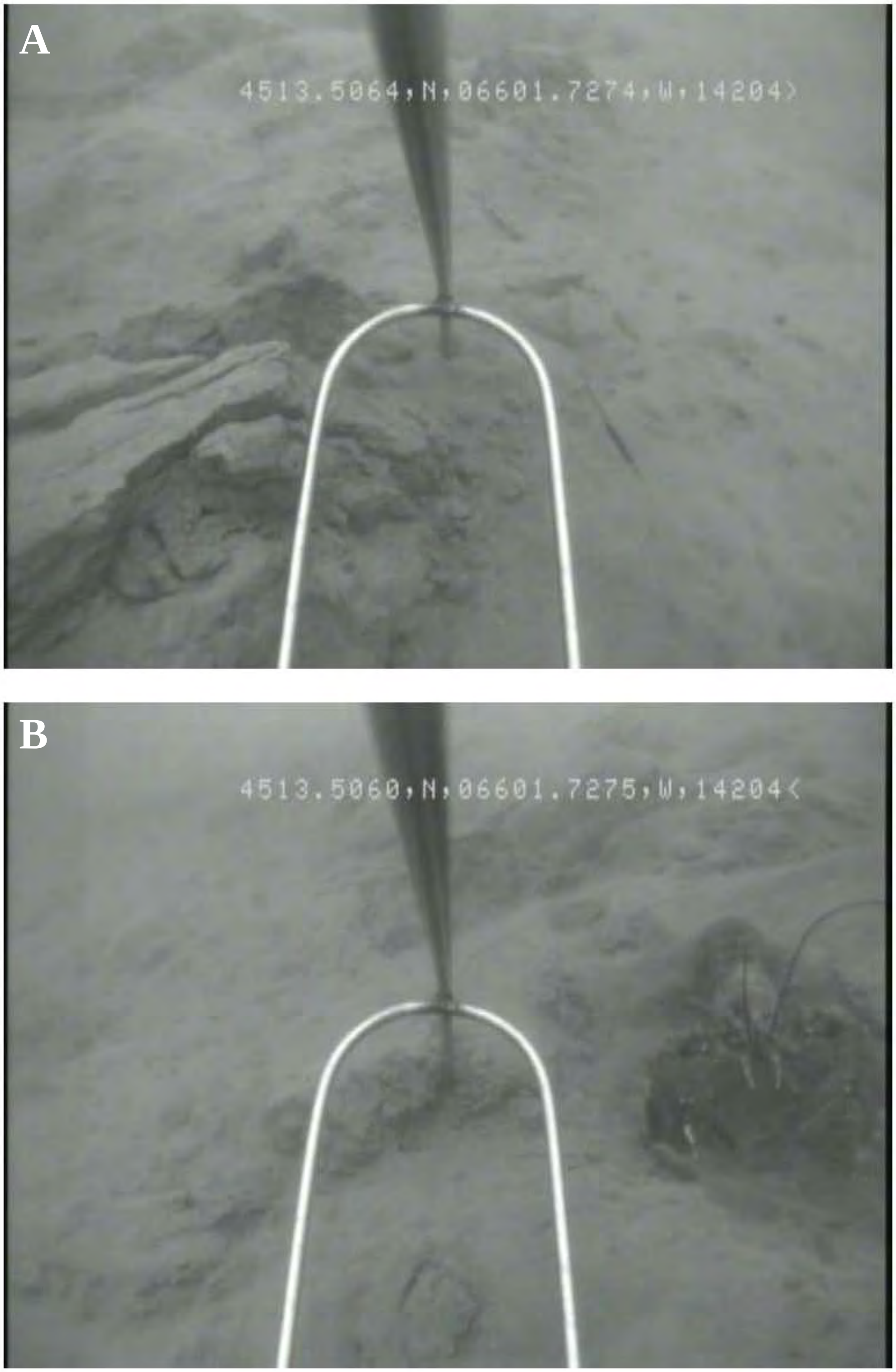


Figure 27. Image captures from URCHIN video surveys of the seabed during the Anthony's Cove experiment. (A) Fresh spoil material, termed "clay mounds". Image collected on Set 117 on August 30, 2005. (B) Lobster present in the treatment area two days following disposal events (Set 117). Refer to Appendix 2 for other details on the Survey Set.

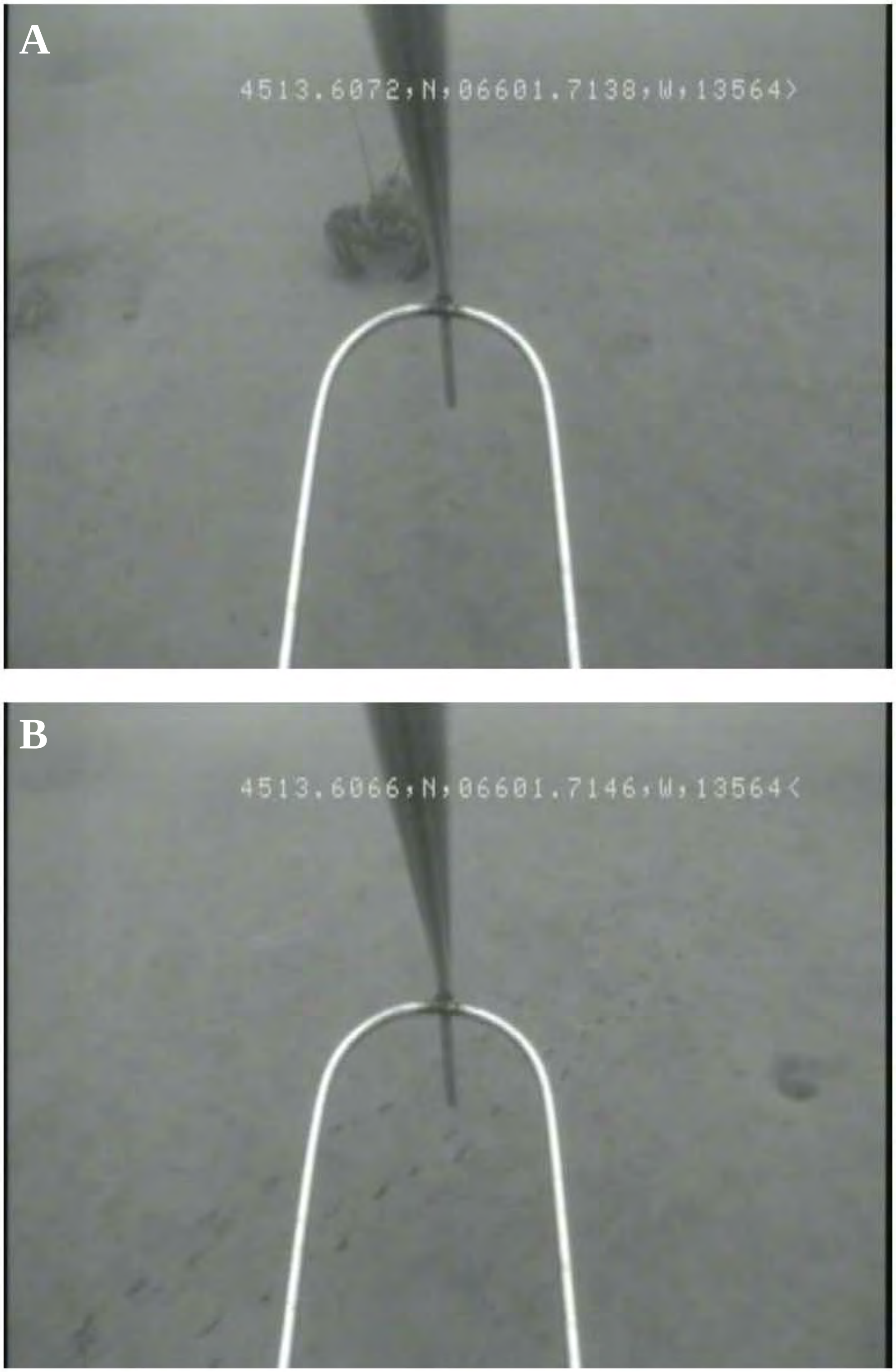


Figure 28. Image captures from URCHIN video surveys of the seabed during the Anthony's Cove experiment. (A) Lobster encountered moving left to right across video path. (B) Characteristic "lobster tracks" marking lobster's path, several video frames later. Images collected on Set 117, August 30, 2005. Refer to Appendix 2 for other details on the Survey Set.

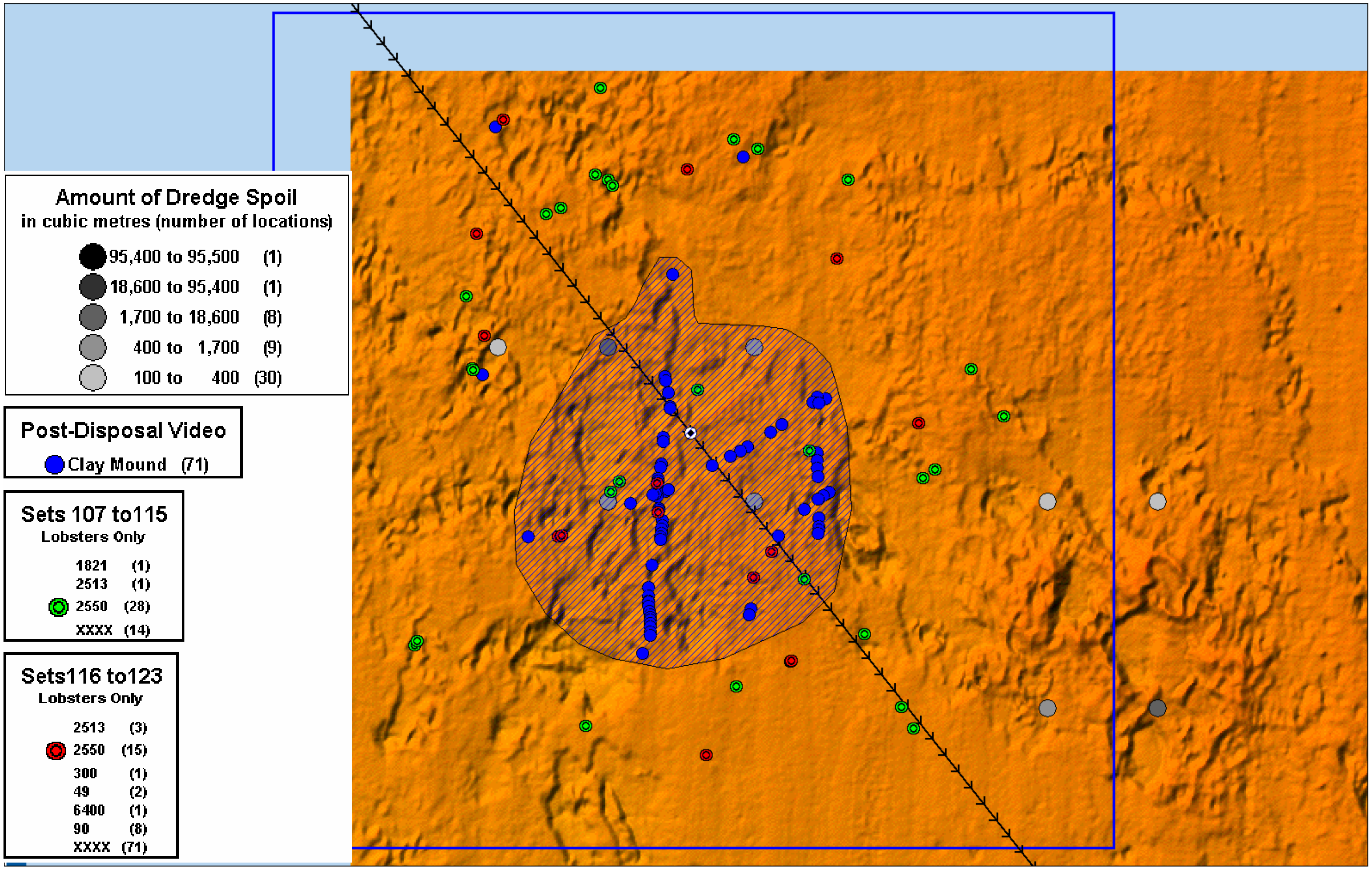


Figure 29. Video-based definition of dredge spoil disposal "footprint" at Anthony's Cove. Locations of discrete features indicating dredge spoil accumulation (clay mounds) and polygon interpreted to be the area that received most of the dredge spoil. Positions where lobsters were observed along video transects pre- (sets 107 - 115) and post-disposal (sets 116 – 123) are indicated, along with estimates of the total amount of dredge spoil deposited in study area, as derived from dredge spoil disposal monitoring documents.

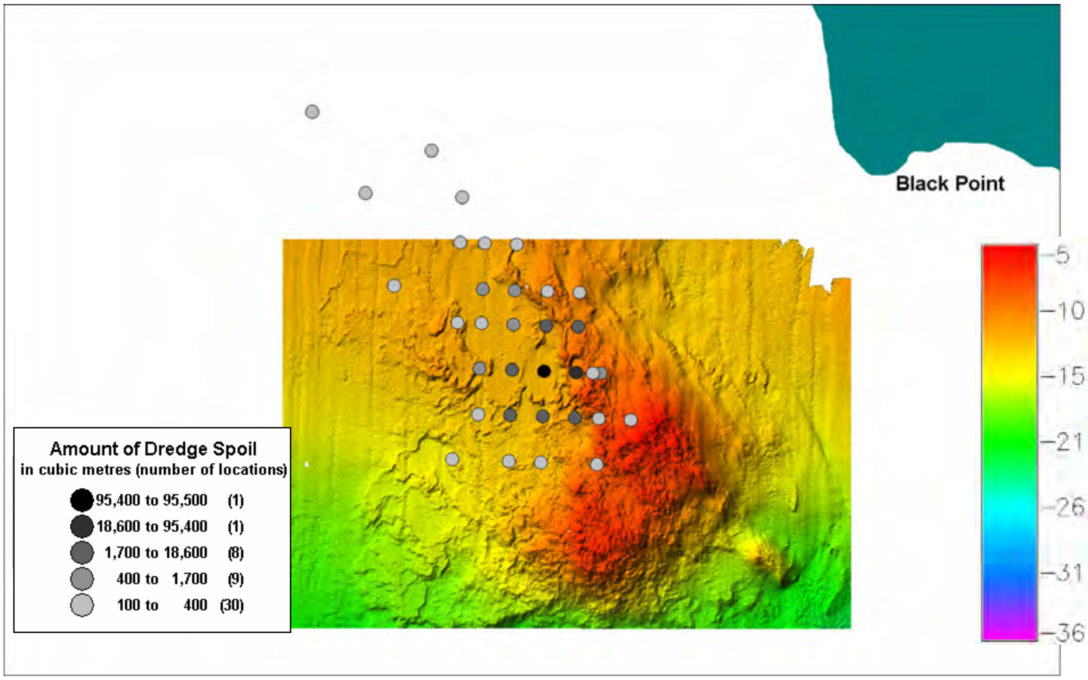


Figure 30. Amounts of dredge spoil disposed at each recorded location at the Black Point disposal site. This plot does not include 143 events which did not have position information in the data set received from EC (as of January 19, 2006).

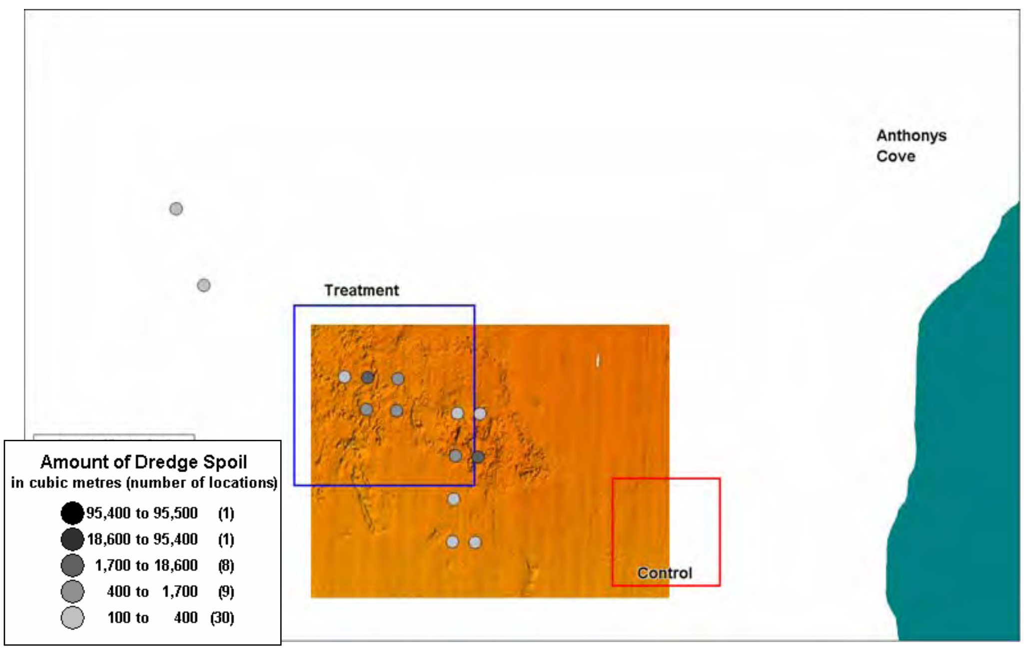


Figure 31. Amounts of dredge spoil disposed at each recorded location at the Anthony's Cove alternative disposal site. Disposals in the treatment box were part of the field experiment. This plot does not include 143 events which did not have position information in the data set received from EC (as of January 19, 2006).

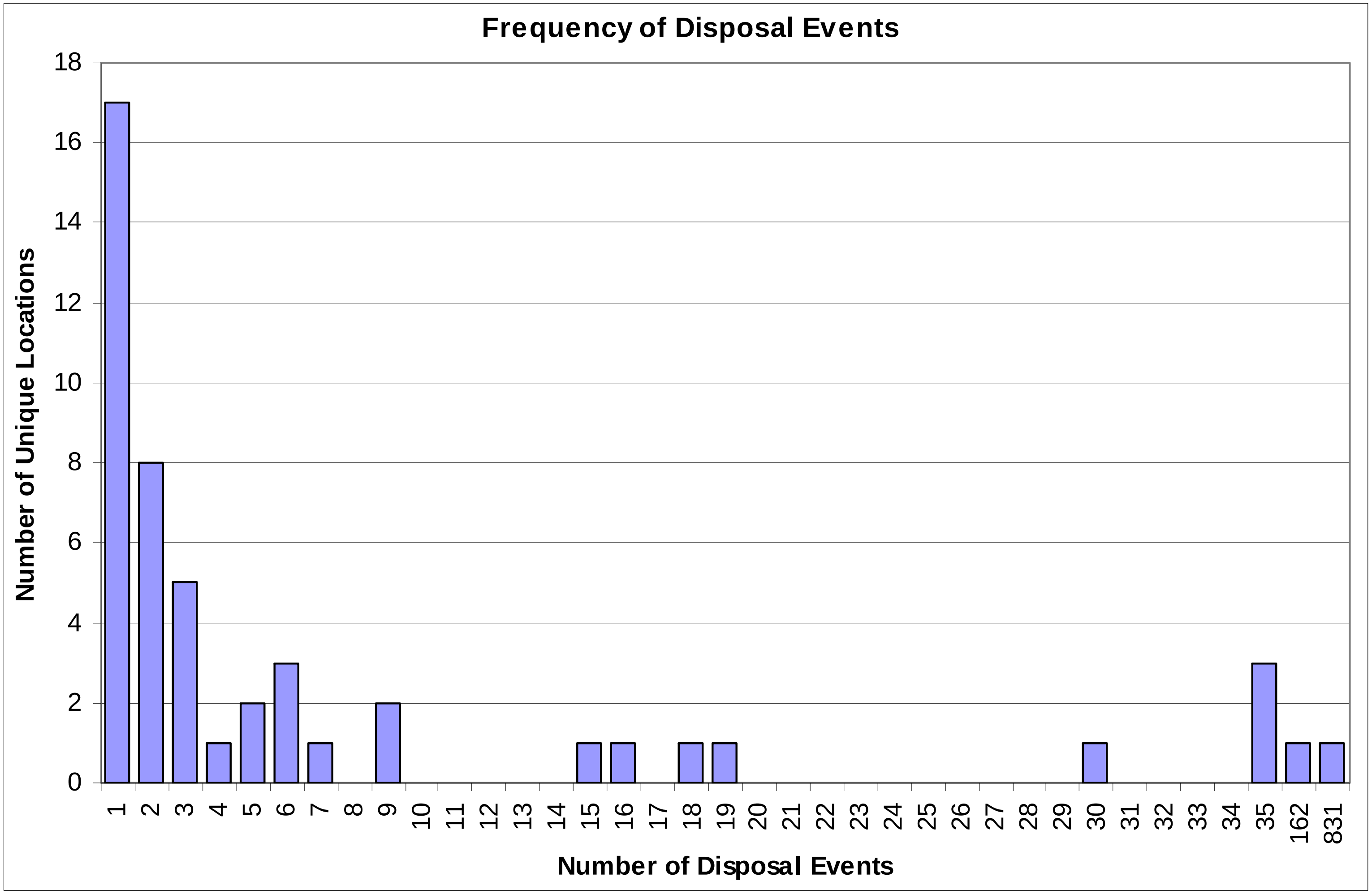


Figure 32. Frequency of disposal events at unique reported locations at the Black Point disposal site and the alternative disposal site in Anthony's Cove. This plot does not include 143 events which did not have position information in the data set received from EC (as of January 19, 2006).

APPENDIX 1: HABITAT CLASSIFICATION CODES FOR VIDEO ANALYSIS

A. Location Information

To geo-reference post-processed video data with the field acquired video, a spreadsheet-based data entry form was used such that it could link to a separate Oracle database that stored position information recorded at sea. This was accomplished by using set number and time stamp to create a unique identifier with which to query the database.

Column	Format	Descriptive Guide
Set	Number	Sequential remote video set number
Time	hh:min:ss	Time at which a NEMA update occurred in the source Class:Event software, to which the recorded attributes will be matched with position, depth, and temperature variables.

B. Habitat Table

Class designations under the Features listed in the Habitat table are assignments derived by Valentine et al. (2005) for their classification of marine sublittoral habitats, with application to the Northeastern North America Region.

Data to Record for Class 3 is the Percent Cover of each texture category. Must sum up to 100%

Feature	Attribute	Descriptive Guide
Image Quality	Good	Easily able to discern small features, low turbidity
	Adequate	Can see large features, may lose some small ones
	Marginal	Difficult, but still possible to interpret features
	Inadequate	Not able to use footage
Seabed Dynamics (Class 2)	Mobile	Likely subject to tidal and storm activity, typically mud and sand substrates
	Immobile	Typically associated with larger sediment particle sizes (pebbles and higher) or rock outcrop
	Intermixed	For example boulders on mobile sand
	Uncertain	Not able to make attribute decision

APPENDIX 1, CONTINUED

B. Habitat Table, continued

Feature	Attribute	Descriptive Guide
Seabed Texture (Class 3)	Mud	Mud and fine sands. If unconsolidated may form plume when tripod leg grounds. If consolidated, front tripod leg may penetrate and "stick" in mud
	Sand	Fine to very coarse grain sediment (0.125 – 2mm) Not able to discriminate within types by video; bedforms may be associated with different types of sand (also related to currents)
	Pebble	Includes granules (2mm) to pebbles (4mm), evident as a grainy texture on video
	Cobble	Round or angular particles from 4 – 64mm. Reference by size relative to parallel frames of tripod when grounded on bottom (10 cm apart) – cobbles are approx 50% or less of the distance between frames
	Boulder	Round or angular particles greater than 256mm. Exceed distance between laser scales (set at 25 cm)
	Flat Rock	Exposed bedrock which appears to have low relief (video may not discern low slopes, but flat rock will be evident as a region over which there is no difficulty in maintaining the camera "flight" over the bottom). Note: this feature does not define the structural complexity of the rock feature (e.g. fissures) at sub-meter resolution
	Vertical Rock	Exposed bedrock that has high relief. Difficulty in traversing large rock features will be evident as the camera frame is hauled, or becomes caught down
Physical Structure (Class 24)	Biogenic structure	Crab or lobster depressions/burrows; extensive bivalve siphon holes
	Ripples on sand	Use where there are identifiable bedform elements on sediment bottom
	Shell accumulation	Use where there are accumulations of shell hash
	Featured hard seabed	Use where complexity is derived from hard seabed features (cobbles, boulder, rock)
	Featured clay seabed	Use this keyword where the bottom is obviously mud or clay base, but has significant complexity, leading to features similar to those with rough sediment or hard seabed
	Anthropogenic structure	Discarded fishing gear, construction debris, etc

APPENDIX 1, CONTINUED

C. Habitat Table, continued

Feature	Attribute	Descriptive Guide
Biological Structure (Class 11)	*Refer to species table for actual structure forming species*	

Record percent of seabed covered by physical structures (class 24) and biological structures (class 11) separately, based on visual observations being coded in to nine semi quantitative intervals from 0 – 100%

Degree of structural complexity may subsequently be recoded into 7 levels (whenever more than 50% of seabed is covered by structures, complexity is considered very high, thus condensing from 9 percent cover categories)

Can be over 100% cover if both physical and biological are high, e.g. abundant epifauna on rough seabed.

Percent cover	Degree	Code
0	none	n
<1	very very low	vvl
1 – 5	very low	vl
5 – 10	low	l
10 – 25	medium	m
25 – 50	high	h
>50	very high	vh
>90	very high	vh
100	very high	vh

Important point is to score physical and biological structural complexity separately

D. Species Table

Feature	Attribute	Descriptive Guide
Species View	Contact	Frame in contact with bottom
	Near	Lasers visible in lower ½ of screen
	Far	Lasers in top ½ of screen or not visible
Species Code	Numerical	Use the Marine Fish Species Codes

APPENDIX 1, CONTINUED

D. Species Table, continued

Where more than one species is observed between position updates (every 2s), the spreadsheet row is to be repeated and the next species code entered to create a separate instance using primary keys of set no and time. Adopt a consistent approach for each species, recording either a simple count, a count code, or percent cover. Record the approach selected against the species code in a separate table. Species enumeration should be typically undertaken when organisms are within the lower ½ of the screen or frame is in contact with the seabed. Organisms should only be counted once (i.e. if recorded during one 2s interval, and still in frame during next time stamp, do not recount.

Organisms for which percent cover is used can be recorded using the following scheme:

Percent cover	Degree	Code
0	none	n
<1	very very low	vvl
1 – 5	very low	vl
5 – 10	low	l
10 – 25	medium	m
25 – 50	high	h
>50	very high	vh
>90	very high	vh
100	very high	vh

Fauna: Habitat Association	
(Class 18)	Lobster tracks
	Other tracks

E. Human Usage Table

Feature	Attribute	Descriptive Guide
Object View	Contact	Frame in contact with bottom
	Near	Lasers visible in lower ½ of screen
	Far	Lasers in top ½ of screen or not visible
Usage		
(Class 19)	Disturbed	
	Undisturbed	
	Recovering	
	Unknown	
	Clay mound	Discrete mass resulting from recent dumping

APPENDIX 2: REMOTE VIDEO SURVEY SETS DURING 2005.

Original mini-DV tapes are archived at the Biological Station, St. Andrews, NB; duplicates are archived at the Bedford Institute of Oceanography, Dartmouth, NS. Start and end positions recorded in decimal degrees. Distance estimate (DIST, in m) derived by summing change in position between navigation updates (at 2 s intervals) where the change in position is less than or equal to 5 m (to exclude positioning errors).

SET	START TIME	DATE	STARTLAT	STARTLON	TAPE	END TIME	ENDLAT	ENDLON	DIST (m)
Video sets 53 to 92 were conducted at the Black Point ocean disposal site, July 2005									
53	152303	04-Jul-05	45.207013	66.015163	35	155120	45.20909	66.016648	304
54	160045	04-Jul-05	45.207295	66.014315	35	160710	45.207598	66.015045	101
55	162558	04-Jul-05	45.208495	66.01174	36	163842	45.209423	66.013862	197
56	164600	04-Jul-05	45.208805	66.011978	36	170048	45.21002	66.015463	315
57	171448	04-Jul-05	45.208782	66.010472	36	172920	45.210438	66.01345	301
58	173734	04-Jul-05	45.209305	66.010638	36	175118	45.209973	66.012775	194
59	175720	04-Jul-05	45.205927	66.013	37	181256	45.206885	66.015323	225
60	181742	04-Jul-05	45.20631	66.012513	37	182548	45.205962	66.013213	94
61	182932	04-Jul-05	45.20747	66.013413	37	184244	45.206227	66.012913	161
62	132528	05-Jul-05	45.206907	66.013428	37	133432	45.206518	66.011588	99
63	134422	05-Jul-05	45.20819	66.014393	38	135312	45.208365	66.012692	143
64	140046	05-Jul-05	45.20766	66.013193	38	140804	45.207987	66.012803	60
65	141050	05-Jul-05	45.207048	66.013457	38	142456	45.207197	66.011395	185
66	143100	05-Jul-05	45.20688	66.01452	38	145406	45.207735	66.011745	266
67	150818	05-Jul-05	45.209943	66.015172	39	152226	45.211495	66.014068	205
68	152748	05-Jul-05	45.2103	66.016015	39	154156	45.211888	66.015273	192
69	154602	05-Jul-05	45.209728	66.015535	39	160752	45.212667	66.015033	323
70	161404	05-Jul-05	45.210478	66.016915	39	162742	45.212043	66.01729	182
71	163614	05-Jul-05	45.20835	66.01683	40	164818	45.209588	66.017623	166
72	165258	05-Jul-05	45.208152	66.015678	40	171218	45.209912	66.017187	241
73	171800	05-Jul-05	45.208618	66.01485	40	172020	45.208757	66.015022	29
74	131544	07-Jul-05	45.208267	66.017788	40	132100	45.206445	66.016328	238
75	132748	07-Jul-05	45.213182	66.023737	40	134532	45.208317	66.020853	614
76	135208	07-Jul-05	45.213845	66.02317	41	140844	45.209195	66.021925	531
77	142024	07-Jul-05	45.213273	66.024703	41	143316	45.21047	66.024277	326
78	144258	07-Jul-05	45.213398	66.022257	41	145508	45.211323	66.022248	280
79	145946	07-Jul-05	45.211043	66.021295	41	151318	45.208993	66.021453	325
80	152046	07-Jul-05	45.214363	66.021033	42	153910	45.211507	66.021883	368
81	154824	07-Jul-05	45.211522	66.021742	42	155456	45.211032	66.022597	149
82	161112	07-Jul-05	45.211753	66.018353	42	162522	45.210372	66.021177	297
83	163016	07-Jul-05	45.212197	66.017912	42	164336	45.211653	66.021315	269
84	170622	07-Jul-05	45.211057	66.018298	43	172024	45.211037	66.021812	302
85	172634	07-Jul-05	45.210915	66.017553	43	173612	45.211742	66.020025	223
86	174028	07-Jul-05	45.210425	66.019372	43	174826	45.211238	66.022058	236
87	130952	08-Jul-05	45.209207	66.017742	43	131336	45.208218	66.016413	150
88	131908	08-Jul-05	45.21072	66.015685	43	132232	45.209875	66.01469	141
89	132934	08-Jul-05	45.21339	66.02214	43	133536	45.211757	66.021532	189
90	133946	08-Jul-05	45.214673	66.020657	43	135554	45.210572	66.01834	507
91	140230	08-Jul-05	45.21401	66.020555	44	142120	45.209617	66.018658	518
92	142842	08-Jul-05	45.21086	66.020593	44	143540	45.209517	66.019665	173

APPENDIX 2: REMOTE VIDEO SURVEY SETS DURING 2005, CONTINUED

SET	START TIME	DATE	STARTLAT	STARTLON	TAPE	END TIME	ENDLAT	ENDLON	DIST (m)
	Video sets 107 to 123 were conducted at the Anthony's Cove alternative disposal site, August 2005								
107	143802	23-Aug-05	45.22791	66.031038	48	151104	45.226687	66.02706	354
108	151822	23-Aug-05	45.227392	66.03142	48	154048	45.22762	66.028708	235
109	154836	23-Aug-05	45.225793	66.030887	49	160322	45.227027	66.028947	211
110	161036	23-Aug-05	45.223507	66.030008	49	163132	45.226638	66.025585	503
111	163954	23-Aug-05	45.223968	66.031278	49	170458	45.22758	66.02716	530
112	172126	23-Aug-05	45.223473	66.030517	50	173152	45.22568	66.02567	1
113	150130	24-Aug-05	45.227105	66.029567	50	151830	45.223888	66.02637	443
114	152650	24-Aug-05	45.227068	66.030622	50	155020	45.223267	66.026275	563
115	160248	24-Aug-05	45.226593	66.031335	51	163022	45.222577	66.026757	605
116	132550	30-Aug-05	45.22716	66.029713	52	134808	45.225532	66.03014	207
117	135448	30-Aug-05	45.226877	66.02837	52	143436	45.224062	66.029038	345
118	144020	30-Aug-05	45.227185	66.02755	53	145334	45.226302	66.028805	151
119	145720	30-Aug-05	45.22643	66.02704	53	142456	45.226008	66.028887	164
120	152046	30-Aug-05	45.225582	66.026657	53	155034	45.224825	66.029943	298
121	155602	30-Aug-05	45.22471	66.026867	54	161848	45.22353	66.028603	203
122	162228	30-Aug-05	45.225453	66.026738	54	164234	45.224357	66.028068	181
123	164654	30-Aug-05	45.225867	66.027583	54	170544	45.224073	66.027625	204

APPENDIX 3: DATA FORM - LOBSTER CONDITION ON PLACEMENT INTO TRAPS

Black Point Project: Task 3: Lobster Placement at Anthonys Cove

Port: Mispec **Captain** ____________ **Vessel** ____________ **Date (DD/MM/YY)**____________

Sampler ____________ Page______ of ______

Trawl # ________

Trap Details		Lobster Size Range	Band #	Size (mm)	Sex	Shell Hardness	Shell Condition	Left Antenna	Right Antenna	Left Claws	Right Claw	Left Walking Legs	Right Walking Legs	Gill condition	Activity	Comments
Trap # 3	120 m	70 - 79 mm														
WPT		70 - 79 mm														
Latitude		70 - 79 mm														
Longitude		70 - 79 mm														
Depth (ft)		80 - 99 mm														
Trap Tag #		80 - 99 mm														
		80 - 99 mm														
		80 - 99 mm														
Trap # 2	80 m	70 - 79 mm														
WPT		70 - 79 mm														
Latitude		70 - 79 mm														
Longitude		70 - 79 mm														
Depth (ft)		80 - 99 mm														
Trap Tag #		80 - 99 mm														
		80 - 99 mm														
		80 - 99 mm														
Trap # 1	40 m	70 - 80 mm														
WPT		70 - 80 mm														
Latitude		70 - 79 mm														
Longitude		70 - 79 mm														
Depth (ft)		80 - 99 mm														
Trap Tag #		80 - 99 mm														
		80 - 99 mm														
		80 - 99 mm														

Trawl # Code: TW1 = Trawl 1, TW2 = Trawl 2; TW3 = Trawl 3; TW4 = Trawl 4; C1 = Control 1; C2 = Control 2

Sex: 1 Male, 2 Female, 3 Berried

Shell Hardness: 1 = just moulted; 2 = soft; 5 = hard; 7 = ready to moult (shell splitting)

Shell condition: 1 = no visible shell disease; 2 = minor shell disease; 3 = major shell disease

Antennae (left & right separately): 1 = no visible injury; 2 = < 1/2 length broken off; 3 = > 1/2 length broken off; 4 = lost completely

Claws (left is lobster's left): 1 = no visible injury; 2 = minor injury; 3 = major injury; 4 = autotomised

Walking legs: 1 = no visible injury to any leg; 2 = minor injury to one or more; 3 = one or two legs missing/with major injury; 4 = three or more legs missing/with major injury

Gill margin condition: 1 = clean; 2 = less the 50% coated with sediment; 3 = greater than 50% coated with sediment; 4 = clogged with sediment

Activity: 1 = fully responsive (able to easily move appendages); 2 = lethargic (slow and limited movement when stimulated); 3 = non-responsive; 4 = dead

Other Codes:

APPENDIX 4: DATA FORM - LOBSTER CONDITION ON RETRIEVAL FROM TRAPS

Black Point Project: Task 3: Lobster Retrieval at Anthonys Cove

Port: Mispec **Captain** ____________ **Vessel** ____________ **Date (DD/MM/YY)**____________

Trawl # ____________ **Sampler** ____________ Page______ of______

Time Trawl on deck____________

Trap Details		Time Blood Sample Taken	Band #	Blood Sample #	Shell Hardness	Shell Condition	Left Antenna	Right Antenna	Left Claws	Right Claw	Left Walking Legs	Right Walking Legs	Gill condition	Activity	Photo #	Comments
Trap #3	120 m															
WPT																
Latitude																
Longitude																
Depth (ft)																
Trap Tag #																
Trap #2	80 m															
WPT																
Latitude																
Longitude																
Depth (ft)																
Trap Tag #																
Trap #1	40 m															
WPT																
Latitude																
Longitude																
Depth (ft)																
Trap Tag #																

Trawl # Code: TW1 = Trawl 1, TW2 = Trawl 2, TW3 = Trawl 3, TW4 = Trawl 4, C1 = Control 1, C2 = Control 2

Sex: 1 Male, 2 Female, 3 Berried.

Shell Hardness: 1 = just moulted, 2 = soft, 5 = hard; 7 = ready to moult (shell splitting)

Shell condition: 1 = no visible shell disease, 2 = minor shell disease, 3 = major shell disease

Antennae (left & right separately): 1 = no visible injury, 2 = < 1/2 length broken off, 3 = > 1/2 length broken off, 4 = lost completely

Claws (left is lobster`s left): 1 = no visible injury, 2 = minor injury, 3 = major injury, 4 = autotomised

Walking legs: 1 = no visible injury to any leg, 2 = minor injury to one or more, 3 = one or two legs missing/with major injury, 4 = three or more legs missing/with major injury

Gill margin condition: 1 = clean; 2 = less the 50% coated with sediment; 3 = greater than 50% coated with sediment; 4 = clogged with sediment

Activity: 1 = fully responsive (able to easily move appendages); 2 = lethargic (slow and limited movement when stimulated); 3 = non-responsive; 4 = dead

Other Codes: