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Middle Shoal Channel Improvement Project-- Environmental Effects Monitoring

by

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ABSTRACT

The "Middle Shoal Channel Improvement Program" is a channel dredging project at the entrance to the Bras d'Or Lake in the southern Sydney Bight area of Cape Breton Island, Nova Scotia. The dredging was undertaken by Little Narrows Gypsum Company Limited for the purpose of allowing fully loaded bulk carriers to access the company's mine at Little Narrows. One of the requirements for proceeding with the work was that a monitoring program be undertaken. This program was designed to determine the impacts of the dredging operation and the resultant changes in the channel bathymetry on fisheries. There were several components of the program including, physical oceanographic observations and measurements, turbidity measurements, surveys and monitoring of fish migration and behaviour, monitoring of the disposal area for commercial species, and measurement of noise. The proponent and their consultants presented the results of this program at an open meeting of the DFO Maritimes Region Habitat Regional Advisory Process Subcommittee on December 18, 1996. The meeting considered whether or not the monitoring program was effective in determining the impact of the dredging operation on the movement of fish in and through the channel and on fish habitat. It was concluded that the program did not clearly demonstrate the degree of impact on fish movement but did adequately document changes and impact on fish habitat.

RÉSUMÉ

Le « Programme d'amélioration du chenal du Haut-fond » est un projet de dragage du chenal à l'entrée du lac Bras d'Or dans le sud de Sydney Bight à l'île du Cap Breton en Nouvelle-Écosse. La Little Narrows Gypsum Company Limited a entrepris ces travaux de dragage pour que les vraquiers en pleine charge aient accès à la mine de l'entreprise à Little Narrows. Les travaux ne pouvaient débuter avant qu'un programme de contrôle n'ait été réalisé. Le programme a été conçu pour déterminer les répercussions sur la pêche des travaux de dragage et des changements qu'ils entraîneraient dans la bathymétrie du chenal. Il comportait plusieurs composantes dont les observations et mesures de l'océanographie physique, les mesures de la turbidité, les relevés et l'évaluation des habitudes de migration et le comportement des poissons, la surveillance des effets sur les espèces commerciales dans la zone d'évacuation et la mesure du bruit. Le promoteur du projet et les experts-conseils ont présenté les résultats de ce programme le 18 décembre 1996 lors d'une réunion publique du sous-comité consultatif régional de Pêches et Océans Canada sur l'habitat de la région des Maritimes. Les participants à la réunion ont cherché à déterminer l'efficacité du programme de contrôle pour déterminer l'impact des travaux de drainage sur l'entrée et la sortie de poissons dans le chenal et sur l'habitat du poisson. Les participants ont conclu que le programme n'avait pas démontré clairement les répercussions sur la circulation des poissons mais documentait adéquatement les changements dans l'habitat du poisson et les effets sur ce dernier.

Project Description

The "Middle Shoal Channel Improvement Program" is a channel dredging project at the entrance to the Bras d'Or Lake in the southern Sydney Bight area of Cape Breton Island, Nova Scotia. The project involves the removal of approximately 350,00 m^3 of materials over a 2.25 km channel and the disposal of the material at three marine sites; Revised Site "A", Table Head and Little River. Undertaken by the Little Narrows Gypsum Company Limited for the purposes of increasing channel depth and realignment, the proponent claims that the end result will enable bulk carriers transporting gypsum from the company's mine at Little Narrows to foreign and domestic markets to be more fully loaded, and hence to operate more cost effectively. The authorization for the project by the federal government included the requirement for a monitoring program to be undertaken to "...verify that permit conditions are met and that assumptions made during the review process were correct and sufficient to protect the environment." Dredging commenced on August 20, 1996. It was halted on October 24, 1996, following the suspension of permits by a Federal Court order after the Union of Nova Scotia Indians requested a judicial review of the Canadian Environmental Assessment Act (CEAA) review of the project. The dredging project was approximately ninety percent complete at this stage. Monitoring was undertaken before, during and after the dredging operations for varying time periods according to the requirements of the monitoring program.

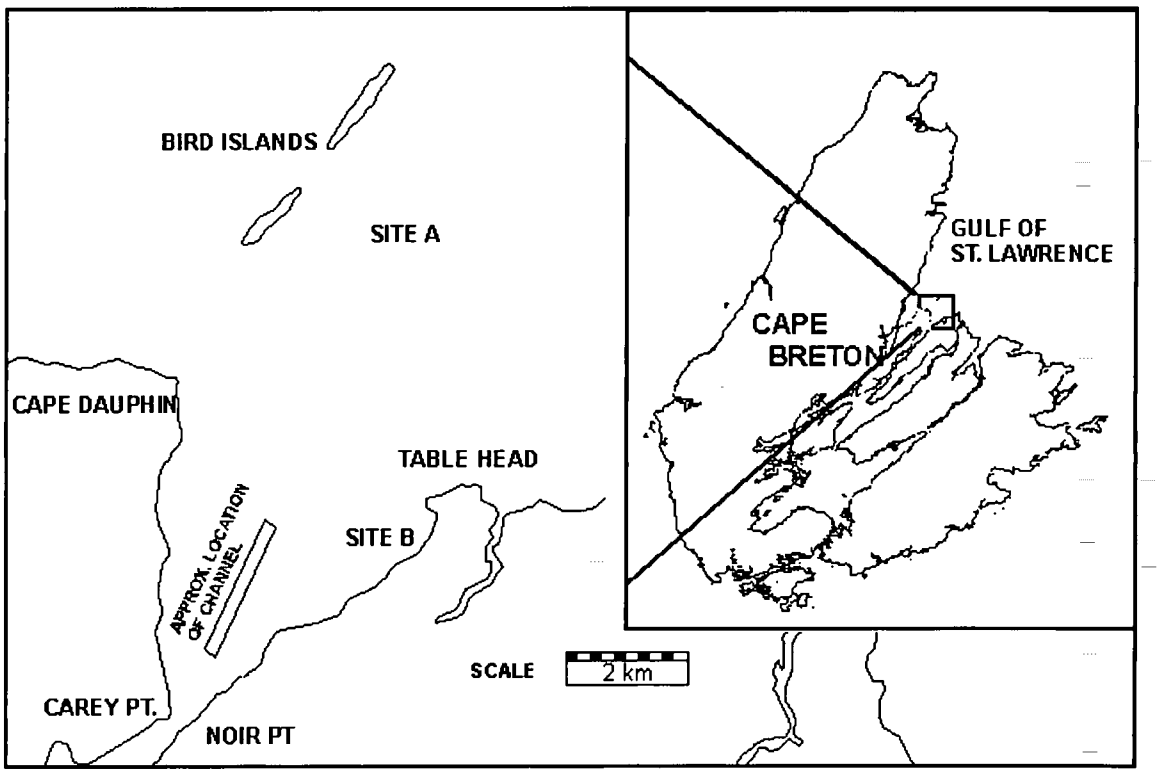

Figure 1. Location of project

Fishery

The Bras d'Or Lake and southwestern Sydney Bight waters have long supported commercial fisheries. In 1994 these were worth over $1.5 million, with the lobster fishery accounting for most of the value. In addition to lobster, other species landed are mackerel (~48% of the total fishery landings by weight, but <4% of total landed value), scallops, eels, sea urchins, herring, rock crab, and flatfish. In 1994, 129 fishermen were employed in the area with 25 fishing vessels operating out of several communities. Lobsters are trapped over Middle Shoal at certain times of the fishing season when yields decline on the preferred fishing grounds (Bird Islands and Great Bras d'Or channel). Salmon are fished recreationally and by aboriginal people as part of their food fishery. The Eskasoni Fish and Wildlife Commission has identified and mapped some 36 species, including cod, oysters and mussels, in the lakes using the traditional knowledge of Mi'kmaq elders and fishermen (Union of Nova Scotia Indians, pers. comm. 1996).

Habitat

Middle Shoal is a relatively shallow area off the approaches to the Bras d'Or Lake with typical depths not exceeding 10 m. It represents a sill between the waters of the Gulf of St. Lawrence and the Great Bras d'Or channel at the main entrance to the Bras d'Or Lake system. The deepest water in the area (>20 m) occurs northwest of Table Head and opposite Noir Point near Middle Shoal (Canadian Hydrographic Chart 4277). Wave and ice scour prevent seaweed and other macrophytes from growing near shore. However, kelp beds are present at depths > 2 to 8 m. The shoreline consists of eroding sedimentary rock cliffs in excess of 20 m in height. Underwater surveys reveal that the bottom material is dense and consists of a poorly graded mixture of sand and gravel, cobbles, and boulders with only traces of silt. Among bottom species are lobsters, scallops, flatfish, rock crabs, seastars, sea urchins and sea anemones.

Dump Site A (Revised) is located approximately 3 km east of Hertford Island in approximately 28 m of water. The site was recommended by commercial lobster fishing interests as an area of poor lobster habitat which might benefit from the deposition of dredged rock material. DFO trawl surveys have shown large numbers of lobsters present in the fall (Pringle, 1996), and large numbers of rock crab throughout the year. Other invertebrate species taken regularly by these surveys include sea urchins, starfish and scallops. In addition to juvenile cod (Pringle, 1996), the DFO surveys showed that flounders, skates and sculpins are common, as well as indicating a fairly rich epifaunal community. Video coverage by the proponent revealed a bottom of fine sand and silt; sediment samples were characterized as silty sand with low levels of contamination. The benthic community is dominated by polychaetes, bivalves, and amphipods.

Dump Site B (Table Head) is located near shore and southwest of Table Head in approximately 12 m of water. The site was also recommended by commercial fishing interests as an area of poor fisheries habitat suitable for enhancement. Video coverage revealed a bottom of rippled fine sand, becoming rockier at the perimeter of the site in shallower water. Kelp and rock weed are present near the shallow water margins. Sediment samples are characterized as primarily clean sand. The benthic community is dominated by polychaetes and bivalves.

Dump Site c (Little River): The site, located approximately 6 km north of the Bird Islands, has been approved for the disposal of small volumes of dredged material on at least two occasions in

the past 20 years. The site is in about 44 m of water and is composed predominantly of clean gravel and cobble. Diversity and abundance of megafauna is relatively high while the diversity and abundance of benthic invertebrates is low. Species observed were generally of low commercial value. The site received only one barge load of Middle Shoal dredged spoils.

Monitoring Program

The approvals for the Middle Shoal Channel Improvement Program included an Authorization to Alter Fish Habitat from DFO (Authorization No. 96-AUTH-0007) and an Ocean Dumping Permit from Environment Canada (Ocean Disposal Permit No. 4543-2-5813). The project was also submitted to scrutiny by the Canadian Coast Guard under the requirements of the Navigable Waters Protection Act, and in addition the Nova Scotia Department of Natural Resources issued a permit for the removal of near shore materials. The DFO and Environment Canada authorizations jointly included the requirement for the proponent to develop an Environmental Management Plan to ensure that any potentially adverse effects of the project were identified early and action taken to minimize impacts. The environmental management plan had to be approved by DFO and Environment Canada. A key component of this plan (Little Narrows Gypsum Company, 1996[a]), is an "Environmental Effects Monitoring and Compliance" program. The Environmental Management Plan states that the fundamental objective of such monitoring, according to Environment Canada's "Monitoring Guidelines for Ocean Disposal," is to "...verify that permit conditions are met and that assumptions made during the permit review process were correct and sufficient to protect the environment."

The Environmental Management Plan specified that the following potential environmental effects should be monitored:

CATEGORY	ENVIRONMENTAL EFFECT (EE)
Dredging Operations	1. Noise and light disturbance
	2. Release of pollutants
	3. Chemical contaminants
	4. Operating schedule/hours
Fisheries	5. Re-suspended sediment
	6. Fish migration
	7. Habitat degradation and recovery
	8. Mortality at work sites
Oceanographic	9. Current changes in channel near Carey Point
	10. Changes to flow exchange rate to lake
	11. Changes to water properties of salinity and temperature
	12. Changes in tidal timing and magnitude
	13. Changes to wind induced surge events
	14. Sediment flux at entrance to lake
	15. Sediment re-suspension due to dredging
	16. Sediment deposition due to dredging

The actual monitoring program comprised the following components:

Physical Oceanography

The objectives of this component were to:

a) Collect oceanographic data prior to the commencement of dredging operations for use in identifying and tracking sediment plumes and in determining water properties.

b) Verify previous hydrodynamic current modeling scenarios and predict hydrodynamic conditions following channel alterations.

c) Determine the exchange of water into and out of the lake for pre-dredge and post-dredge conditions.

d) Identify regions of stratification and mixing that may influence hydrodynamic modeling of sediment dispersion during the dredging activities.

The objectives were addressed with the deployment of state-of-the-art oceanographic instrumentation, e.g., Acoustical Doppler Current Profiler (ADCP). The region of study extended from Seal Island Bridge (inside the Great Bras d'Or Channel) to the Bird Islands (offshore of the dredging region) and involved the collection of discharge data from Great Bras d'Or, ADCP transects across Middle Shoal, water elevation measurements, and temperature and salinity measurements.

Sediment Dispersion (Turbidity)

The objectives of this component were to:

a) Minimize environmental impacts of sediment re-suspension due to dredging by ensuring that concentrations of suspended particulate material (SPM) near the dredges and dump sites were within compliance levels.

b) Assess the turbidity produced by dredging activities in relation to the natural suspended load generated by the flow conditions (tidal and density flows) and storm related events.

c) Ensure that the turbidity levels entering the lake during dredging activity were less than 10 mg/L above background.

Measurements of turbidity levels throughout the outer entrance to the Great Bras d'Or were carried out before, during, and after the dredging activities on Middle Shoal. These measurements involved the use of four optical backscatter sensors (OBS) and water bottle sampling. The program utilized bottom mounted, surface mounted, and depth profile OBS stations.

Fish migration surveys

Three transects across the entrance to the Great Bras d'Or were run on a regular basis, using sounders (fish finders) on board fishing vessels. The objective was to ascertain if fish migrations through the Great Bras d'Or Channel were blocked by project dredging. It was recognized that

species identification was needed to assist in the interpretation of the fish finder survey data. One of the methods used was to the set gillnets, but this was done only during the final weeks of the monitoring. This provided information on the species present which, aside from mackerel, included herring (in appreciable amounts) and several other species.

Fish behaviour monitoring

Fish behaviour monitoring involved ad hoc observation of mackerel in relation to environmental conditions and dredging activity. Individual fish were tagged with a surface marker (styrofoam catamaran). The fish were released in the vicinity of a school and their movements recorded for periods of 10 to 15 hours. It was assumed the mackerel would remain associated with the same school throughout the tracking period. The tracking vessel stayed in the general vicinity of the marker (up to three fish could be tracked simultaneously), and came alongside the markers every hour to record coordinates and to check by means of a fish finder if the mackerel were in the vicinity of a school. A total of 24 mackerel were tracked in various areas of the Great Bras d'Or Channel on 10 dates during the period from Sept. 17 to Oct. 25.

Work area monitoring

The abundance of commercial species, i.e., lobster and crab, was monitored in the disposal areas, Site A and Site B, using lobster traps and ROV surveys. Also the abundance of juvenile cod was assessed using the ROV surveys. Considerable information on lobster and rock crab was collected. Juvenile cod were not found to be overly abundant. However, DFO surveys on September 18, 1996, that trawled along the SE and NE sides of Site A for one-mile tows encountered juvenile cod numbers of 52 and 72 respectively (Lambert, pers. comm. 1996). This and the results of earlier surveys are reported in the results of a previous RAP on Middle Shoal Channel (Anon 1996; Pringle 1996).

Fish habitat stations

Four habitat sites and one control site were established to provide indicators of changes as a result of the dredging operations. One habitat site was located near Dump Site A, one near Dump Site B, and two adjacent to the dredge site. An assessment of the initial condition of these sites was based on underwater video and analysis of triplicate, diver-collected, benthic samples. The sites were not reoccupied as originally planned, but the proponent plans to revisit the test sites in 1997, in order to evaluate longer-term impacts on habitat quality.

Underwater sound

Noise measurements were taken at four distances from the dredging activity, ranging from 70 to 1730 m, on one day (September 30) when all four dredges were operating. For full details of all the monitoring undertaken, including dates and durations, refer to the proceedings of the December, 1996 Regional Advisory Process Habitat Subcommittee meeting on the Middle Shoal Channel Environmental Effects Monitoring Program (Nicholls, 1997).

Monitoring Committee

A monitoring committee was established by the proponent in accordance with the requirements of the Environmental Management Plan. The committee comprised members representing the following groups: Great Bras d'Or Fishermen's Group, Great Bras d'Or Community, DFO, Environment Canada, and the proponent. Its mandate was:

- To provide vigilance with respect to environmental and community issues in relation to the dredging program;
- To review environmental effects monitoring activities which were directed to confirm environmental assessment predictions; and
- To participate in decisions taken to mitigate adverse environmental effects.

The committee met on a regular basis throughout the duration of the project but adjourned its activities approximately one month following the suspension of dredging. It will reconvene as and when there is additional data to consider.

Issue

The Statement of Issue for the meeting was:

"Does the monitoring program developed and undertaken by the proponent, along with scientific expertise derived from other such projects and general scientific theory, allow us to discern the impact of the 1996 dredging operation in Middle Shoal Channel on the movement of fish in and through the channel, and on fish habitat?"

Assessment

The physical oceanographic and sediment monitoring programs produced results that provide descriptions of water movement and background levels of suspended sediment at the dredging site. These programs also produced information on the behaviour of the dredged material and its residency time in the water column.

While the physical oceanographic monitoring got underway in July, several weeks prior to the commencement of dredging on August 20, 1996, it did not continue after the termination of dredging on October 24, 1996. Therefore a "before-and-after" comparison of actual conditions cannot be made. It is noted, however, that the proponent plans to return to the site in August 1997 to repeat the flow measurements in order to get an indication of any changes in flow during the same lunar cycle. A corresponding comparison based on modeling may be open to question because only a 2-D tidal model was used for a region with expected vertical stratification whereas historical data and data collected by the proponent suggest significant meteorological-forced flows. In spite of the above concerns, and based on the proponents monitoring results and other work, it is concluded that no significant changes could be detected to channel currents near Carey Point (EE#9), flow exchange rate to the lake (EE#10), tidal events (EE#12), water salinity and temperature (EE#11), and wind-induced surge events (EE#13).

While an increase in sediment loading did occur, the proponent's monitoring studies showed that turbidity levels due to dredging could not be distinguished from natural turbidity caused by natural suspension and erosion, and did not persist. The latter showed considerable variability according to weather conditions, i.e., higher during severe storms (35 mg/L), and three to five times the levels experienced due to the dredging and disposal operations. Actual turbidity levels, as measured by the proponent downstream of the dredges, were found to be well below the compliance levels set by DFO and Environment Canada. The coarse dredge material (cobbles, gravel and sand) excavated and the large volumes of water discharged were the two main factors which contributed to the observed low suspended sediment concentrations, e.g., maximum suspended sediment concentrations measured 100 to 200 m away from the dredges were less than 30 mg/L, while mean concentrations at these distances were only 1 to 4 mg/L above background. The proponent's grain size measurements indicate that there is a very low percentage of fines present (EE#14, #15, and #16). Turbidity levels decreased to natural levels very quickly after discharge by the scows, the main reason for this being the high settling velocities associated with the coarse sediment.

While the removal and dumping of dredged materials can have severe consequences for fish, the very low levels of fines in the dredged materials, and consequently its rapid settling, suggest minimal, if any, adverse impact on fishes at both the removal and dump sites. Based on data collected by the proponent, fish in the vicinity of the channel are periodically exposed to 'natural' levels of suspended materials comparable to, or in excess of, those caused by the dredging. The low dispersal of dredged materials also suggests that the dredging and dumping caused no, or little alteration of fish habitat other than at the dredge and dump sites. There is little doubt that fish in the area could avoid regions of high suspended load during the dredging operation (EE#5).

One point not raised in the proponent's documentation or presentation was whether the dredged materials contained potential toxins which could have been released into the water (EE#2 and #3). This issue was part of the original assessment of the project which concluded that based on historic and site-specific data as well as physical characteristics of the dredge material and distance from sources of pollution there was no significant concern. The proponent also advised that a number of chemical tests were conducted during early sampling of the dredged materials, which supported the original assessment (Amirault, pers. comm. 1997). Movement of fish through the channel was not monitored prior to the start of dredging. This would have required a major survey spanning the season during which dredging took place. However, impacts cannot be discerned unless it is known how the system varies seasonally and annually.

Information obtained with the fish sounder transects is of limited value in interpreting fish movements. Based on the information presented by the proponent, all that can be concluded from these surveys is that fish were present along each transect throughout the study. Differences in the number of fish (or schools) along each transect can be statistically compared with one another, and for different time periods, but it is not clear what this might mean, and it is not easy (possible) to directly relate these findings to questions about effects of the dredging on fish migration through the channel. Although the contractor intended to marry the results of these surveys with subsequent tagging experiments (see below), this was not done. The efforts

made to calibrate the sounder units in each boat based on known targets is important, but leaves open the question of differences between boats.

It is possible to design studies that determine if particular species of fish avoid dredging activity. This seems to have been the approach taken by the proponent, with mackerel being the focus of the field work. This species was chosen mainly for reasons of abundance and relative ease of capture. The specific technique used (attaching surface floats to fish via monofilament line) is well established and was used in some of the earliest fish homing work done by Professor A. Hassler's group at the University of Wisconsin. Professor J.M. Green of Memorial University, who was present by invitation at the December 18, 1996, RAP meeting as an expert on fish behaviour and who subsequently submitted a report (Green, 1996) on which several of the comments in this section are based, used similar methods in experiments several years ago on a coastal marine fish in Newfoundland. This technique has been replaced by telemetry methods that provide more reliable data from much less stressed subjects. There is no doubt that the mackerel used in these experiments would have been highly stressed, and for this reason alone the results need to be interpreted with caution. As well, the assumption that tagged fish rejoined schools did not seem to have been explicitly tested (not that this would have been easy to do) and appeared to be based more on anecdotal observations that tagged subjects swam fast at times - which was interpreted as an attempt to catch up with a school. Perhaps when one sees the full data set, there are patterns to be discerned. But (again) these patterns will represent hypotheses that would need to be tested. There appears to be little doubt that some mackerel pulling floats (trackers) made their way through the channel and passed close to or under the dredging equipment. Were these the responses of highly stressed fish escaping to more open water, or were the mackerel attracted to the dredging activity because of food items churned-up into the water column, or do they indicate that the movements of mackerel were not influenced by dredging activity and equipment? It is not possible to say (EE#6). The proponent has objected to the statement that the fish tracking may have been "the responses of highly stressed fish escaping to more open water" as an interpretation of the results. The proponent notes that: "Tracked fish were merely used to help follow schools; that the presence of the schools was always confirmed when a sighting was reported; and that it is not believed that a school was following the movements of one highly stressed fish."

The proponent's studies on fish migration focused on one species, mackerel. However, other species are known to migrate through the Great Bras d'Or channel between the lakes and the coastal waters of Sydney Bight. Even if migrating mackerel were not impacted by the dredging activity, other species may have been. Such species include herring, salmon, cod and gaspereau. Herring in particular is known to be sensitive to underwater noise, particularly to changes in the level of the sound (see also below). However, there is uncertainty regarding the pattern of migration of this species through the Great Bras d'Or: Does the species migrate during the July to October period and, if so, in which direction? If herring were trying to enter the Bras d'Or during the dredging project there could have been impacts, but a verbal report by R. Crawford, N.S. Department of Fisheries, at the December 18, 1996, RAP meeting, suggests the pattern of herring migration is similar to that of mackerel (Nicholls, 1997).

Acoustic noise measurement appears to have been reasonably well conducted from an instrumentation and processing point of view, but the volume of data collected was small and no true "natural background" ambient noise levels were obtained. The proponent claims that

examination of the data collected indicates that the levels of the dredge noise were not sufficient to terminate fish movements throughout the area. However, an influence on the transit of herring (if present), and possibly other species, cannot be ruled out (Cochrane 1997) (EE#1). The possibility of light disturbance arising from night time dredging does not appear to have been quantitatively assessed by the proponent (EE#1).

Four habitat sites and one coastal site were established to provide indicators of changes as a result of the dredging operations. A detailed assessment of the initial condition of the sites was undertaken. However, because general observations at the cessation of dredging indicated there had been no significant degradation of the habitat, comprehensive re-surveys were not undertaken. Therefore, no quantitative assessment of the short-term impacts of the dredging operation on habitat adjacent to the two disposal sites and the dredge site is available (EE#7).

The overall objective of the work area monitoring component was to assess fish mortality due to the dumping of dredge spoil at the two disposal sites, Site A and Site B. As previously noted, data was collected on the abundance of lobster and rock crab at the two sites prior to, during, and after the dredging operation. Only limited analysis of the data collected with respect to the overall objective was undertaken by the proponent. While the assessment of fish mortality due to the dumping of dredge spoil at the two disposal sites does not appear to be feasible based on the data collected, there was no evidence of significant fish kills during the actual operations (EE#8).

Summary Statement

The monitoring program does not allow us to fully discern the impact of the 1996 dredging operation in Middle Shoal Channel on the movement of fish in and through the channel. After considering the information provided in the proponent's 1996 draft Environmental Monitoring Report on the Middle Shoal Channel Project (Little Narrows Gypsum Company 1996[b]), information presented at the December 18, 1996, RAP meeting, a review of the relevant literature, and experience derived from the research of persons involved in this issue, it was not possible to reach consensus on the impacts on fish populations using this body of water. With respect to the impacts on fish habitat, it was concluded that: (a) no significant changes could be detected to channel currents near Carey Point, flow exchange rate to the lake, tidal events, water salinity and temperature, and wind-induced surge events; (b) while an increase in sediment loading did occur, turbidity levels due to dredging could not be distinguished from natural turbidity caused by natural suspension and erosion, and did not persist; and (c) with respect to bottom (benthic) habitat at locations other than at the dredge and dumpsite, there was little alteration of such habitat over the short term (note, however, that there will be further monitoring of the habitat test sites in 1997).

Management Considerations

Concerns were raised by a local fisher at the December 18 RAP meeting that mackerel catches were lower after the dredging took place compared with periods (years) before. Historical data is available in order to undertake an assessment of the long-term effects of the dredging on commercial fisheries in Sydney Bight, the Great Bras d'Or and in the lakes. In response, it was

suggested that DFO should facilitate the undertaking of such an assessment, as well as a corresponding assessment of the impacts on the aboriginal food fishery in the Bras d'Or Lakes. With respect to the impacts of the project on fish habitat, it was suggested at the RAP meeting that further monitoring of the fish habitat stations, the disposal sites, and the dredged channel bottom be undertaken.

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