Peninsula Harbour
Fish Habitat Assessment

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Executive Summary

Existing fisheries and habitat reports, mapping, underwater video, and geospatial data were reviewed for the Peninsula Harbour Area of Concern on Lake Superior near Marathon, Ontario. This review is to support an environmental assessment of proposed capping of mercury and PCB contaminated sediments in the Jellicoe Cove "hotspot". A list of 26 species of fish that have been confirmed from Peninsula Harbour was compiled, including 18 that have been found in Jellicoe Harbour. Approximately 80 fish species are known from Lake Superior, additional species may use Jellicoe Cove and the proposed cap area given the very limited fisheries assessment has been conducted in Peninsula Harbour.

Underwater video and ponar grabs indicate that the proposed 25 ha cap area is comprised of soft sediments, primarily fine sands and silts, with some clay. Coarser sands, limited patches of cobble, and some rip rap is found in a narrow nearshore band along the western portion of the proposed cap, but represents a small fraction of the total cap area (likely <5%). Although there were historic accounts of lake trout spawning prior to 1955, there is very little suitable (<2000 m^2) cobble or gravel substrate in the proposed cap that appears suitable for lake trout spawning and there are no contemporary accounts of spawning fish. Suitable clean cobble substrate in 2-16 m of water is found along the shoreline west of Beatty Cove near Yser Point where significant historical lake trout spawning grounds were mapped by Goodier (1981).

Approximately 10 ha of the southeastern portion of the proposed cap have sparse to dense aquatic macrophytes dominated by the stonewort (*Chara*), Canada waterweed, and pondweeds. Submergents are densest in approximately 4-10 m water depth and provide cover for larval and adult fish. A few fish eggs and larval fish of unknown species were observed on underwater video in or immediately adjacent to the proposed cap. Yellow perch are known to spawn over submerged vegetation and young-of-the-year (YOY) were caught in Jellicoe Cove. The nearshore zone in and near the proposed cap is used by larval fish including longnose suckers, rainbow trout, and salmon. These likely originated from Shack Creek on the eastern shore of Peninsula Harbour. Other larval or juvenile fish such as round whitefish and rainbow smelt may have come from potential spawning grounds over coarse sand, gravel and cobble/rip rap along the periphery of the proposed cap or elsewhere in Peninsula Harbour.

Recognizing the limitations of the existing data, the proposed cap area does not appear to be critical fish habitat. Less than 2% of the cap is in shallow (<2 m) water preferred by many YOY fish including salmonids and suckers, and relatively similar littoral habitat is abundant elsewhere in Peninsula Harbour along more natural shorelines. The unvegetated portion of the proposed cap in deep water over fine-textured substrate is likely used by adult longnose

suckers and round whitefish in particular. The proposed capping will cover silt substrate with sand; this may benefit slightly species that prefer sand compared to silt and vice versa, but will probably not have a significant effect on fish habitat use. Furthermore, deepwater silt habitat is common in elsewhere in Peninsula Harbour.

Available evidence suggests that the most significant impact will be the potential reduction in aquatic macrophyte abundance in the proposed cap area, which could reduce the habitat suitability for foraging adult longnose suckers and northern pike. Although data are lacking, yellow perch and small fish species in various life stages could also be affected by a reduction in submergent density. The response of submergents to disturbances such as the proposed capping is poorly understood for oligotrophic systems like Peninsula Harbour. Various lines of evidence suggest however that the plant species present in Jellico Cove are will be able to recover in the short to medium term.

Finally, the long-term benefit of reducing exposure to contaminated sediments by capping it with a layer of sand probably outweighs the any potential short-term negative impacts to fish habitat. Although the proposed cap area provides habitat for a number of species of fish, in various life stages, it does not represent ideal foraging habitat due to contaminated sediments with mercury that bioaccumulates and can impair fish health and reproduction.

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1 Introduction

Peninsula Harbour, a large embayment adjacent to the town of Marathon on Lake Superior, was identified as an Area of Concern in 1985 as part of the review by the Water Quality Board of the International Joint Commission (; Stage 1 RAP 1991). Jellicoe Cove encompasses approximately 97 ha of Peninsula Harbour south of Skin Island (Figure 1, Figure 2). It has been the focus of numerous studies due to elevated concentrations of mercury and polychlorinated biphenyls (PCDs) in sediment and fish as the result of industrial contamination (e.g., Biberhofer and Dunnet 2005; Golder 2005; Richman 2004).

The objectives of Thin layer capping (AECOM 2009a) are:

- To reduce risk to biota from contaminated sediment in Jellicoe Cove thus reducing bioaccumulation into the food chain;
- To reduce the spread of contaminated sediment from Jellicoe Cove to the rest of Peninsula Harbour;
- To expedite the natural recovery of Jellicoe Cove; and
- To facilitate ecosystem recovery in Peninsula Harbour which will contribute to "delisting" as an Areas of Concern (AOC) identified in the *Great Lakes Water Quality Agreement between Canada and the United States*).

The proposed cap would cover approximately 25 ha, or about ¼ of Jellicoe Cove or about 2.5% of Peninsula Harbour (approximately 1000 ha) and even less of the Peninsula Harbour AOC, which extends further out into Lake Superior. The 33% design build specifies proposes a 15-20 cm capping layer of medium sand, with coarse sand in nearshore areas less than 5 m water depth.

Northern Bioscience has been engaged to independently review existing fish community and fish habitat data for Peninsula Harbour. Existing fish and fish habitat information has been synthesized, and its significance assessed based on these data. Potential short and longer term impacts of the proposed capping and remediation are also discussed.

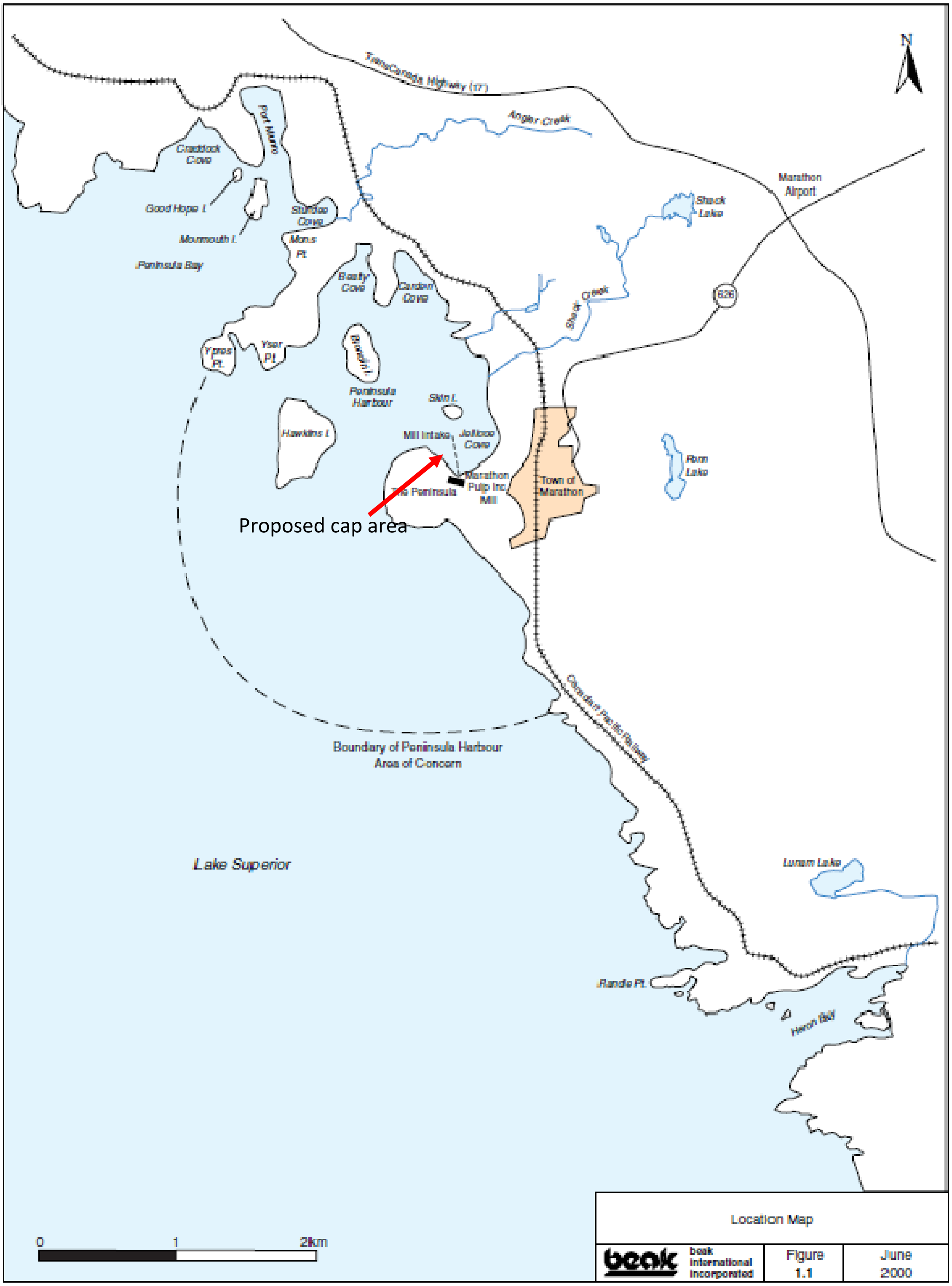


Figure 1. Map of Peninsula Harbour Area of Concern near town of Marathon (Beak 2001).

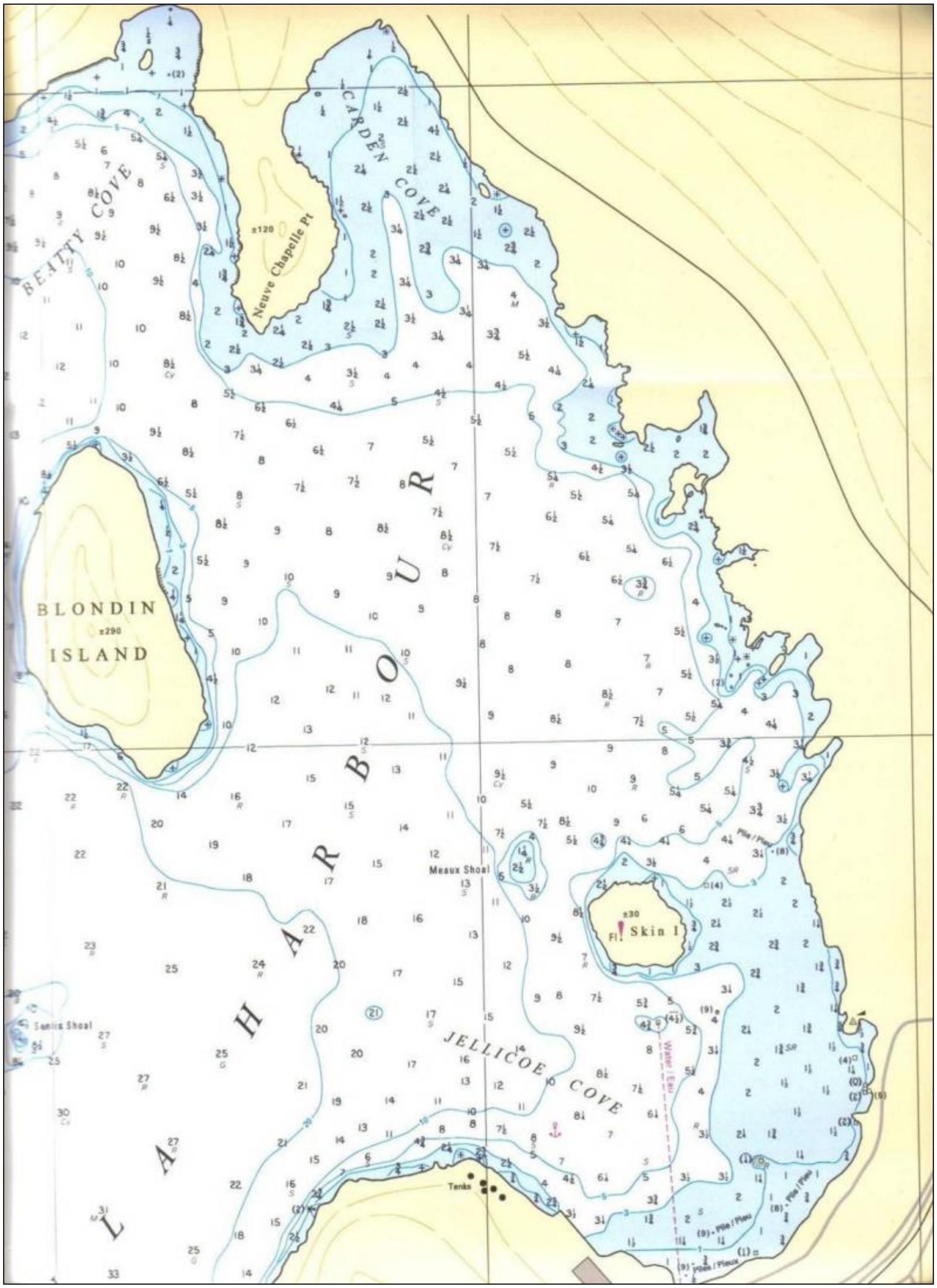


Figure 2. Detail of Canadian Hydrographic Service Chart 2306 Peninsula Harbour and Port Munro showing Jellicoe Cove and surrounding waters.

2 Fisheries

Limited information on fish and fish habitat use is available for Peninsula Harbour and Jellicoe Cove.

2.1 Historic Documentation

Goodier (1981, 1982) conducted interviews with experienced commercial fishermen and compiled other historical evidence on the location of historic (pre-1955) spawning and fishing grounds for lake trout and other species in Lake Superior. The spawning grounds identified for Jellicoe Cove were identified as "average or not known" meaning that they did not stand out in commercial fisherman interviewed as either particularly significant or relatively minor (Goodier 1981)(Figure 4). Significant historic (pre-1955) lake trout spawning shoals were also mapped along the north shore of Peninsula Harbour at Yser Point and along the western shore at the mouth of Beatty Cove. Although mapped, there was no text describing use of Peninsula Harbour by lake trout. Goodier (1981) suggest that there existed many discrete and semi-discrete stocks with Lake Superior prior to their collapse in the 1950s. Goodier (1981) stated that many of the original spawning grounds are now deserted in the fall (the status of the Peninsula Harbour was unknown at the time of his thesis). Goodier's historical observations are the only available supporting documentation for the statement in AECOM's (2009b, p. 1-1) 33% design brief that "Historical lake trout spawning grounds along the shorelines of Jellicoe and Beatty Coves, have been destroyed through the accumulation of organic matter from mill operations." In the case of Beatty Cove, it is organic matter from log booming, not mill operations, that may have impacted spawning grounds.

Goodier (1982) stated that "Peninsula Harbour continues to receive herring in November, although effluent and debris from the American Can paper mill is undoubtedly deleterious." The location of spawning grounds is very roughly depicted with the symbol overlapping The Peninsula (Figure 3). No historic spawning or fishing grounds for chub (*Coregonus* spp.), lake whitefish, walleye, northern pike, yellow perch, and lake sturgeon were identified for Peninsula Harbour in Goodier (1982). These historic spawning grounds from Goodier (1981, 1982) were reproduced in Beak (2001) and AECOM (2009)(Figure 5,Figure 6).

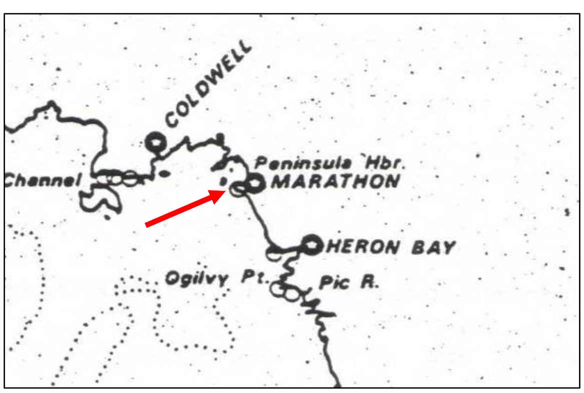


Figure 3. Detail of lake herring spawning locations (open circles) from Goodier (1982) northeastern Lake Superior including Peninsula Harbour (red arrow).

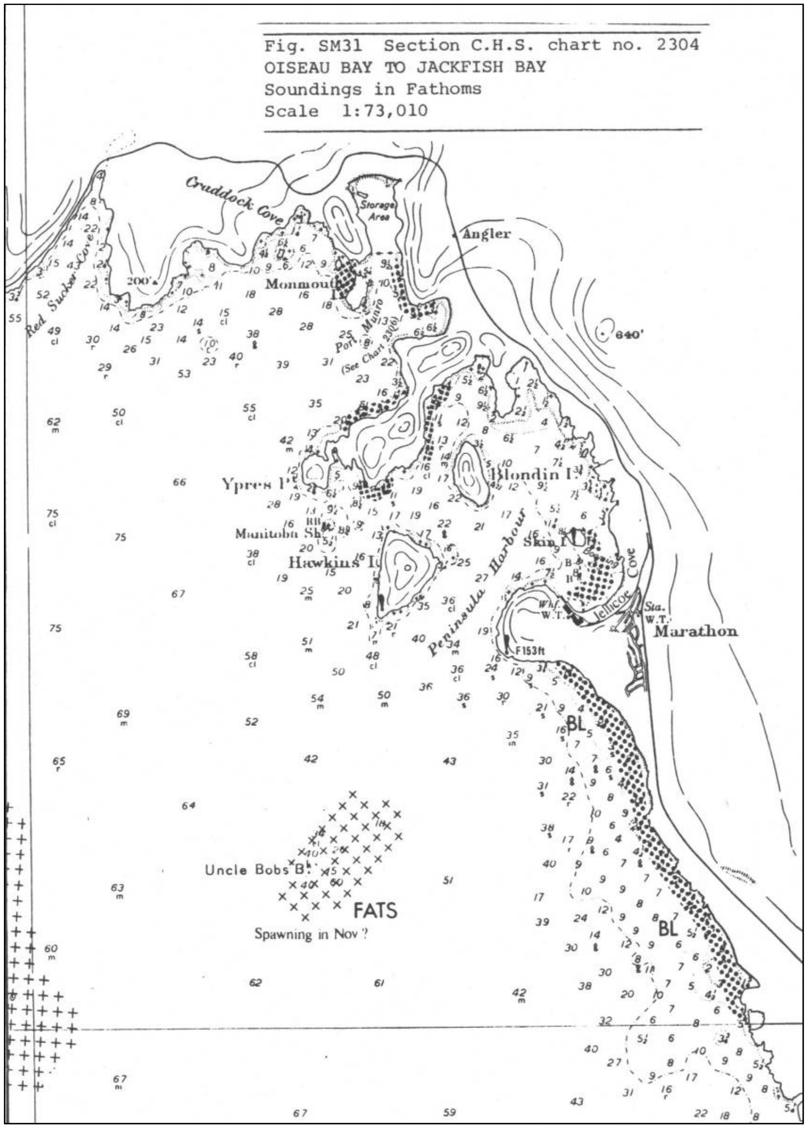


Figure 4. Summary of spawning grounds (stippled) and fishing grounds (hatched) for native lean lake trout stocks prior to 1955 (Goodier 1981, Fig. SM31).

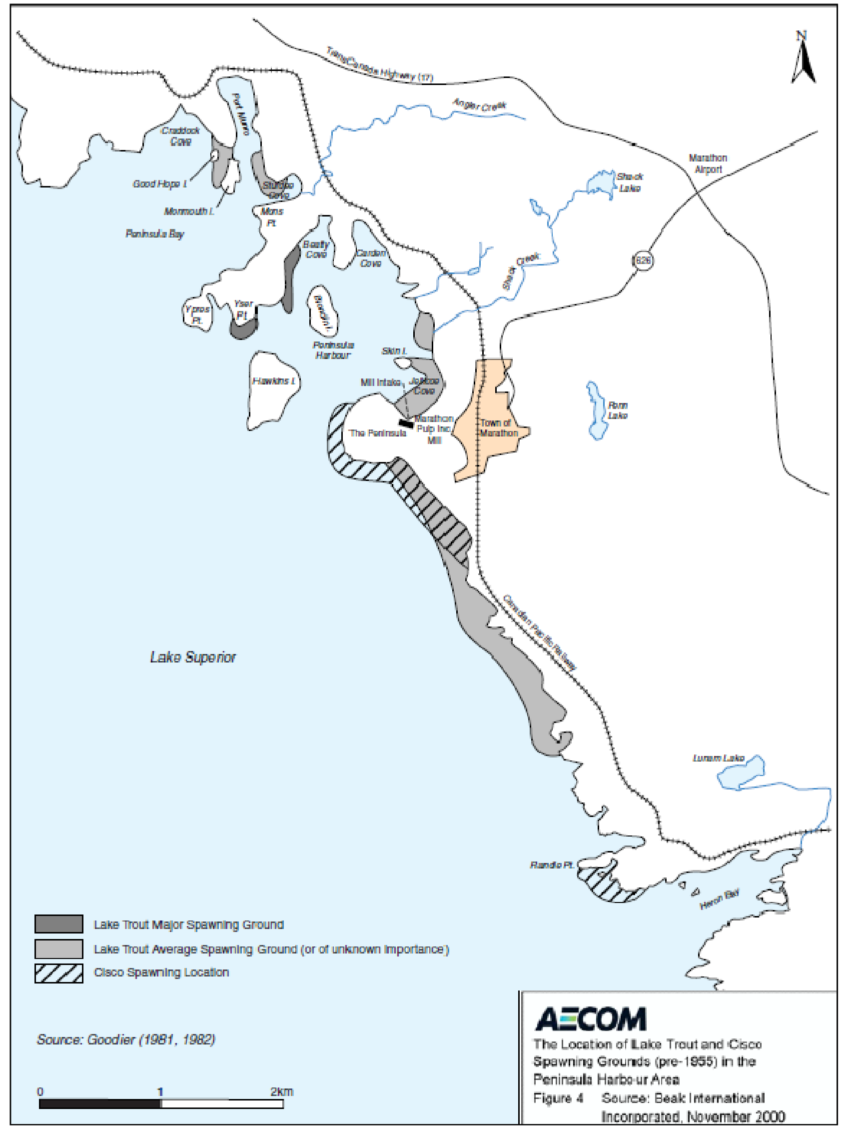


Figure 5. AECOM map of lake trout and cisco spawning ground prior to 1955 based on Goodier (1981-1982).

Spawning and nursery habitat for a number of economically important fish species were mapped by Goodyear et al. (1982) for Lake Superior based on a variety of existing sources (Figure 6). For Peninsula Harbour, Goodier (pers. comm. 1979) was the cited source:

> "Spawning occurred at Port Munro (48°46', 86°26'), Ypres Point(48°44', 86°27'), Peninsula Harbor (48°44', 86°24'), along shore around Craig's Pit (48°41, 86°22'), Randle Point (48°39', 86°21'), Heron Bay(48°38', 86°20'), Ogilvy Point (48°36', 86°21'), and the points outside Playter Harbour (Goodier, pers. comm. 1979)."

Although mapped, there was no supporting text for Peninsula Harbour in Goodyear et al. (1982). No spawning or nursery grounds for other lake-spawning fish species (including lake herring) are depicted for the Peninsula Harbour in Goodyear et al. (1982). Spawning habitat for rainbow trout in Lake Superior tributaries is mapped in Goodyear et al. (1982), but Shack Creek is not specifically listed.

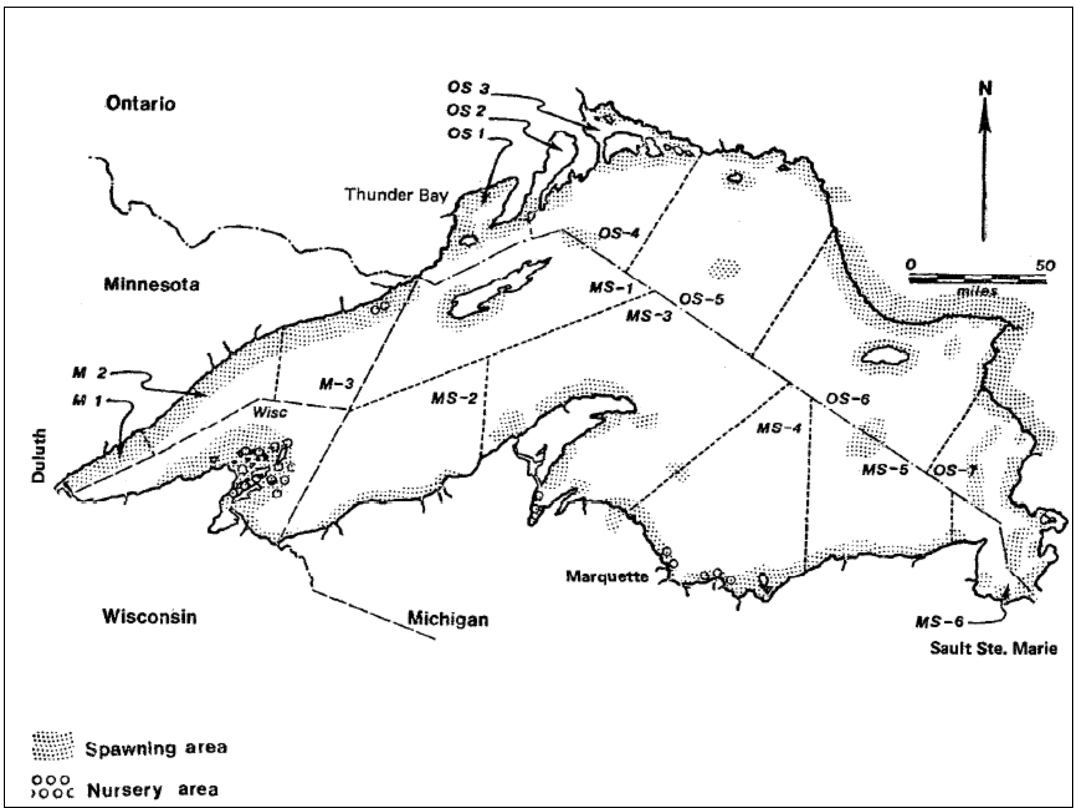
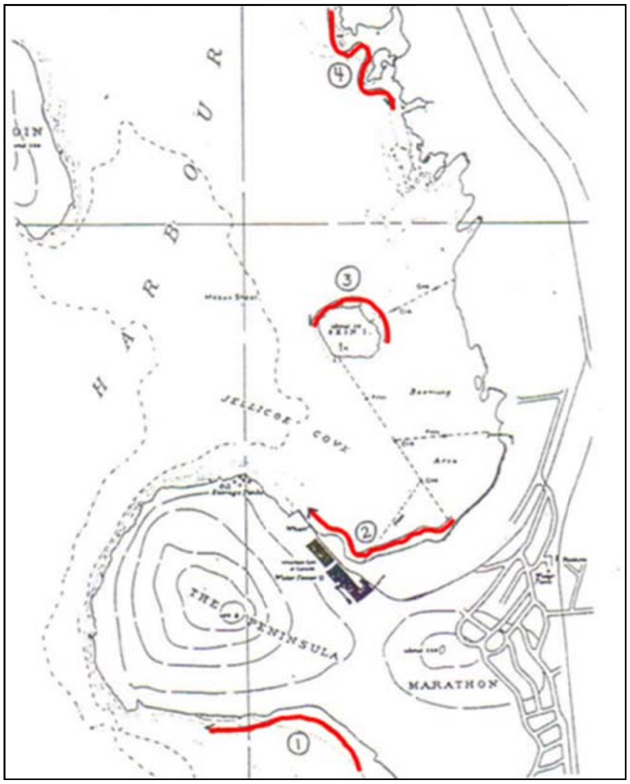


Figure 6. Lake trout spawning and nursery areas mapped by Goodyear et al. (1982)

2.2 Contemporary Fisheries Assessments



The first documented fisheries assessment for Peninsula Harbour appears Hamilton (1987). Four, night-time, boat-based electrofishing runs (3889 seconds total) in 1-4 m of water of Jellico Cove, Peninsula Harbour and adjacent Lake Superior (Figure 7) yielded 73 fish of 8 species (Table 1). An additional 11 species were noted from a personal communication with Suns (Table 1). No aquatic macrophytes were observed and no nursery habitat was identified. Substrate for Jellico Cove electrofishing run was described as sand/rubble, old cribs, and sawdust.

Figure 7. Location of four electrofishing runs (red lines), August 27-28, 1986 (Hamilton 1986).

Beak conducted sampling in Peninsula Harbour (Figure 8a) on August 22-27 , 2000, consisting of 5 overnight gillnet sets (1½”-5” mesh), beach seining (36 x 4 bag seine with ¼” mesh) at four locations (50-150 m distance), and backpack electrofishing (total 1299 seconds) in Jellicoe Cove (Figure 8). Slightly less effort was used in Carden Cove (Figure 9a.). Gill-netting catch per unit effort (CUE) by Beak (2001) was three times higher in Carden Cove compared to Jellicoe Cove, but CUE for backpack electrofishing and beach seining were similar.

Based on this sampling, maps of sensitive fish habitat in Jellicoe Cove were prepared by Beak (Figure 8b, Figure 9b). Nursery habitat was mapped along the southwest shoreline of Jellicoe Cove adjacent to the proposed cap (rainbow trout and coho salmon) and in the small embayment along the eastern shore approximately 500 m east of the cap (yellow perch and longnose sucker). Sensitive fish habitat was only delineated for areas that were sampled; other areas that were not sampled may or may not contain sensitive habitat. Areas with YOY large fish species were called nursery habitat, but small fish species were not considered. Similar criteria were used for the longnose sucker and round whitefish nursery habitat mapped for Carden Cove.

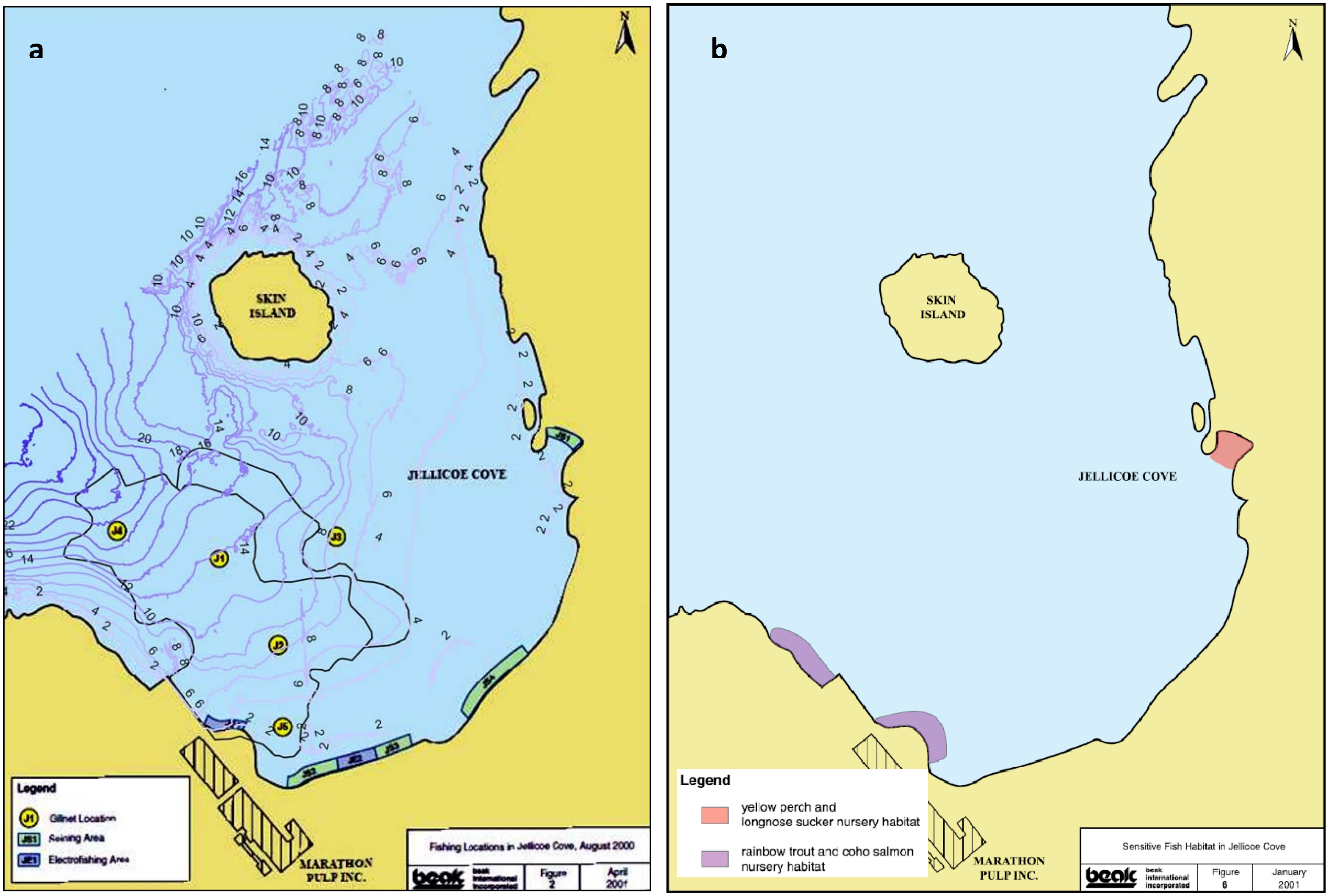


Figure 8. Beak (2001) fisheries assessment locations in Jellicoe Cove, August 22-27, 2000 modified to show proposed cap area and bathymetry (a) and identified sensitive fish habitat (b).

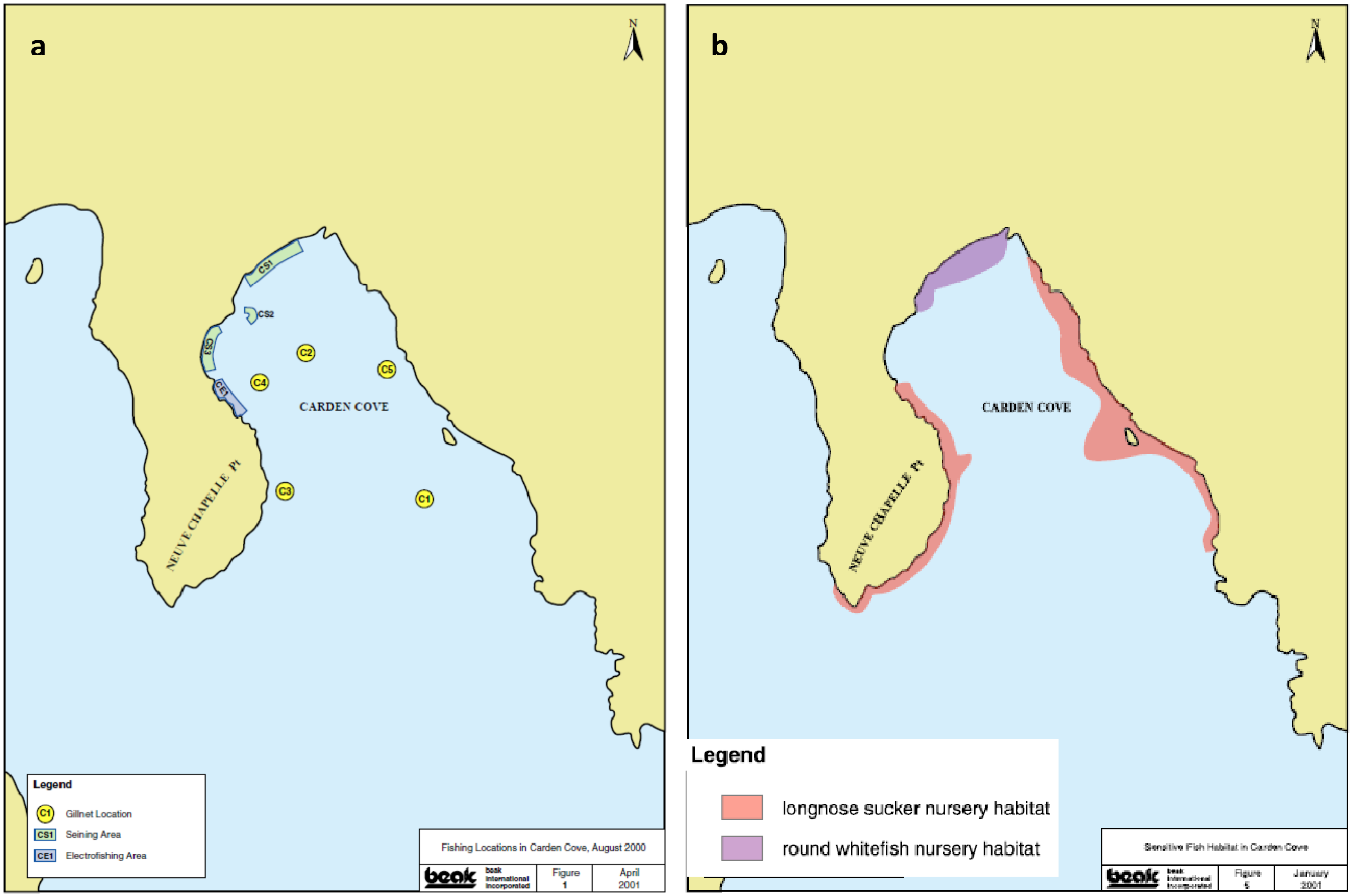


Figure 9. Beak (2001) fisheries assessment locations in Carden Cove, August 22-27, 2000 and identified sensitive fish habitat.

2.3 Video Interpretation

During examination of Environment Canada videos recorded for substrate analysis (see 3.1.1.5), fish eggs and/or larval fish were observed at several locations. What appears to be a single fish egg was observed on video at two locations within the proposed cap (these are difficult to see on still photographs but are more evident in the video). At location #1, a single egg was observed on silty sand substrate with scattered stonewort at approximately 10 m depth. Egg #2 was observed on silt with abundant bark deposits in 14 m of water depth. At the west end of the cap (Location #3), a small school of larval fish and several fish eggs were observed in approximately 21 m of water. It appears that at least 2 cm of silt overlays bedrock where the fry and egg were observed (Figure 11). At 3:21 of video run time, several fish eggs can be seen rolling about on the surface of the substrate. Approximately 300 m west of Skin Island, another small school of small larval fish were observed on video (Figure 12). The water depth was 21 m and the substrate was silty as well.

It is not known if the eggs were laid in the locations observed on video, if they were viable or not, or what species they are. Similarly, the larval fish are too small to positively identify. Both are difficult to pick out in still photos, but are more readily distinguished in the video.

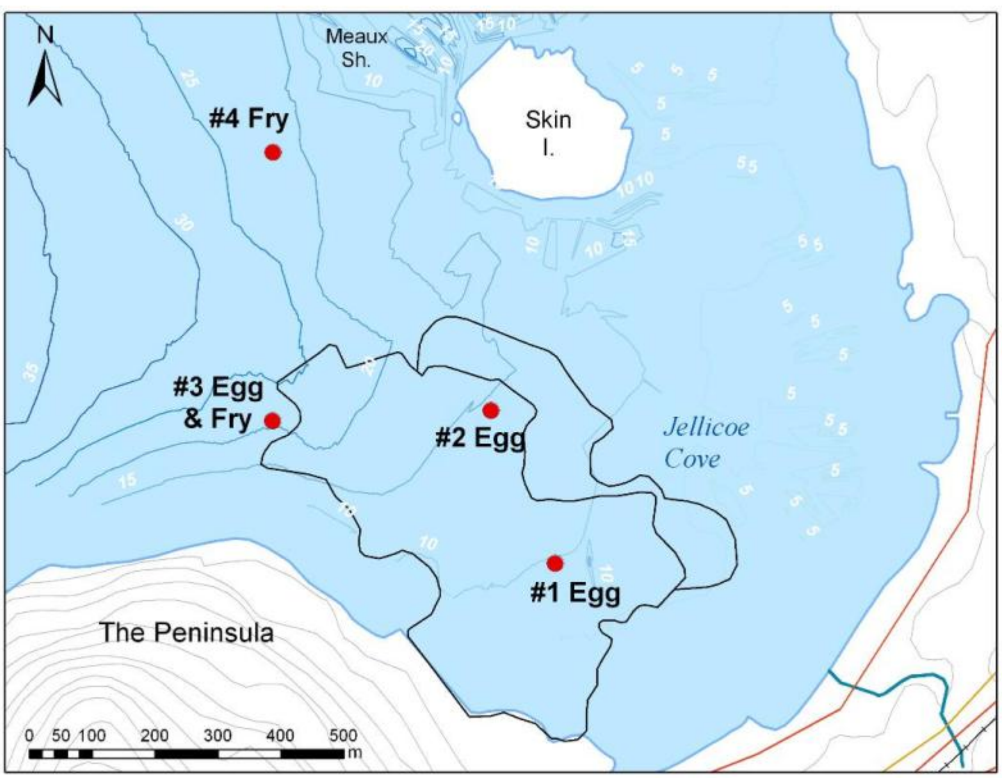


Figure 10. Location of apparent fish eggs and fry observed in Environment Canada videos.

Figure 11. Silty sediment at 21 m depth west of proposed cap with larval fish (red arrow) and fish egg (black arrow)(Photo 36b).

Figure 12. Silty sediment at 21 m depth west of Skin Island with larval fish (arrow) near bottom.

2.4 Fish Community

According to Beak (2001) and Peninsula Harbour RAP Team (1991), Peninsula Harbour supports a fish community which includes at least 31 species, citing Scott and Crossman (1973), Lawrie (1978), Goodyear *et al.* (1982); and Mandrak and Crossman (1992). Species lists were not provided. A total of 20 species were confirmed in Peninsula Harbour by Hamilton (1986) and Beak (2001), with another 6 species from personal communications. Based on these sources, Beak (2000), and AECOM (2009), a total of 26 species has been compiled in Table 1, of which 18 have been recorded from Jellicoe Cove.

Approximately 80 species of fish are documented from Lake Superior and other species not found during sampling may potentially utilize Peninsula Harbour at some point in their life cycle such as trout-perch (*Percopsis omiscomaycus*) and cyprinid (minnow) species. Young of the year (YOY) and juvenile longnose sucker and round whitefish were the most abundant species sampled by Beak (2001) in Peninsula Cove, followed by rainbow trout and longnose dace in the lower reaches of Shack Creek. However, relative abundance of larval fish can be very variable depending on the time of year, type of sampling gear used, and time of day that the sampling was conducted (e.g. night vs. daytime sampling, particularly for habitats with little or no cover such as beaches). For example, no offshore areas were mapped as nursery areas by Beak (2001) since all seining and electrofishing was done along the shoreline or in tributary streams.

The significance of fish populations is difficult to determined based on published fisheries assessments given the paucity of available data i.e., only two, limited effort, point-in-time sampling sessions in 1986 and 2001. Hamilton's (1986) observation that Peninsula Harbour has the lowest species diversity in Lake Superior must be considered in the context of the limited sampling effort and that is was only being compared to other Areas of Concern (AOC) that were sampled on Canadian Lake Superior.

2.5 Species at Risk

Several aquatic Species At Risk (SAR) are known from Lake Superior and could potentially use Peninsula Harbour at some point in their life cycle. In particular, lake sturgeon are known to spawn and reside in the Pic and Black rivers (e.g., Foster and Tost 2010) and it is conceivable that they could forage in Peninsula Harbour. There is no evidence of their use of the Peninsula Harbour (AECOM 2009a), but no assessment sampling with appropriate gear (e.g., large mesh gill net) has been there. Great Lakes populations of lake sturgeon is considered Threatened in Ontario and protected under the Endangered Species Act (ESA) 2007.

Shortjaw cisco (*Coregonus zenthicus*) is also Threatened under SARA and Ontario's ESA and could potentially use Peninsula Harbour since there is a single record in Mandrak and Crossman (1992) near Marathon. However, the species typically inhabits deeper water i.e., 55 to 144 m, and shows seasonal differences, moving into shallower water to spawn (COSEWIC 2003). In Lake Superior, spawning probably occurs in 37-73 m over a clay bottom (Scott and Crossman 1998). There is no evidence that it is found in Peninsula harbour however.

The upper Great Lakes population of kiyi (*Coregonus kiyi kiyi*) is listed as Special Concern federally and is known from Lake Superior as well. This cisco species lives in the deepest part of Lake Superior and is rarely collected in waters less than 108 m deep (COSEWIC 2005). It lives in a clear, poorly lit, coldwater environment year round and spawning occurred at a depth of 108 m (Parker 1989; Scott and Crossman 1998). It is highly unlikely to be found in Jellicoe Cove.

Northern brook lamprey (*Ichthyomyzon fossor*) is a non-parasitic lamprey that is resident in a number of Lake Superior tributaries. It is considered Threatened in Ontario and nationally. There are no records of it from Shack Creek or the other unnamed tributary in Peninsula Harbour, though it is known from the nearby Pic River (Schuldt and Goold 1980; COSEWIC 2007). Shack Creek is not listed as a tributary treated by the Sea Lamprey Control Centre, so it is unlikely there has been any recent targeted surveys. As this species does not live in Lake Superior itself, it would not be impacted by the proposed capping in Jellicoe Cove.

The deepwater sculpin (*Myoxocephalus thompsonii*) is a Special Concern species that is known from Lake Superior (COSEWIC 2006a). In Lake Superior, deepwater sculpin are most common at depths greater than 70 m and have been found as deep as 407 m (Selgeby 1988). None have been recorded within 100 km of Peninsula Harbour (Mandrak and Crossman 1992) and it is highly unlikely that they are present in Jellicoe Cove due to the comparatively shallow water depths.

Table 1. Documented fish species and life stages* for Jellicoe Cove, Peninsula Harbour, Shack Creek and adjacent Lake Superior (taxonomic order).

Common Name	**Scientific Name**	**Lake Superior**	**Peninsula Harbour**	**Jellicoe Cove**	**Shack Creek**
Alewife	*Alosa pseudoharengus*		U[4]	A[5]	
Emerald Shiner	*Notropis atherinoides*		U[4]		
Lake Chub	*Couesius plumbeus*		U[4], N[5],U7	N[5]	N[5]
Longnose Dace	*Rhinichthys cataractae*		U[4], N[5]	N[5], A[5]	N[5], A[5]
Spottail Shiner	*Notropis hudsonius*		U[4]		
Longnose Sucker	*Catostomus catostomus*	N[3]	N[3], N[5], A[5]	N[3], N[5], A[5]	S[6]
White Sucker	*Catostomus commersoni*		N[3], A[5]	N[3]	S[6]
Northern Pike	*Esox lucius*		U[4]	A[5]	
Rainbow Smelt	*Osmerus mordax*		N[3]	N[3]	
Brook Trout	*Salvelinus fontinalis fontinalis*				S[6], N[5], A[5]
Chinook Salmon	*Oncorhynchus tshawytscha*	N[3],U[7]			S[6]
Cisco (Lake Herring)	*Coregonus artedi*	S[1]		N[5]	
Coho Salmon	*Oncorhynchus kisutch*			N[5], A[5]	N[5]
Lake Trout	*Salvelinus namaycush*	S[1,2]	S[1]	N[5], A[5]	
Lake Whitefish	*Coregonus clupeaformis*		N[3], N[5], A[5]	N[3]	
Round Whitefish	*Prosopium cylindraceum*		N[5], A[5]	N[5],A[5]	
Pink Salmon	*Oncorhynchus gorbuscha*			N[5]	S[6]
Rainbow Trout	*Oncorhynchus mykiss*		U[4], N[5], A[5]		N[5]
Burbot	*Lota lota*	A[3]	N[5]	N[5]	
Sticklebacks	Unknown		U[4]		
Threespine Stickleback	*Gasterosteus aculeatus*			A[5]	
Mottled Sculpin	*Cottus bairdi*		N[5], A[3]	N[5], A[5]	A[5]
Slimy Sculpin	*Cottus cognatus*	N[3], U[7]		N[5], A[5]	N[5], A[5]
Johnny Darter	*Etheostoma nigrum*		U[4]		
Walleye	*Zander vitreus*		U[4]		
Yellow Perch	*Perca flavescens*		U[4]	N[5]	

*S=Spawning; N=Nursery (presence of YOY or Juveniles based on total length);
A=Adult; U=unknown life stage

[1] (Goodier 1981, 1982); [2] Goodyear et al. (1982);
[3] Hamilton (1986); [4] Suns pers. comm. in Hamilton (1986)
[5] Beak (2001) [6] AECOM (2009)
[7] (GBIF 2011)

3 Aquatic Environment

3.1 Substrate

3.1.1 Existing Studies

3.1.1.1 Beak 2001

Initial habitat mapping was conducted by Beak (2000) in conjunction with fisheries assessment. Visual assessment of substrate, aquatic vegetation, bedrock outcroppings, in-water structure and shoreline features were recorded on base maps. According to Beak (2000), the lake bed was visible to a depth of approximately 6 m due to clear water and sunny skies. Substrate types were verified at “numerous” locations (no map or coordinates were provided) in Carden and Jellicoe coves with the aid of a petite Ponar grab and visual/manual inspection in the field. Samples of aquatic macrophytes were collected for species determination and photographs of representative habitat features were taken. The resulting habitat map prepared by Beak is shown in Figure 13.

3.1.1.2 Environment Canada Reports

Numerous toxicological studies examined sediments in the Peninsula Harbour AOC on behalf of Environment Canada, and have included particle size analysis. Reports by Milani et al. (2001) and Grapentine et al. (2005) included tables with particle size distributions, depths, and geographic coordinates. These have been compiled (Appendix 1) and are portrayed in Figure 15. These are the only particle size data from laboratory analysis that was readily available for the current review.

3.1.1.3 AECOM 2009

The Beak habitat map was largely reproduced by AECOM (Figure 14) with new bathymetry and some minor refinements i.e., a small area of silt/mud was delineated based on a couple of substrate grab samples from Grapentine et al. (2005) and Milani et al. (2002)(Figure 15). No new field sampling was conducted for this revised habitat map.

Based on several other previous studies, AECOM 2009 summarized sediment quality in Jellicoe Cove as the following:

> “Substrates in the area of the proposed capping were described as having coarse sand over gravel (Burt and Fitchko 2001), and photographs indicate material consists predominantly of a soil matrix (*i.e.,* clay, silt, sand, gravel spectrum) with occasional layers of darker organic matter resembling peat. Eakins and Fitchko (2000) have also reported that substrate in Jellicoe Cove is generally a silty sand in the shallows becoming mud offshore in deeper waters with areas of exposed glacial clay also present. The “hotspot” area that contains the highest mercury concentrations overlies two types of hard uncontaminated substrate comprised of either glacial till (*i.e.,* light gray

> compacted fine sand with clay) or light gray glaciolacustrine clay (Burt and Fitchko 2001, Beak 2000), and occupying approximately 3 and 2 ha, respectively (Dainty 2003)."

3.1.1.4 BioSonics 2011

Contracted through EcoSuperior Environmental Programs, BioSonics (2011) conducted a hydroacoustic survey in 2010 to map the substrate in Peninsula Harbour for the identification of fish habitat. Submersible video and ponar grabs used for spot confirmation, with substrate determination from ponar grabs done visually in the field (Mike Burger, BioSonics, pers. comm.). The substrate classes could be roughly compared to those used Beak (2001) and AECOM (2009).

3.1.1.5 Northern Bioscience

The following underwater video coverage was reviewed by Northern Bioscience to confirm existing habitat mapping:

1. October 21-22, 2005 Environment Canada (VTS_01_1, VTS_01_02, VTS_01_03, VTS_01_04)
2. September 18, 2007 Environment Canada (Transects 1, B, C, C1, C2, D, E, F, F1)
3. BioSonics 2010 video from acoustic mapping (Cardin Cove, inside Beatty Cove entrance, middle Beatty Cove, outside entrance to Beatty Cove, Outside Blondin I., Skin I. Beatty shoreline, Yser Pt)
4. Ministry of the Environment (VTS_01_1, VTS_01_02, VTS_01_03, VTS_01_04) with audio.

The Environment Canada and BioSonics videos have global positioning system (GPS) coordinates overlain with the image, allowing the video images to be georeferenced. Environment Canada personnel interpreted their 2005 and 2007 videos and created two georeferenced databases (point ArcGIS shapefiles) with 372 and 552 data points respectively. At each these 924 locations, the substrate, woody debris, aquatic vegetation, and other notable features were described. Due to limitations of video interpretation, substrate were identified as fine sediments (<2 mm), gravel (2-64 mm), cobbles and boulders (>64 mm) and bedrock (Environment Canada 2007). For this study, the Environment Canada shapefiles were reviewed in ArcGIS concurrently with georeferenced videos (where available) to assess their accuracy.

Environment Canada videos CPS01 to CPS13, HDT1, HDTD2, and NC02 to NC04 were not provided but point shapefiles interpreted from them were available for this review. Not all BioSonics videos were available for review, but their 2011 draft report provides descriptions of the results from 42 spots with video and/or ponar grabs (Figure 17).

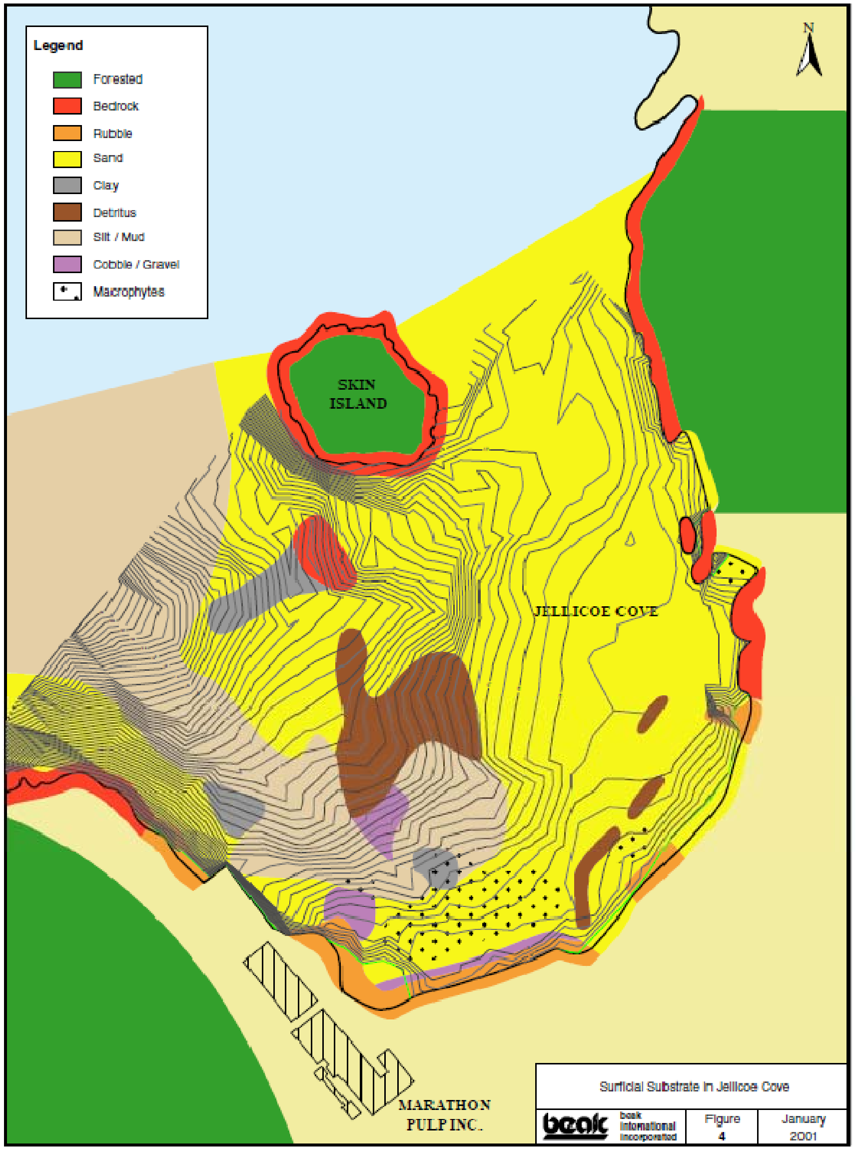


Figure 13. Beak (2001) habitat map for Jellicoe Cove.

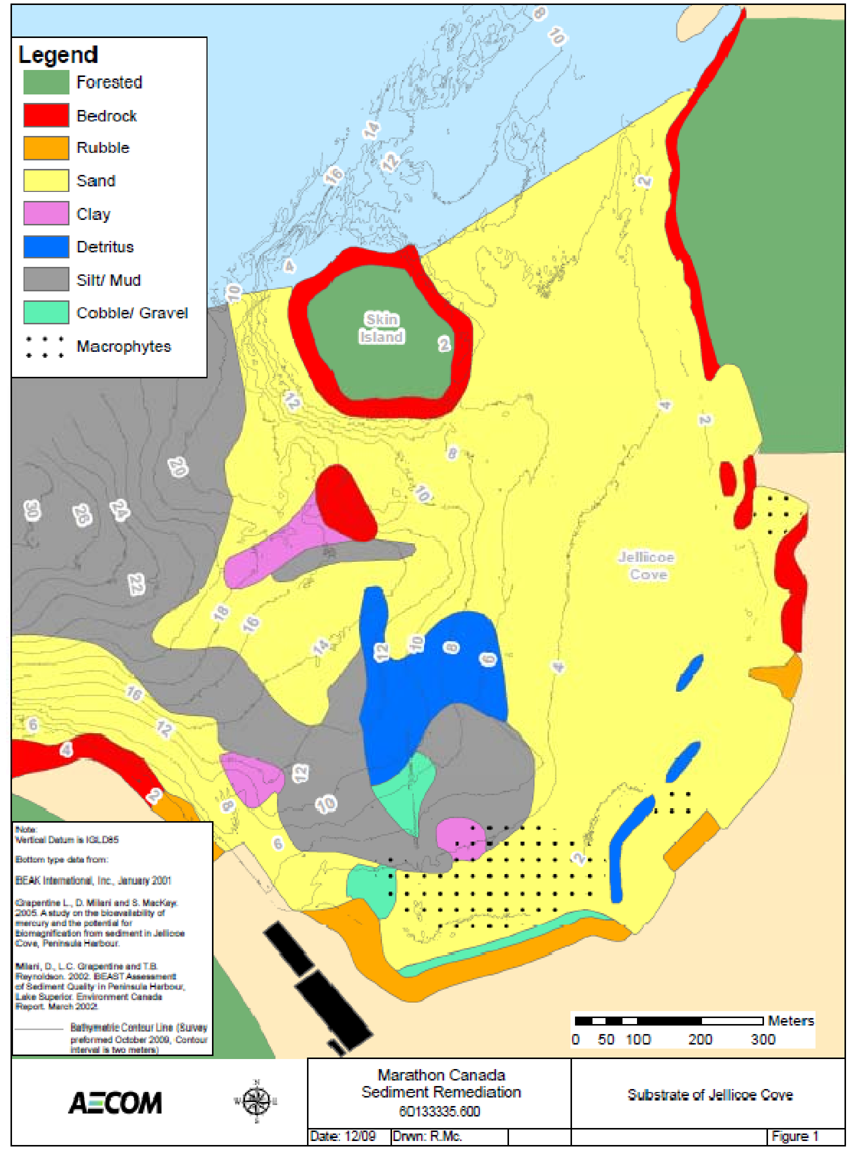


Figure 14. AECOM habitat map for Jellicoe Cove based on Beak (2001).

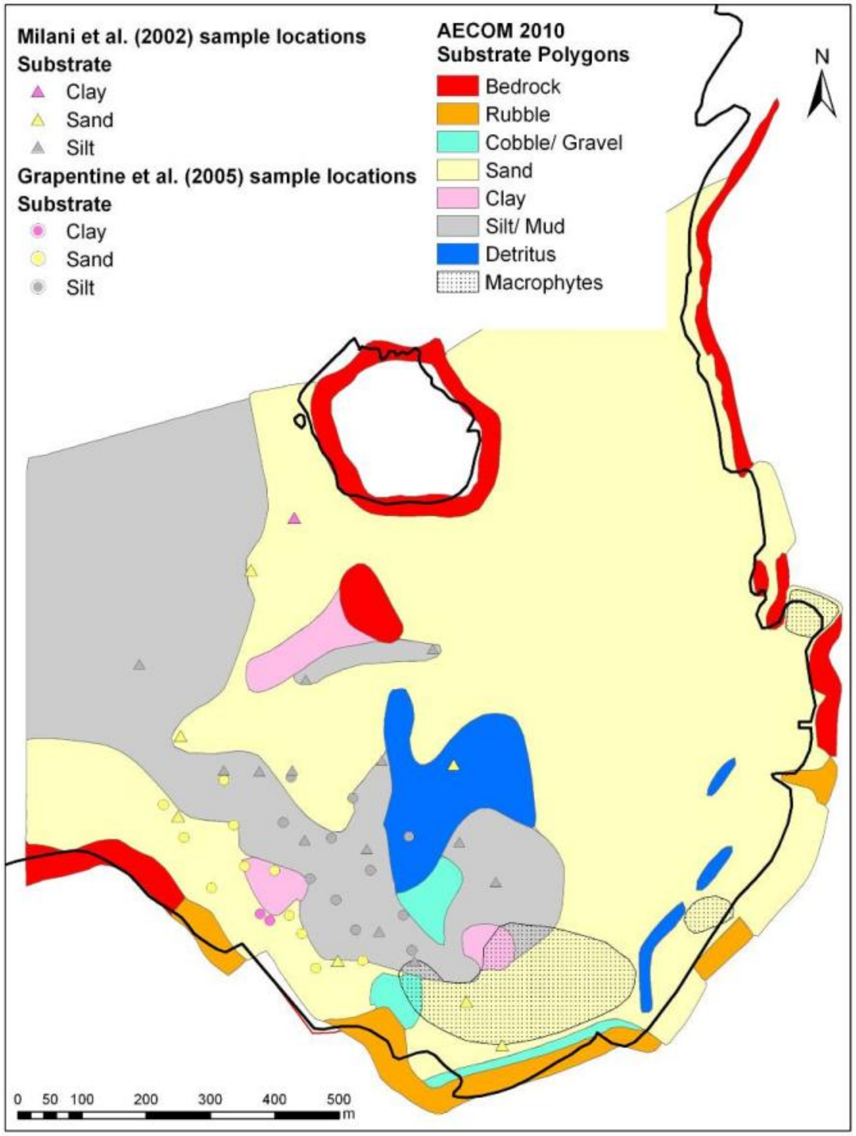


Figure 15. Substrate polygons (AECOM 2009a) overlain with substrate samples from Milani et al. (2002) and Grapentine et al. (2005).

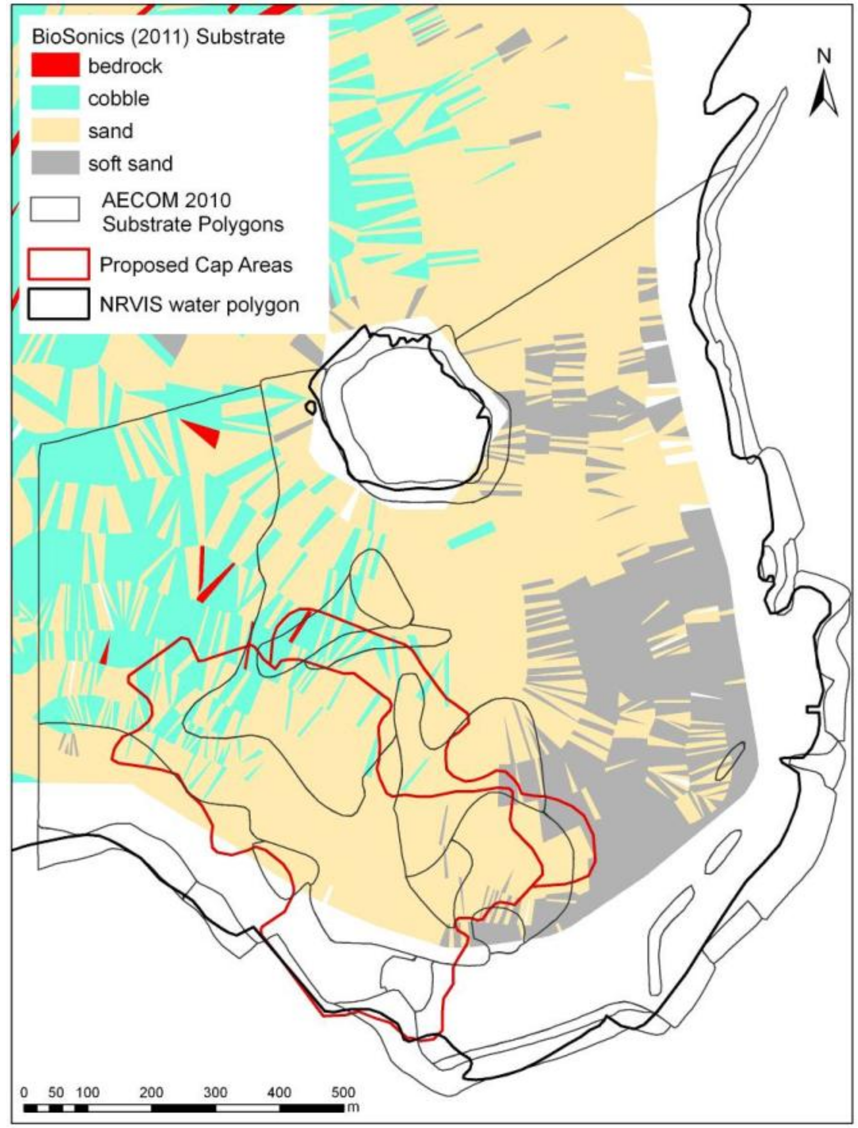


Figure 16. Substrate mapping from BioSonics (2011) overlaid with substrate polygon boundaries from AECOM (2009) in relation to proposed cap area.

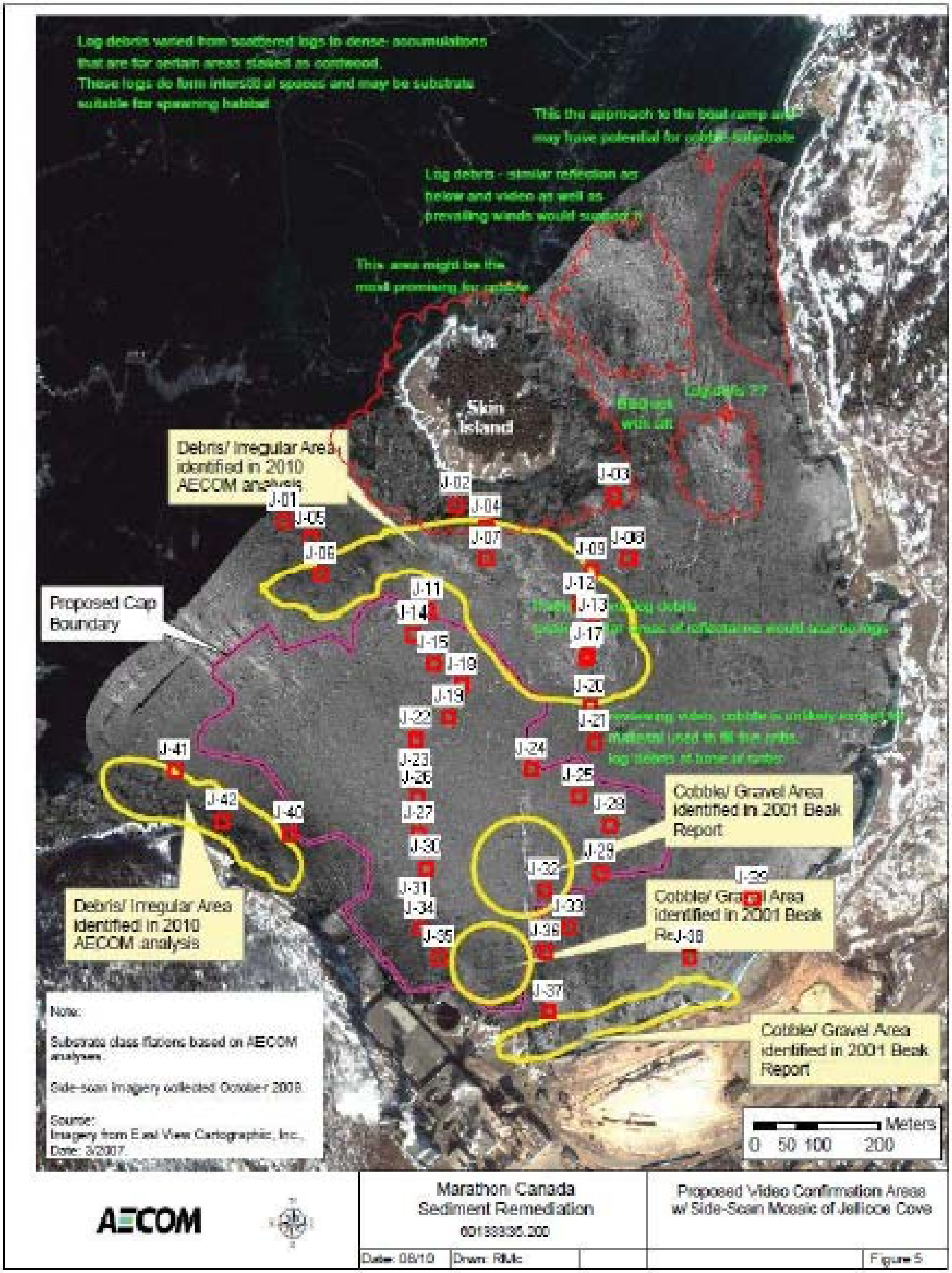


Figure 17. Site locations (red squares) for BioSonics video and ponar confirmation for their 2010 hydroacoustic survey (BioSonics 2011).

3.1.2 Substrate Synthesis

3.1.2.1 Jellicoe Cove and Proposed Cap Area

Based on sediment sampling, acoustic analysis, and review of underwater video, the proposed cap area is predominantly soft sediments. Laboratory particle analyses of Environment Canada samples from the proposed cap area indicated they were a mixture of sand and silt; samples from shallower water tended to have a higher proportion of sand, with offshore samples from greater water depth have more silt (Appendix 1; Figure 26). Of the 576 points in or within 100 m of the proposed cap that were interpreted by Environment Canada from their 2005 and 2007 videos, 78% were visually classified as soft sediments and 18% as mixed substrates (Figure 18). Review of these videos confirmed this interpretation; see Appendix 2 for representative video images and key map for the proposed cap area and elsewhere in Peninsula Harbour. Most of the mixed substrate was located in shallow water near the shoreline (Figure 26), and appeared to be predominately sand, with patches of overlying gravel and the occasional cobble (Figure 19).

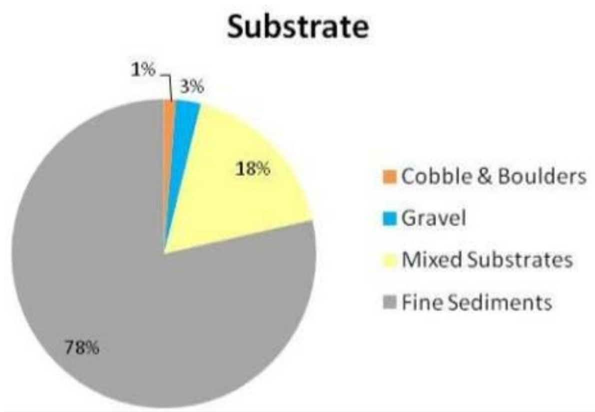


Figure 18. Substrate composition based on 568 interpreted Environment Canada 2005 &2007) video points within the proposed cap area and 100 m buffer.

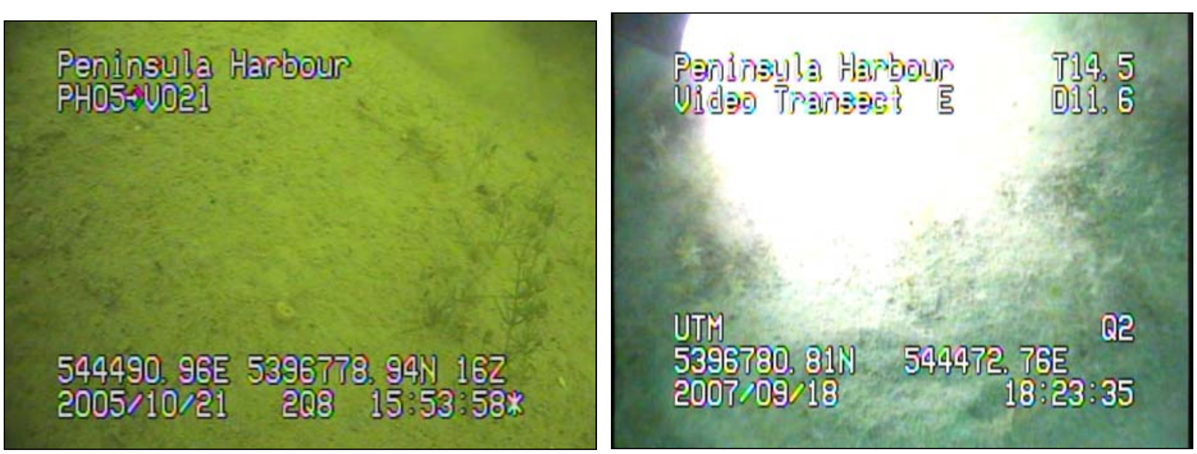


Figure 19. Centre of proposed cap area with soft sediment and sparse macrophytes (note dead planorbid snail in photo on left).

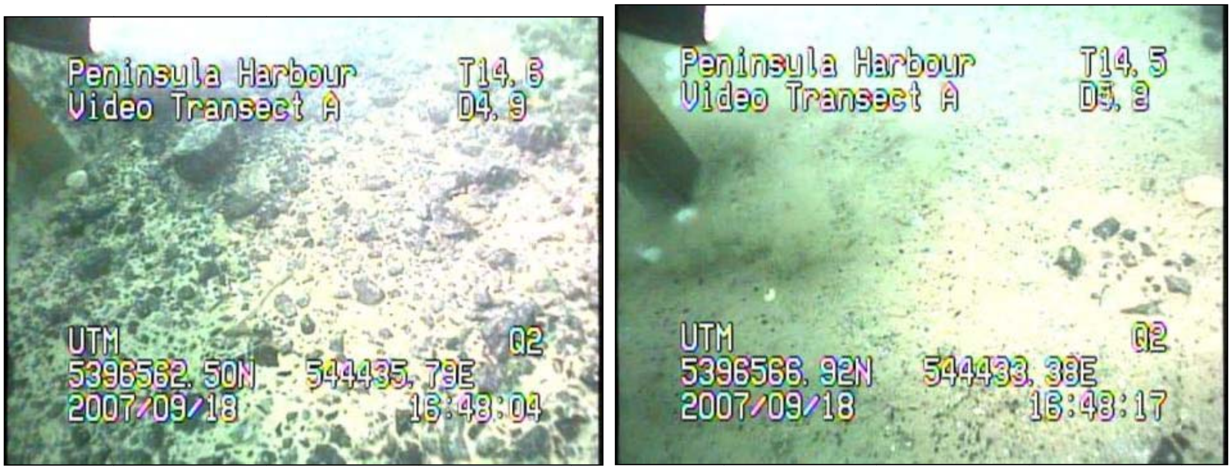


Figure 20. Mixed substrate in shallow water along southwest margin of proposed cap.

The original mapping by Beak (2001) correctly shows that the majority of the proposed cap is soft sediments (e.g., either sand or silt), but maps the northern and eastern portions of the cap as sand, rather than as silt. These areas, in 6-16 m of water and more than 200 m from the shoreline, are predominately silt, rather than sand based on sediment samples and video interpretation. The silt polygon added by AECOM (2009) at the northern edge of the cap (Figure 15) is accurate based on grab samples and video interpretation, but the surrounding area should be silt rather than sand. AECOM (2009b) characterized the surficial sediments on the eastern side of the cap area and near the existing dock as predominantly silty sands (SM and SP-SM), while the remainder of the surficial sediments in the cap area as low plasticity silts, based on their 11 bore holes and sampling by Terraprobe (2008). The characterization of the northern portion of the cap as cobble by the BioSonics hydroacoustic survey (Figure 16) therefore appears erroneous.

Figure 21. Bark overlying silty substrates at northwest edge of proposed cap.

Beak (2001) mapped two polygons within the proposed cap as cobble. Video analysis showed that the 6800 m^2 polygon approximately 200 m from shore near the centre of the cap was not cobble, but rather silty deposits, typically vegetated (Figure 22). Ponar grabs around the polygon were predominantly silt as well. The field observations of cobble may have been of rip rap used in association with cribbing found in the mapped polygon (Figure 23). Unfortunately, the type of substrate could not be confirmed for the other smaller (5000 m^2) polygon near the southern edge of the cap that was mapped as cobble by Beak (2001) since no video or ponar grabs were taken at that location. BioSonics (2011) observed cobble in video and ponar grabs at samples J36 and J37 approximately 50 m to the east, just outside the cap. This cobble is likely associated with the effluent pipe and associated cribbing that runs north approximately 700 m from the shore near this location. Beak (2001) also mapped some long, narrow polygons of cobble in shallow water (<3m water depth) along the eastern shore of Jellicoe Cove. Two BioSonics video and ponar stations (J38, J39) targeted these polygons, but instead of cobble, they were actually sand.

Figure 22. Soft sediments with dense stonewort with boot for scale in southern portion of proposed cap.

Figure 23. Cribbing in cap area mapped as cobble by AECOM/Beak within the proposed cap area.

At least in the area of the cap for which video was available, there is a narrow band (perhaps 10-20 m) of coarser sediments close to shore in shallower (<5 m approximately) water where there is too much wave energy for finer silts to settle out, at least during the ice-free season. The substrate consists of patches of rounded, natural–looking cobble and larger, darker, angular, rocks that are presumably rip rap used for fill and shoreline armouring. There are also areas of coarse sands rippled from wave action and mixed substrates. Farther west along The Peninsula was an area along the shore mapped as bedrock by Beak/AECOM (Figure 15). Although too shallow for a hydroacoustic survey, three video and ponar stations were conducted there by BioSonics (Figure 17) which confirmed that is was gravel and sand over bedrock, as well as cobble and rubble. East of the proposed cap, at the head of Jellicoe Cove is a beach, with coarse sand and gravel (ENVIRON 2008a, b).

Figure 24. Angular rocks (upper right) and rounded cobbles in shallower water along margin of proposed cap.

Beak (2001) mapped several polygons in the cap area as clay, including one adjacent to the AECOM silt polygon at the northern edge of the cap. There were no grab samples or video in the adjacent clay polygon mapped by Beak at the northern edge of the cap, so the substrate could not be confirmed. The one BioSonics ponar grab (J33; Figure 17) in the polygon mapped as clay at the southern edge of the cap in 4 m of water indicated that it was "sand, plants and some cobble"(BioSonics 2011). On the southwest edge of the cap in 7-11 m of water, a Grapentine et. al. (2005) ponar grab in the polygon mapped as clay by Beak (2001), indicated that the sediment composition as 55% sand, 31% silt and only 13% clay. It appears that clay is a minor component of the surficial substrate in the proposed cap zone, although it is possible that it may be more predominant deeper in the sediment profile.

The AECOM (2009a) Peninsula Harbour 33% Design Report (p. 6) identifies a couple of isolated rock outcrops at location #28 and #29 (relabelled as #34 and #35 on AECOM CAD plot MRT-030m002.dwg but with the same plotted location and UTM coordinates) in the proposed cap area, adjacent to silty deposits to the south and east. No sediment grabs or video footage was available for this area, but the contours derived from hydroacoustic mapping suggest some bottom irregularities and hydroacoustic survey by BioSonics (2011) also characterized that area as bedrock (Figure 25). These locations are in approximately 17 m of water, and if not bedrock, are likely another substrate with similar acoustic properties such as hardpan clay.

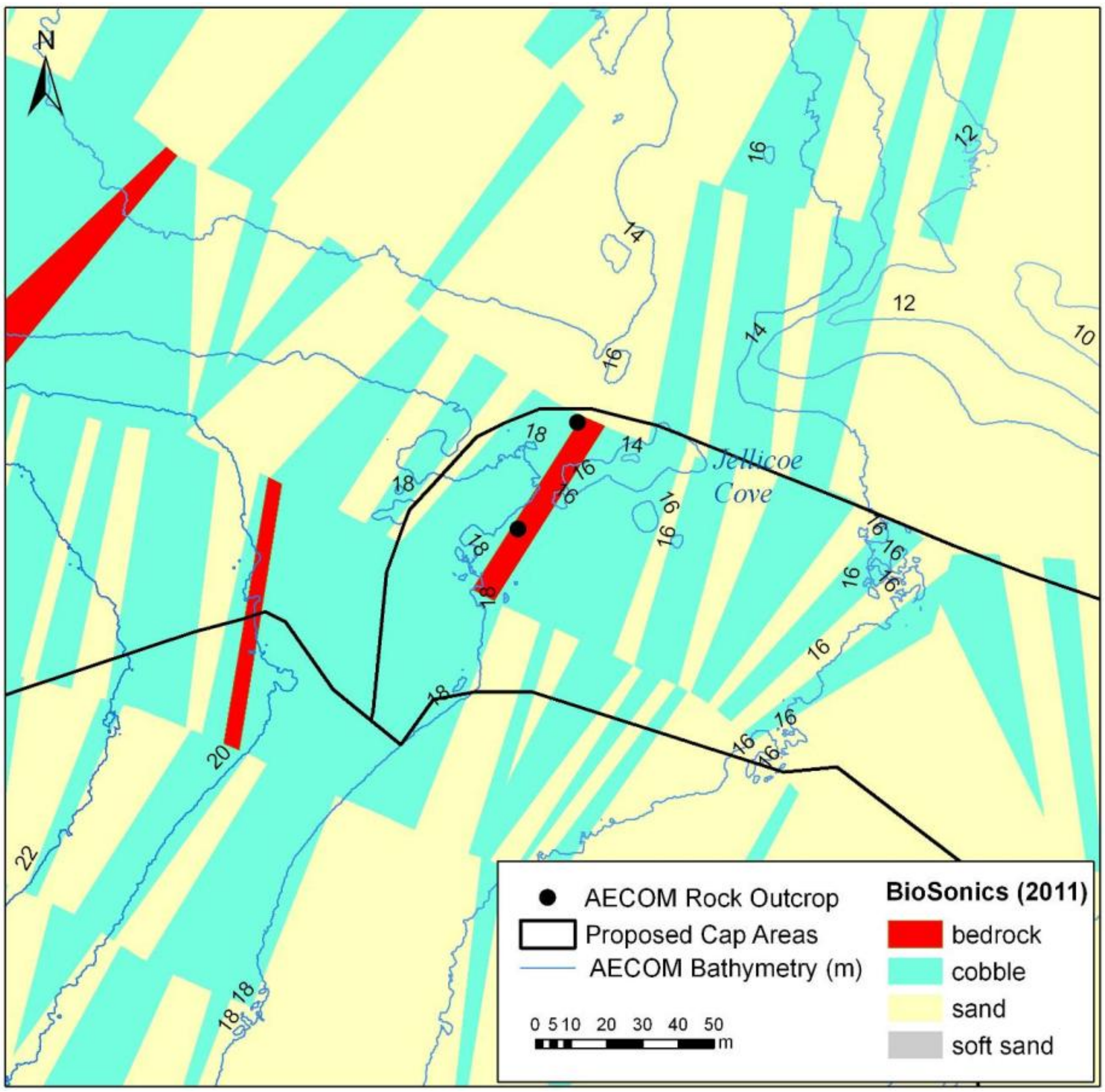


Figure 25. Location of rock outcrops identified in AECOM (2009a) 33% Design Build at locations 28 and 29 at the northern edge of the proposed cap.

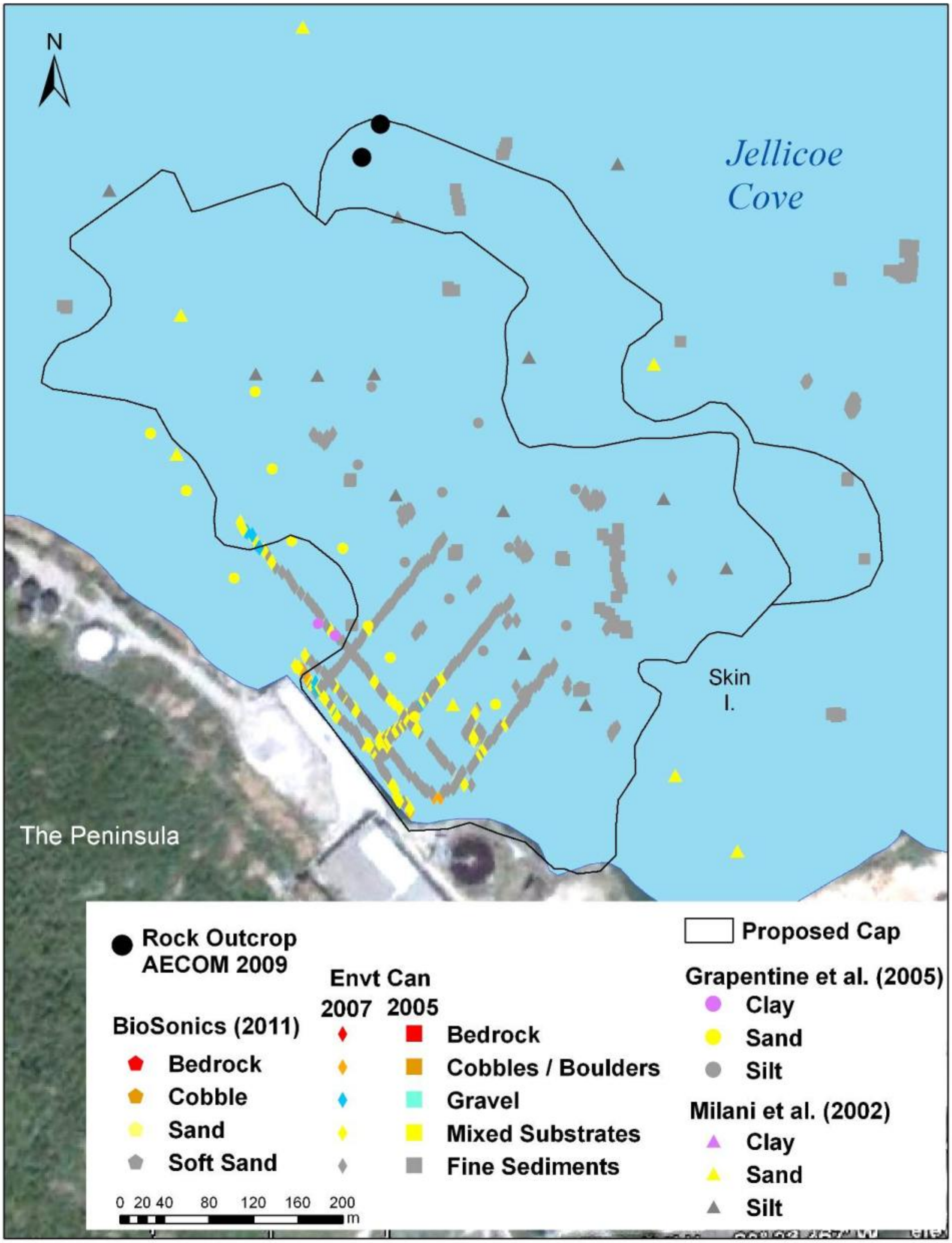


Figure 26. Detail of substrate verification points for proposed cap area in Jellicoe Cove based on underwater video review and sediment grabs.

3.1.2.2 Peninsula Harbour

Most of the substrate sampling in the Peninsula Harbour AOC has concentrated on the contaminated sediments in Jellicoe Harbour, and apart from the 2010 BioSonics survey there has been limited effort elsewhere. Appendix 2 shows representative video images from various locations in Peninsula Harbour. Of the 621 ha covered by BioSonics' hydroacoustic survey, approximately 58% was classified as sand, 10% as soft sand, and 30% as cobble. Bedrock accounted for only 1.3% of the classified area, but the hydroacoustic survey could not be reliably conducted in water depths less than 1 m. Bedrock shorelines are common along the northern and northeastern portions of Peninsula Harbour, in Carden Cove (Figure 27a), and around the islands, so the proportion of bedrock is likely underestimated when shallow waters are also considered. Portions of the shoreline adjacent to the mill have been armoured with large boulder / rubble material, while bedrock occurs along the west and east heads of the Jellicoe Cove (ENVIRON 2008a, b).

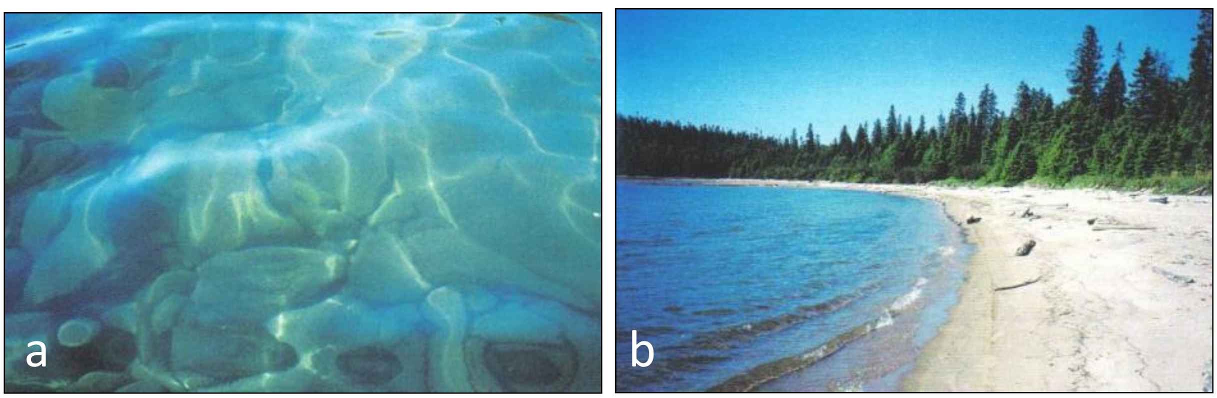


Figure 27. Bedrock and cobble in shallow water on west side of Carden Cove and sand beach at the head of the cove (Beak 2001).

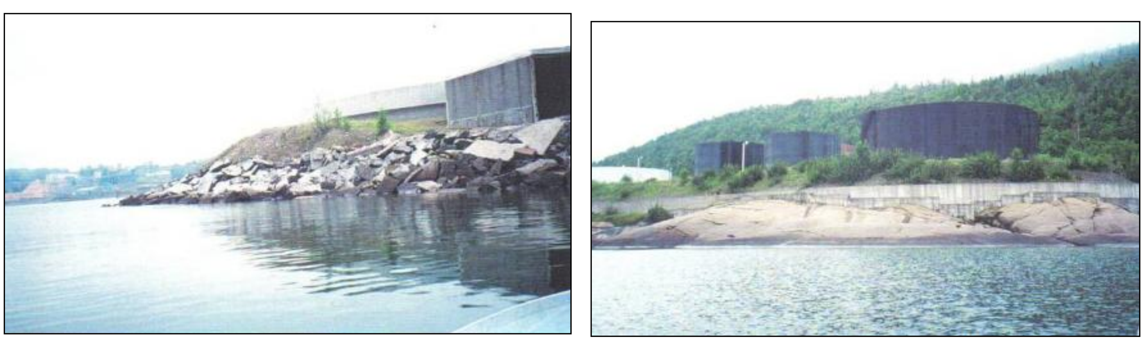


Figure 28. Heavily modified, armoured shoreline adjacent to the proposed cap area and natural bedrock shoreline further west in Jellicoe Cove Beak (2001)

Video interpretation suggests that boulder and cobble are largely restricted to shorelines and a few shoals, and that the proportion of cobble is overestimated. What limited video and ponar grab data there are, indicates that soft sediments is present in many of the deepwater areas that were classified as cobble (Figure 29, Figure 30). It may be possible that there is boulder or cobble, or hardpan clay underlying the silt that could not be identified from the video but was identified by acoustically. In most video, the metal post attached to the submersible camera in Environment Canada videos can be shown penetrating soft sediment. In some cases, it appears to stop fairly abruptly after penetrating a short distance into the sediment; it is not known if this is because the underlying substrate is firm or the camera cable became taut.

Carden Cove and Beatty Cove are the two other sheltered embayments in Peninsula Harbour that were used for log booming. Carden Cove is more protected, smaller (approximately 57 ha vs. 82 ha), and shallower, with most of the cove less than 5 m deep. More than half of Beatty Cove is deeper than 5 m, with a maximum over 20 m depending on how it is defined (Figure 2, Figure 31). Habitat mapping for Carden Cove was conducted by Beak (2001) using visual assessment in conjunction with fisheries assessment (Figure 32). Substrate in the cove was primarily fine sand with a band of clay running east-west across the middle of the bay (Beak 2000). A sandy beach if found at the head of the cove (Figure 27b). Patches of detritus are scattered in shallow water, and are presumably bark from past booming operations (see 3.3 Woody Debris). The very limited video and ponar grabs (Figure 26, Figure 40) conducted in Beatty Cove indicate that silty substrates predominate in deeper waters in the centre of the cove, with some logs present.

Figure 29. Silty sand in middle of Peninsula Harbour 280 m southeast of Blondin Island in 24 m of water classified as cobble in BioSonics (2011). Depression in sediment at arrow made from previous insertion of angle iron support.

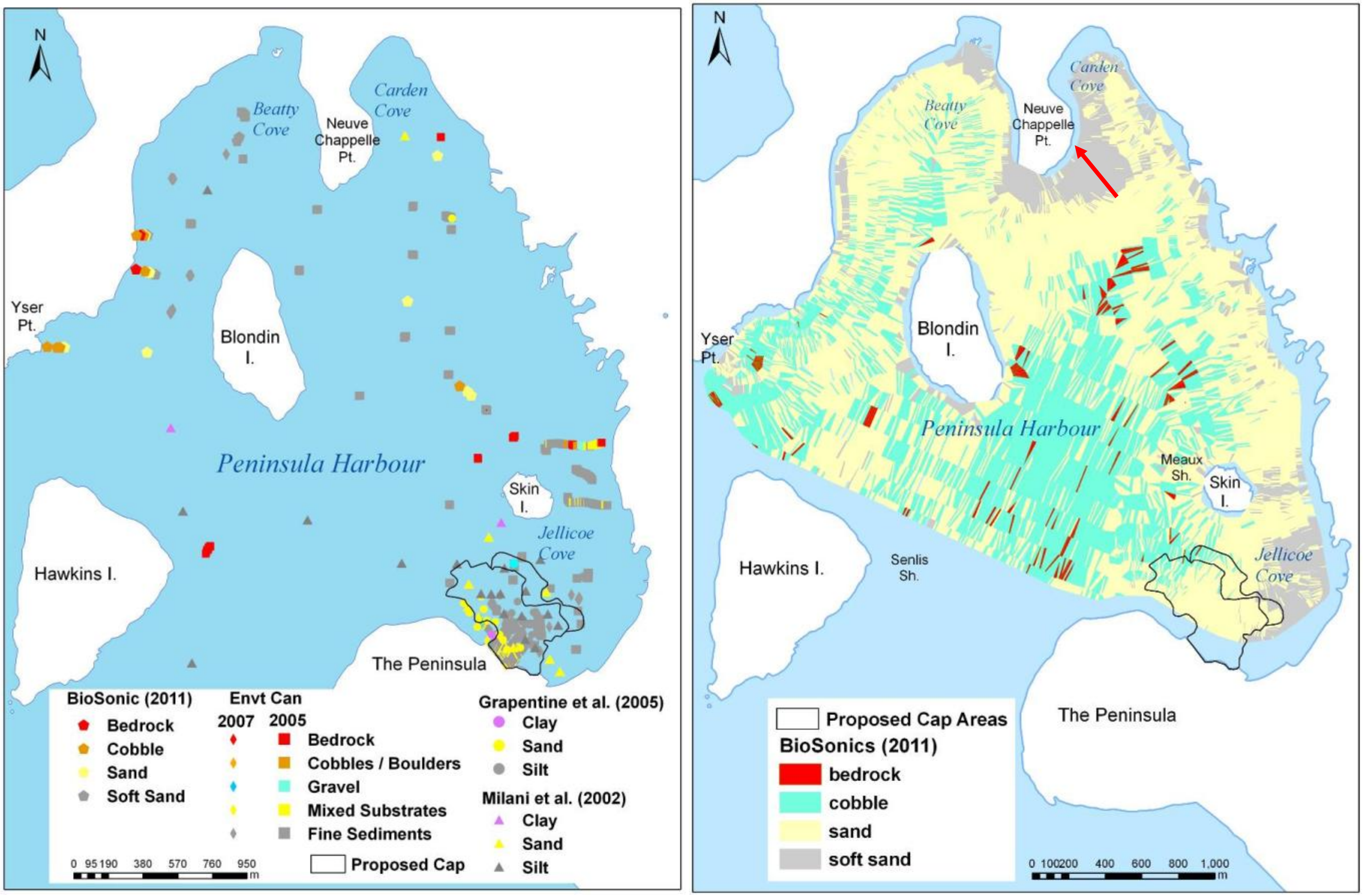


Figure 30. Substrate verification points in Peninsula Harbour based on underwater video review and sediment grabs (left) compared to substrate classification based on hydroacoustic survey (right). Arrow in Carden Cove of map on right indicates location of photo in Figure 27a.

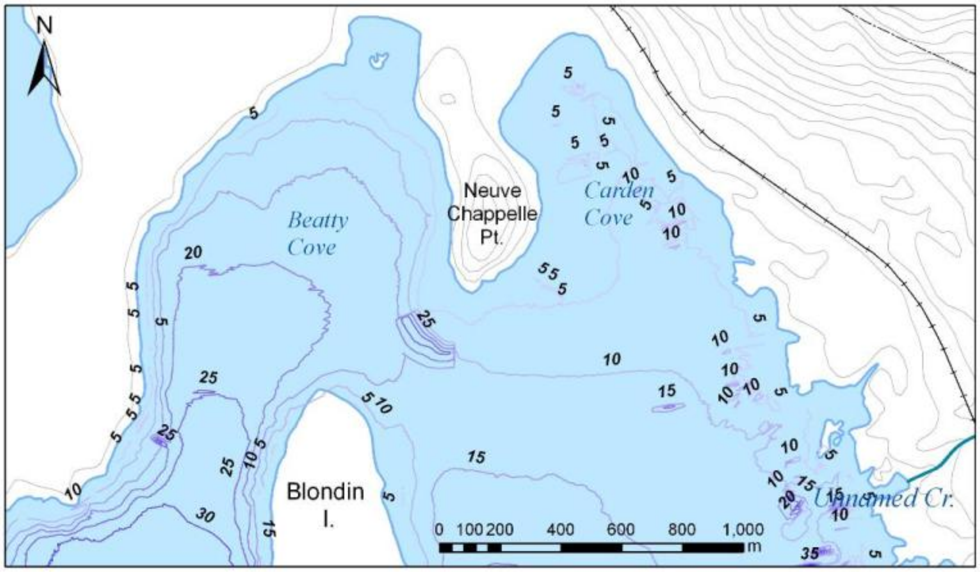


Figure 31. Bathymetry of Beatty and Carden coves based on data from BioSonics (2011) hydroacoustic survey.

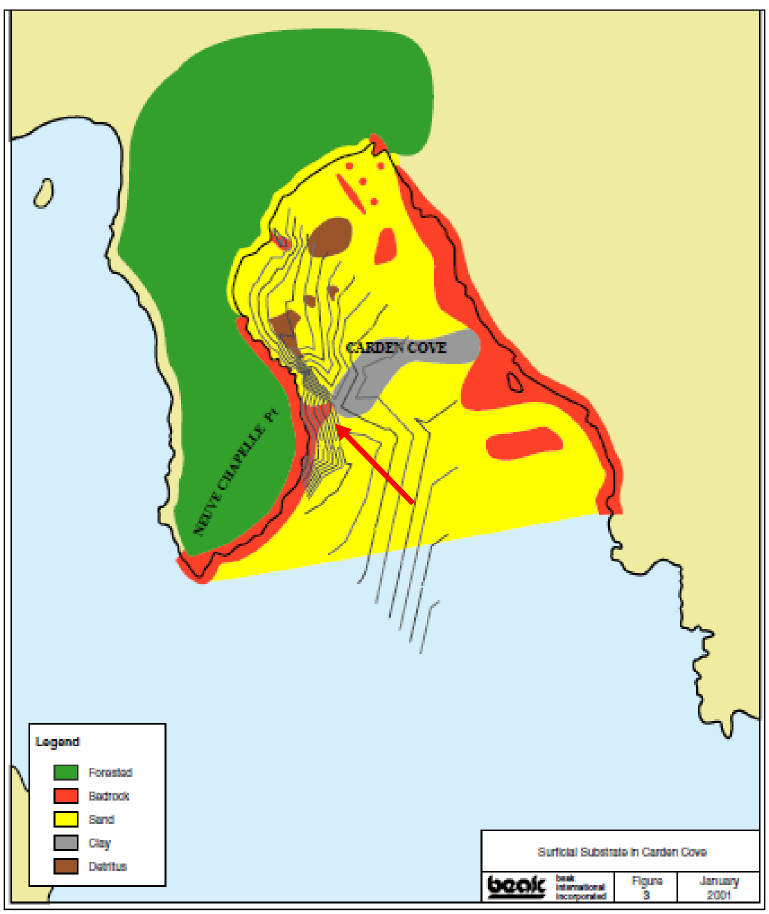


Figure 32. Substrate mapping of Carden Cove based on visual assessment (Beak 2001). Arrow indicates location of photo in Figure 27a.

3.2 Aquatic Vegetation

According to Beak (2001), aquatic macrophytes were fairly common in 2000; observed varieties included pondweed, waterweed (*Elodea* sp.) and stonewort (*Chara* spp.) Approximately 5 ha of aquatic macrophytes were mapped by Beak along the southeast shore of Jellicoe Cove in 2000 (Figure 13) of which approximately only 0.5 ha overlapped the proposed cap area. Underwater video transects in 2005 and 2007 showed a much more extensive distribution of aquatic macrophytes in Jellico Cove, including approximately 10 ha of the southern portion of the proposed cap (Figure 37). The areas where submerged macrophytes were found ranged from shallow water to approximately 12 m, with the greatest density in 4-10 m of water. Density ranged from sparse to very dense beds up to 30-50 cm in height (Figure 33). Wave action may limit submergent growth in shallow water and light penetration ultimately limits macrophyte growth in deep water (it is dependent on water clarity).

Figure 33. Dense stonewort along southern edge of cap zone.

Stonewort or muskgrass (*Chara* spp.), actually a jointed, filamentous macroalgae that resembles vascular plants, was the most abundant species based on video interpretation. The *Chara globularis* Thuill. / *vulgaris* L. complex is one of the predominant macroalgae in Georgian

Bay and the North Channel, and another similar-looking charophyte, *Nitella flexilis* is found there as well (Sheath et al. 1988). *Nitella* is more common in soft waters associated with granitic bedrock and *Chara* are typically associated with harder waters (Wehr and Sheath 2003). It can be difficult to distinguish these species in the field and on the video, but both have similar value for benthic invertebrates and fish. Although less abundant, Canada smartweed (*Elodea canadensis*) and several species of pondweeds (*Potamogeton* spp.) could be also distinguished in the Environment Canada videos (Figure 34; Figure 35).

Aquatic macrophytes are not restricted to Jellicoe Cove, but their extent in Peninsula Harbour is poorly known due to limited sampling. According to Beak (2001), aquatic macrophytes are sparse in Carden Cove, although a few small patches of pondweed (*Potamogeton* spp.) occur near the middle of the bay (Beak 2001).

Figure 34. Sparse stonewort (left) and Canada waterweed (right).

Figure 35. Pondweeds (*Potamogeton* spp.) at mouth of Beatty Cove (left) and Jellicoe Cove (right).

Figure 36. Pondweed (*Potamogeton* spp.) in proposed cap area.

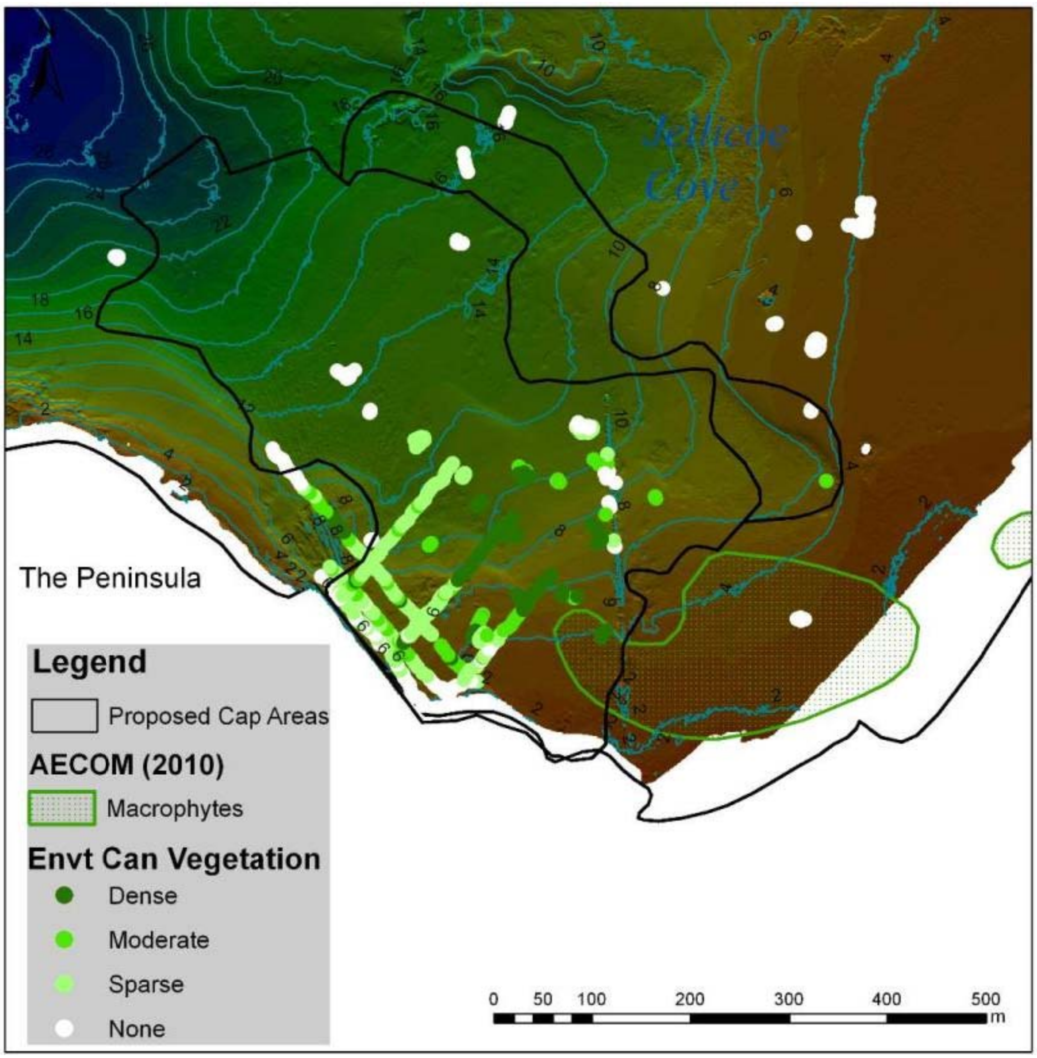


Figure 37. Distribution of submerged aquatic vegetation (macrophytes) in proposed cap area based on interpreted Environment Canada video (2005 & 2007) in relation to polygon in AECOM (2010; reproduced from Beak 2001) and bathymetry (AECOM 2009a contours; BioSonics 2010 hillshade).

3.3 Woody debris

Peninsula Harbour was used historically for building log rafts to be transported to Wisconsin (Boultbee 1967) and Buchanan Forest Products Ltd build rafts of sawlogs as recently as 1987 and 1988 (Jardine and Simpson 1990). Jellicoe, Carden, and Beatty coves were also used for log storage for over 40 years, leading to an accumulation of bark and fine woody debris that impairs water quality and aquatic biota (Peninsula Harbour RAP Team 1991). Logs were boomed in Peninsula Harbour until 1983 (Peninsula Harbour RAP Team 1991), and approximately 25,000 m^3 in Peninsula Harbour contain at least 20% bark (OMOE video commentary).

Based on video interpretation, bark and logs are abundant in Jellicoe Cove, including the proposed cap area (Figure 40). Densest concentrations observed on video were east of Skin Island, although video coverage is very unevenly distributed. Most of the logs observed in videos were relatively near the shoreline in water less than 15 m deep, reflecting booming areas). Some logs are found in much deeper water e.g., 28 m west of Blondin Island, which likely reflect logs lost from booms in transit. Single, isolated logs area present in some areas of Peninsula Harbour, but numerous logs were often observed in close proximity on video Figure 38).

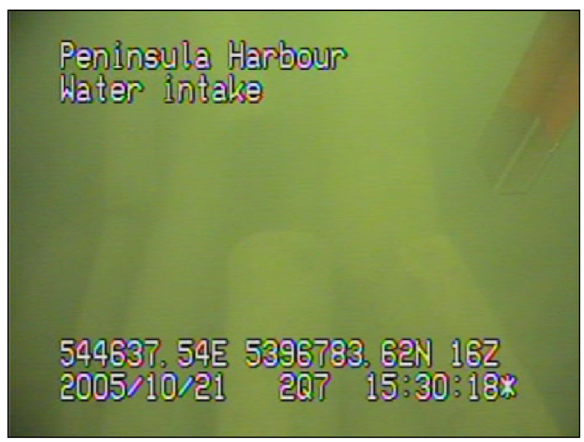


Figure 38. Coarse woody debris in north end of Beatty Cove (left) and in proposed cap (right).

Most of the logs lacking bark (Figure 38). Dense accumulations of bark are found near many of the boom logs (Figure 39), and often accumulates in shallow water in wave-scalloped grooves between ridges in sand flats off the boat launch (OMOE video). Bark debris has been misinterpreted as gravel for the Environment Canada video shapefile due to its dark colour.

Logs can provide structure that may promote establishment of aquatic vegetation and cover for benthic invertebrates and fish. However, dense accumulations of logs were not natural habitat feature in Peninsula Harbour since it lacks large tributaries that would provide a source for woody debris swept downriver.

Organic material concentration in Jellicoe Cove ranges from 1-11% and is derived from woody debris and bark (AECOM 2009b). Wood, sawdust, and fibrous material with a strong hydrocarbon odour has also been observed in sediment grabs from the cove, often overlain by a thin layer of fine sediment (AECOM 2009b). Dense bark accumulations were identified as an impairment of fish habitat in Jellicoe Cove and Peninsula Harbour (RAP 1991) since their decomposition can lead to release of organic leachates, reduced oxygen availability due to microbial decomposition of organic material, and the production of toxic compounds by microbial decomposition of wood under anaerobic conditions. Milani and Grapentine (2005) found benthic invertebrate communities in Jellicoe Cove are “different” than reference, with a trend towards greater diversity and abundance of taxa in the cove, indicative of enrichment likely due to the high organic matter present in the sediment.

Figure 39. Bark (misidentified as gravel in Environment Canada shapefile) overlying sand east of Skin Island.

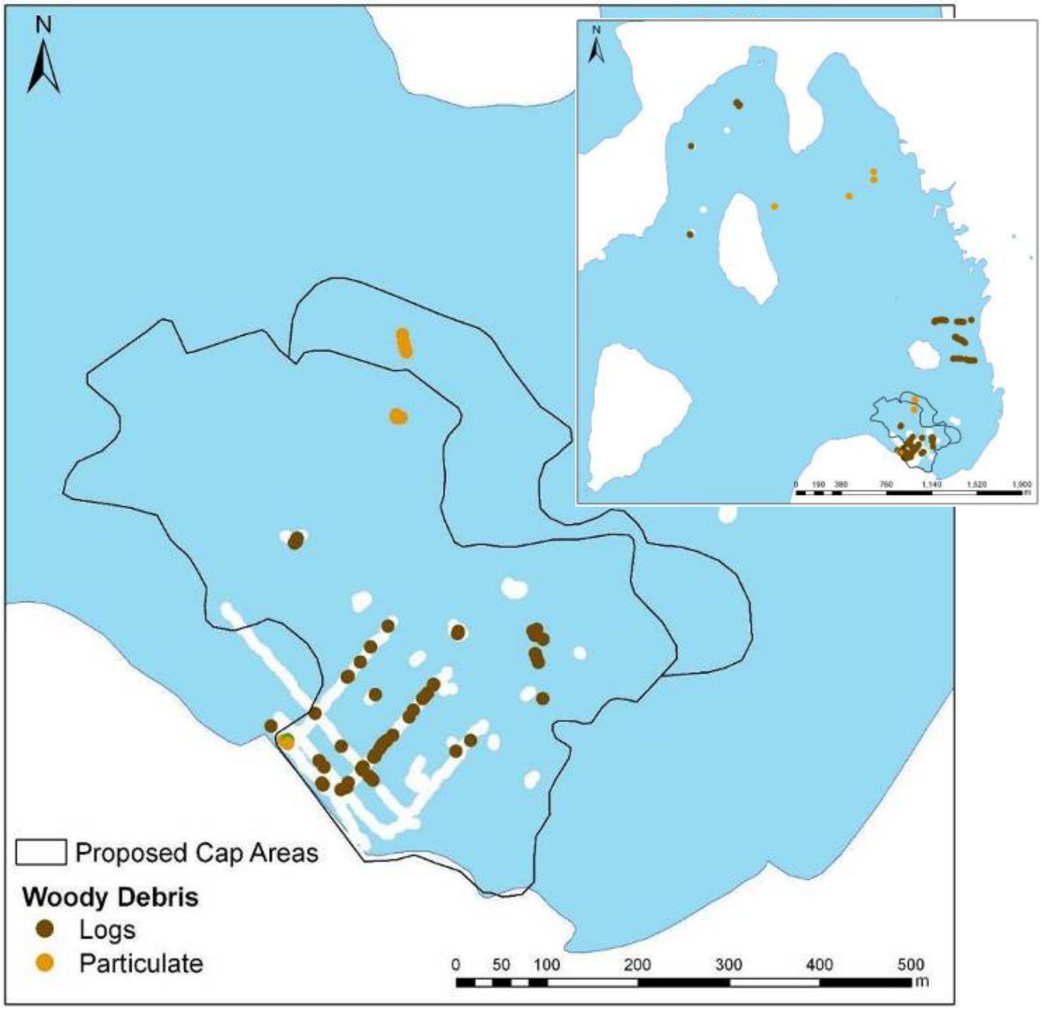


Figure 40. Woody debris identified by Environment Canada (2005, 2007) video interpretation for Jellicoe Cove and Peninsula Harbour as a whole (inset). White dots represent surveyed areas with no woody debris.

3.4 Other Environmental Parameters

3.4.1 Water Depth / Slope

Water depth in the proposed cap area increases fairly gradually from towards the northwest, reaching a maximum depth of approximately 25 m at the northwest limit of the proposed cap (Figure 41). Maximum depth in the cap area of 25 m was found in the BioSonics (2011) hydroacoustic survey as well. According to AECOM (2009b p. 26) however, the water depth in the area of the proposed cap ranges from 3-18 m; the reason for this discrepancy is unknown. Approximately 40% of the 25 ha proposed cap is in 10-16 m of water (

Table 2). Median depth in Jellicoe Cove is 12.5 m (Environmental Hydraulics Group 1993) and maximum observed depth is 28 m (Beak 2001). A summary of water depths by substrate type and vegetation is presented in Table 3. The approximate areas should be considered estimates only due to the incomplete nature of the vegetation and substrate data for the proposed cap area, and interpolation of depth classes, particular in shallow water less than 2 m.

There is a steep slope along the shore on the northern side of The Peninsula, particularly adjacent to the wharf, but much more gradual at the head of Jellico Cove. Water depths in the area of Peninsula Harbour that was surveyed by BioSonics (2010) averaged 14.3 m with a maximum of 49 m. Water depths in the protected coves were typically less than 10 m (BioSonics 2010).

The northern and eastern shorelines are very irregular with outcrops protruding into the harbour. There are three named shoals in the harbour: Meaux Shoal west of Skin Island, Senlis Shoal east of Hawkins Island and Manitoba Shoal on the outer edge of Peninsula Harbour exposed to the main Lake south of Ypres Point. All three shoals are relatively small in areal extent, approximately 1-2 ha. The total length of the Jellicoe Cove shoreline, including Skin Island, is approximately 3.3 km.

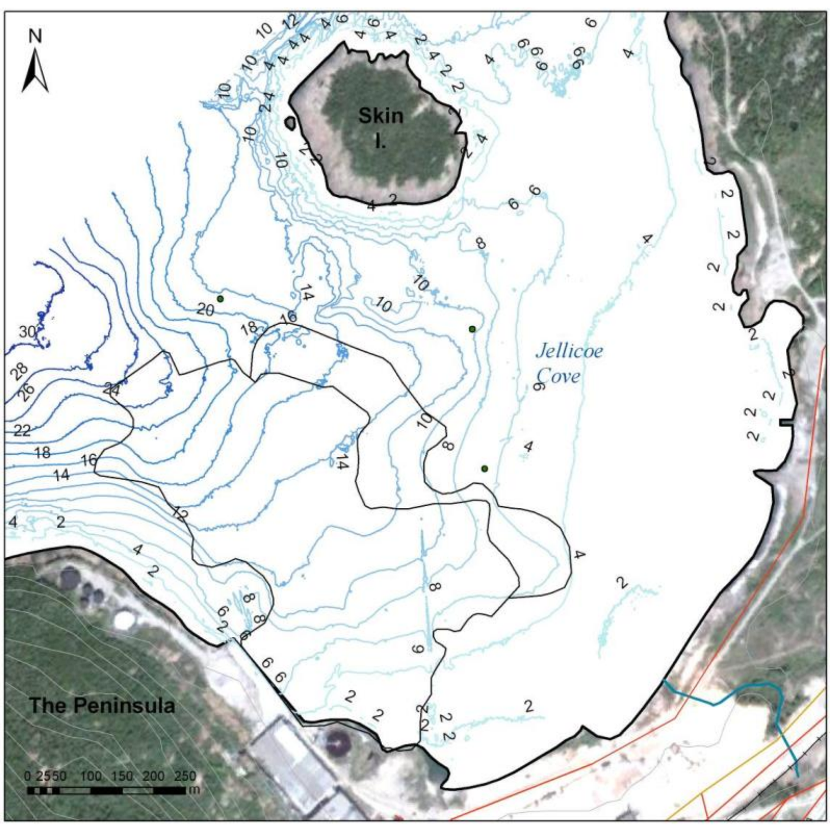


Figure 41. Proposed cap areas (black outline) overlain with bathymetry (m) (AECOM 2009a).

Table 2. Area of proposed cap within 2 m depth classes based on bathymetry (AECOM 2009a)

Depth (m)	Area (m^2)			% of Total Cap
	Main Cap	Additional Cap	Total Cap	
0-2	3,643	0	3,643	1.4
2-4	13,820	0	13,820	5.4
4-6	18,280	6,400	24,679	9.7
6-8	26,946	8,207	35,153	13.8
8-10	16,736	1,672	18,408	7.2
10-12	22,193	7,690	29,882	11.7
12-14	29,007	9,633	38,640	15.1
14-16	26,110	8,726	34,836	13.6
16-18	15,104	8,170	23,274	9.1
18-20	11,796	1,920	13,716	5.4
20-22	8,619	0	8,619	3.4
22-24	5,692	0	5,692	2.2
24-26	4,912	0	4,912	1.9
26-28		38	38	0.0
Total	**202,858**	**52,455**	**255,314**	**100.0**

Table 3. Approximate area (m^2) in various depth classes by main substrate type and submergent vegetation presence within the proposed cap area in Jellico Cove.

Depth (m)	Substrate	Vegetation	Area (m^2)
0-1	cobble	vegetated	41
0-1	gravel	vegetated	29
0-1	sand	vegetated	1,112
1-2	gravel	vegetated	37
1-2	sand	vegetated	2,424
2-5	gravel	vegetated	338
2-5	sand	vegetated	17,942
2-5	silt	bare	2,987
2-5	silt	vegetated	4,989
5-10	gravel	vegetated	1,454
5-10	sand	bare	7
5-10	sand	vegetated	12,282
5-10	silt	bare	14,703
5-10	silt	vegetated	37,358
10+	sand	bare	24,687
10+	sand	vegetated	2,324
10+	silt	bare	114,826
10+	silt	vegetated	18,646

3.4.2 Exposure / Fetch / Currents / Clarity

Peninsula Harbour is protected from the open waters of Lake Superior by The Peninsula, Hawkins Island and Ypres Point. Winds and waves from the southwest can pass unimpeded into Peninsula Harbour, but waves predominantly roll from the west and less frequently from the southwest, averaging 1.0-1.7 m during the open water season (Beak 2000). Jellicoe Cove is protected from the southeast by The Peninsula, so the predominant wave direction is from the west-northwest. There is only about 2 km of fetch from Yser Point to Jellicoe Cove, so wave height is lower, averaging 0.4 to 0.7 m (Beak 2000). Freeze-up in Peninsula Harbour generally occurs early in December, with ice break-up typically occurring in mid- to late-April, while Jellicoe Cove is reportedly ice-free during the winter (AECOM 2009). This well-protected location allows finer sediments to settle out in the deeper waters of Jellicoe Cove. Currents in the proposed capping areas average only 0.04 m/s in a west-northwest to east-southeast (Skafel 2006, 2007), which is about two orders of magnitude too low to suspend sediments in Jellico Cove (AECOM 2009; Biberhofer and Dunnet 2003).

3.4.3 Water Clarity and Quality

Secchi depth was at bottom in Carden Cove during 2000 fieldwork conducted by Beak, and over 6 m in Jellicoe Cove, indicating good water clarity and light penetration (Beak 2001). This permits aquatic macrophytes at greater water depth than is typical for more stained or turbid inland waterbodies.

A comprehensive review of water quality data for Jellicoe Cove and Peninsula Harbour was outside the scope of this study. Peninsula Harbour is oligotrophic, with dissolved oxygen ranging from approximately 10-14 mg/L, pH from 7.2 to 8.35, and conductivity 93-134 µS/cm (AECOM 2009). Water quality is Peninsula Harbour is considered relatively good, with infrequent impairment due to sediment re-suspension from storm events and propeller wash (Beak 2000). There some minor variability within the harbour associated with water depth and circulation patterns, but water quality does appear to be a limiting factor with respect to fish habitat. There are no major thermal inputs to Peninsula Harbour, and water temperatures are suitable for supporting a coldwater fish community.

3.5 Tributaries

Limited data are available for regarding habitat in the Lake Superior tributaries that flow into Peninsula Harbour. Although they would not be directly affected by the proposed capping, Shack Creek provides spawning and nursery habitat for a number of fish species that use Jellicoe Cove. Larval fish such as longnose sucker and rainbow trout disperse from Shack Creek into Peninsula Harbour, including Jellicoe Cove. Shack Creek is a permanent stream over 5 km in length with a watershed of approximately 1000 ha that includes Shack Lake (14 ha) and several other smaller waterbodies. It has a bedrock dominated mouth with some cobble and sand (Figure 42). The unnamed creek approximately 600 m north along the eastern shore of Peninsula Harbour is approximately 1 km in length and has a much smaller watershed (approximately 1000 m). Although it did not have sufficient flow to electrofish in 2000, in some years it may provide fish habitat, at least during higher spring flows.

Figure 42. Mouth of Shack Creek looking southeast towards Jellicoe Cove.

4 Fish Habitat

The 1991 RAP report (Peninsula Harbour RAP Team 1991) states that the dynamics of fish populations in the AOC are impaired because "fish habitat has been reduced due mostly to the organic (wood debris) contamination of Jellicoe and Beatty Coves, which were lake trout spawning grounds prior to 1955 (Goodier)."

The very sparse and imprecise information available for historical fish habitat prior to industrial development in Peninsula Harbour limits our ability to compare current fish habitat in Peninsula Harbour to historical use. In addition, the suite of fish species using Peninsula Harbour is different than in the past, due to changes in the Lake Superior fish community from reduced abundance of native species as a result of overharvest, habitat loss, and the introduction of non-native fish such as sea lamprey, rainbow trout, rainbow smelt, threespine stickleback, alewife, and salmon species. Lake trout is given particular emphasis because there were historical spawning records for the area, it is a top predator and the focus of a binational restoration plan (Hansen 1996), and has significant socio-economic value.

4.1 Lake Trout

4.1.1 Beatty Cove Spawning Habitat

Historical (pre-1955) lake trout spawning habitat along the north shore of Peninsula Harbour west of Beatty Cove (Figure 4) that were mapped as "significant" by Goodier(1981) appears to be relatively unimpacted. The limited video available for that area indicates that clean cobble exists out to a depth of at least 14 m along portions of this shoreline (Appendix 2, photos 56, 60), which is consistent with preferred spawning habitat for lake trout (Table 4). The exposed aspect and deeper waters adjacent suggests there is more wave energy here compared to Jellicoe Cove, which would help keep the cobble freer of silt and fine sediments that would reduce suitability as spawning substrate for lake trout and other fish. Whether there are lake trout actually using this habitat is unknown as there has been no assessment in this area. In deeper waters of Beatty Cove, the limited video data available and single ponar grab indicates that silty sediments predominate in deeper water, and at least some woody debris is present (Figure 38, Figure 40). Therefore, although there may some impairment of fish habitat in the deeper waters or farther back in Beatty Cove from logs or bark of past booming activities, impacts to potential lake trout spawning habitat along the shoreline may be minor. Habitat surveys along the western shoreline of Beatty Cove are lacking however.

Table 4. Habitat requirements for fish species confirmed from Peninsula Harbour (taxonomic order).[1]

Common Name	General / Foraging	Spawning	Nursery
Alewife	cool, open, waters (16-28 m) near thermocline to a depth of 50 m (summer) or 90 m (winter); near thermal plant outfall in winter	shallow water of nearshore areas over sand and gravel	same as nursery for summer before moving to deeper water
Emerald Shiner	pools and runs of medium to large rivers with sand or gravel substrates and cool, clear open waters of lakes; preferred water temperature range 9-23°C; often near river mouths	open water over gravel shoals or over sand in streams	0-5 m with moderate affinity for submergents and emergents on a variety of substrates but also captured in open water
Lake Chub	open waters of lakes, lake margins and gravel-bottomed pools and runs of creeks and rivers; moves to deeper, cold, pelagic waters in the summer	tributary streams over sand, gravel, or rocks	usually over gravel, sand or rocks in 0-2 m
Longnose Dace	cobble, boulder or gravel riffles of clean, cool, swiftly-flowing creeks and small to medium rivers, and occasionally along rocky shores of lakes; preferred water temperature range 13-21°C	riffles over gravel	initially pelagic then benthic in 0-2 m water over rubble to silt with low affinity for submergents
Spottail Shiner	usually in open, clear cold or cool waters of large lakes and rivers; less frequently in tributary streams with slow to moderate current and sand or gravel substrates; preferred water temperature range 13-22°C	sandy shoals or lower reaches of tributaries	in shallow to deep (>5 m) with high affinity for submergents over gravel, sand, and silt
Longnose Sucker	clear, cold, deep water (up to 55 m) of lakes and tributary streams; occasionally brackish water; preferred water temperature range 8-17°C	swift-flowing tributaries	young move downstream to lakes in early summer;
White Sucker	pools and riffles of creeks and rivers, warm shallow lakes and embayments of larger lakes usually at depths of 6-9 m; preferred water temperature range 22-26°C	swift-flowing tributaries with gravel or cobble or windswept rocky lakeshores	variety of habitats, especially 0-5 m with submergents on sand and silt, but sometimes coarse substrates
Northern Pike	clear, cool to warm, weedy bays of lakes and slow, meandering, heavily vegetated rivers; preferred water temperature range 17-21°C	shallow, heavily vegetated floodplains or shallows of lakes and rivers	warm, shallow, heavily vegetated bays or rivers with slow current
Rainbow Smelt	cool, clear, mid-waters (14-64 m) of lakes and medium to large rivers; preferred water temperature range 7-16°C	tributaries	upon hatching , larvae drift downstream to lake; often over sand beaches at night
Brook Trout	cold, clear, well-oxygenated streams, rivers, ponds and lakes with maximum water temperature less than 22°C; preferred water temperature range 13-17°C	clean gravel and cobble in tributary streams	tributary streams and nearshore areas, particularly near tributary mouths in 0-5 m with rubble, gravel or sand, and sometimes finer sediments
Chinook Salmon	mid-waters (15-60 m) in or below the thermocline; preferred water temperature range 12-16°C	clean gravel and cobble in tributary streams	tributary streams and nearshore areas, particularly near tributary mouths in 0-5 m with gravel or sand
Cisco (Lake Herring)	open, mid-waters (13-53 m) of lakes and large rivers, below the thermocline; preferred water temperature range 7-10°C	variable; gravel and rocky bottoms, sometimes vegetation, up to 64 m depth in the Great Lakes	0-2 m in spring moving to deeper water in fall, usually over sand or coarser substrates, and with low affinity for submergents.
Coho Salmon	mid-waters (16-60 m); preferred water temperature range 11-17°C	clean gravel and cobble in tributary streams	tributary streams and nearshore areas, particularly near tributary mouths in 0-2 m in spring moving to deeper water in fall; use logs jams for cover, usually on boulder or sandy substrates

Common Name	General / Foraging	Spawning	Nursery
Lake Trout	cold deeper waters (12-18m) of lakes, below the thermocline in summer; preferred water temperature range 9-13°C	clean cobble or rocky areas, often at depths of 10 m or more	cool, open and inshore waters with rocky shorelines
Lake Whitefish	cool waters (18-37 m) of lakes and large rivers, below the thermocline; preferred water temperature range 8-14°C	usually over gravel, cobble or rocks, bottom, typically in less than 8 m of water or in tributary streams or rocky shorelines	over rubble, gravel and sand in 0-2 m of water in spring/summer and moving to deeper waters in fall
Round Whitefish	shallow waters (<37 m) of deep lakes and clear streams; preferred water temperature 17.5°C	over gravel in the shallow water of lakes and streams	cool, open and inshore waters over gravel and sand; in 1-5 m in spring moving to deeper waters as they mature but also caught at surface over deep water
Pink Salmon	mid-waters (6-36 m); preferred water temperature range 13-17°C	clean gravel and cobble in tributary streams	tributary streams and nearshore areas, particularly near tributary mouths
Rainbow Trout	mid-waters of lakes; creeks and rivers with moderate flow, gravelly bottoms and riffle-pool habitat; preferred water temperature range 12-18°C	clean gravel and cobble in tributary streams	tributary streams and nearshore areas, particularly near tributary mouths
Burbot	moderate to deep waters (to 90 m) of lakes, large cool rivers and streams, often under rocks, among roots or in holes in the banks; preferred water temperature range 7-18°C	shallow bays over sand or on gravel shoals	over rubble, gravel and sand in 0-5 m water in spring moving to deeper waters in fall
Sticklebacks	shallow vegetated nearshore of lakes, ponds, pools of sluggish streams, and marine/estuarine environments; preferred water temperature range 9-16°C	nest made out of vegetation	over rubble, gravel and sand in 0-2 m water in spring moving to deeper waters in fall; moderate affinity for submergents
Threespine Stickleback	shallow vegetated areas of creeks and rivers, protected bays of lakes with mud or sand bottom, and coastal marine/estuarine environments; preferred water temperature range 9-12°C; can be pelagic	nest made out of vegetation	over gravel in 0-2 m water in spring moving to deeper waters in fall
Mottled Sculpin	cobble and gravel riffles of cool creeks, small rivers and rocky shores of lakes (<16 m deep); preferred water temperature range 13-18°C	underside of rocks or ledge	in range of water depths using rocks and logs for cover; on coarse substrates and less often on gravel or sand
Slimy Sculpin	gravelly, rocky riffles of cold streams and rocky substrates in deep (37-108 m), cooler waters of lakes; preferred water temperature range 9-14°C	underside of rocks or ledge	in range of water depths using rocks and logs for cover; on coarse substrates and less often on gravel or sand
Johnny Darter	sandy, silty, gravelly, sometimes rocky, pools of creeks and small to medium rivers, and sandy shores of lakes; preferred water temperature 22.8°C; reported to a depth of 42 m in the Great Lakes	rocky, shallow water	on gravel, sand, and silt in 1-5 m of water with a moderate affinity for submergents
Walleye	lakes (at depths up to 21 m), and pools, backwaters and runs of medium to large rivers; preferred water temperature range 19-23°C	clean gravel and cobble in tributary streams, shoals, or windswept shorelines	over gravel and sand in 0-5 m of water in spring moving to deeper water in fall, with a low affinity for submergents
Yellow Perch	lakes, ponds and pools of creeks and small to large rivers with moderate aquatic vegetation and clear water, usually at depths <9 m; preferred water temperature range 18-24°C	over vegetation or logs in lakes and streams, or sand and gravel if vegetation lacking.	over gravel, sand, and silt in 0-5 m of water in spring moving to deeper water in fall, with a moderate affinity for submergents

[1] based on Armstrong et al. (1996), Eakins (2011), Hartviksen and Momot (1987), Holm et al. (2009); Hubbs et al. (2004), Lane et al. (1996); Marsden et al. (1995); Lane et al. (1996a,b,c), Scott and Crossman (1998), Smith (2010), Stewart and Watkinson (2004), and references therein.

4.1.2 Jellicoe Cove Spawning Habitat

If historical reports are accurate, former lake trout spawning habitat in Jellicoe Cove mapped by Goodier (1981) are impaired. Unfortunately, the long history of shoreline and nearshore modification for industrial purposes obscures the historical condition of this area. The bedrock and rocky shoreline farther west in Jellicoe Cove (Figure 28) suggest that the shoreline and nearshore area adjacent to the proposed cap was originally rocky, perhaps grading to cobble, gravel, and sand substrates towards the more protected head of Jellicoe Cove where deposition would be expected to occur. Any natural spawning habitat has been eradicated where the wharf is now located, and coarse rip rap covers the remaining shoreline in the vicinity of the proposed cap and on either side of the wharf (Figure 28).

Video evidence indicates there are only small pockets of natural cobble or gravel remaining in shallow water along edge of the proposed cap, together with some rip rap (Figure 24). Consequently, there appears to be very little suitable potential cobble/gravel spawning habitat for lake trout in the nearshore cap area, apparently less than 1000-2000 m^2 , which is represents less than 1% of the proposed cap area (approximately 25 ha). Some may exist further west in Jellicoe Cove along more natural shoreline but there was no underwater video or sampling data, or fisheries assessment available further west, nor were any mapped there by Goodier (1981). A “debris/irregular area” polygon was mapped by AECOM along the shoreline west of the wharf (Figure 17) but the basis for this description is unclear.

Apart from the immediate nearshore zone mentioned above, the remainder of the proposed cap area and the adjacent areas of Jellicoe cover that were mapped as historic lake trout spawning grounds are predominantly silts, sands or a mixture. The area mapped as cobble along the southern portion of the cap by Beak/AECOM (Figure 13, Figure 14) appears to be erroneous. Based on the reviewed evidence, the proposed cap area is therefore not suitable spawning habitat for lake trout based on substrate type and the abundant submerged aquatic vegetation. Coring of subsurface sediments within the proposed cap and low sedimentation rates (1-2 mm annually) measured for Jellicoe Cove (Biberhofer and Dunnett 2003; AECOM 2009a) do not indicate that there is cobble that has been buried by fine surficial sediments or woody debris, either naturally or from anthropogenic activities. This suggests that if lake trout did spawn in Jellico Cove, they either did shoreline (potentially cobble) that is now covered by riprap or the wharf. Although less likely, they may have spawned over coarser sands and gravels in the shallower waters of the cove if there was enough wave energy to prevent deposition of silts and finer sediments that would otherwise reduce the suitability of the substrate for lake trout spawning (silty sediments can suffocate lake trout eggs).

4.1.3 Other Lake Trout Habitat

Video reviews confirm there is clean cobble in suitable water depth along Yser Point (as mapped by Goodier 1981) that is potentially suitable lake trout spawning habitat. There may be potentially suitable habitat along the rocky shoreline on windswept mainland, islands, and shoals as well, although data are lacking.

Jellicoe Cove and other areas of Peninsula Harbour provide foraging habitat for juvenile and adult lake trout. Five adult lake trout were gill-netted in the deep (>14 m), unvegetated area of the proposed cap by Beak (J1 & J4, Figure 8). The proposed cap area may provide nursery habitat for YOY lake trout, although none were caught in the limited fisheries assessments conducted to date. YOY lake trout reside in shallow water for several weeks after emergence and gradually move to deeper water as the season progresses (Bronte et al. 1995; Peck 1981). For the first few years, Lake Superior lake trout typically feed on invertebrates such as *Mysis* that are found over sandy substrates in deep water (Anderson and Smith 1971; Carpenter et al. 1974). Lake trout YOY are not typically found in heavily vegetated habitat however, so the 10 ha vegetated portion of the cap may not be very suitable nursery habitat particularly due to predation risk from large pike.

Local anglers have noted appreciable numbers of naturally-occurring lake trout in addition to stocked fish (in 1999 and 2000, lake trout were stocked in Jellicoe Cove at the mill dock), indicating successful natural recruitment outside Peninsula Harbour occurs (Peninsula Harbour RAP Team 1999). Angling success in nearshore areas suggests the presence of suitable foraging habitat for lake trout within Peninsula Harbour (Beak 2000).

4.2 Other Species

4.2.1 Spawning Habitat

The proposed cap area and Jellicoe Cove may have provided spawning habitat for some species based on known habitat preferences for fish species reported for Peninsula Harbour, and likely continues to do so. The presence of fish eggs on underwater videos from the proposed cap confirms that some spawning does occur in or near the cap. However, the significance of a few eggs on the video is unclear for a number of reasons including:

- It is unknown if the eggs were deposited in situ or were swept in from outside the proposed cap area. Typically, lake trout spawn on cobble and the eggs settle into the interstitial spaces; in contrast, yellow perch eggs are adhesive to vegetation. It is unlike the eggs were either of these two species.
- It is not known if the eggs are viable or if they hatched. They appear fairly translucent in the video and dead eggs are usually more opaque.

- The species of fish cannot be determined from the images of the egg on the video, nor from the YOY observed on the video (potentially the same species).
- Only a few (<5) eggs were apparent on the video, yet a single fish can produce thousands or hundreds of thousands of eggs depending on the species. For example, a single yellow perch egg mass contains on average 23,000 eggs (Scott and Crossman 1998).

YOY perch were found by Beak (2001) approximately 400 m east of the proposed cap in the small embayment at the boat launch on the eastern shore (Figure 8). In small lakes, yellow perch typically spawn in shallow water near rooted vegetation or coarse woody debris, but also sometimes over sand or gravel (Scott and Crossman 1998). Their semi-buoyant gelatinous egg skeins undulate with water movement and adhere to submerged vegetation or, less commonly, the bottom. The stonewort, Canada waterweed, pondweeds and other aquatic vegetation in the proposed cap may be a suitable substrate, but spawning has not been confirmed there. Less is known about yellow perch spawning behaviour in the Great Lakes, but they spawn over cobble and mixed substrates along waveswept Lake Michigan shorelines where aquatic macrophytes and woody debris are absent (Robillard and Marsden 2001).

Sticklebacks also use vegetation for spawning and the areas of bare sand within the cap could potentially serve as spawning habitat for some species such as cyprinids.

The pockets of gravel, cobble and rip rap near the shoreline may be suitable spawning habitat for species that prefer coarser substrates such as sculpins, Johnny darter, round whitefish, lake whitefish, or lake herring. Lake herring spawning grounds mapped by Goodier (1982) are too vague to determine exact location in Peninsula Harbour, and is unknown if they spawned in Jellicoe Cove and/or the proposed cap area.

Although adult northern pike have been observed in Jellicoe Cove, no suitable spawning habitat appears to be present in Peninsula Harbour due to the lack of emergent marshes or tributary streams with suitable wetlands.

4.2.2 Nursery Habitat

The proposed cap area likely provides nursery habitat for both species that have spawned in Jellicoe Cove as well as YOY that have dispersed from spawning grounds elsewhere. Species that likely spawn in Shack Creek but whose YOY or juveniles have been found in nearshore waters of the proposed cap area include at least 5 species including: rainbow trout, coho salmon, pink salmon, white sucker, and longnose sucker. The cap area also provides nursery habitat for at least round whitefish, yellow perch, burbot, cisco, lake chub, mottled sculpin, and slimy sculpin, which likely spawned in the proposed cap or elsewhere in Jellicoe Cove or Peninsula Harbour.

Most of these species were found in shallow waters (<2 m deep) which is not surprising since the YOY of most fish species in the Great Lakes occur in water depths of 2 m or less (Lane et al. 1993). Most YOY were found only along some sections of shoreline in Peninsula Harbour, but this is likely a function of sampling effort, rather than actual distribution. Larval fish likely disperse along most of the Jellicoe Cove shoreline and into deeper water of the proposed cap (>98% of the cap is greater than 2 m deep; Table 2). Deeper waters of Jellicoe Cove, and the proposed cap area, provide nursery habitat with abundant vegetation and logs to provide cover. Most sampled areas of the shoreline had little or no aquatic macrophytes.

Nursery habitat for many of these species has also been confirmed in Carden Cove or elsewhere in Peninsula Harbour. Larval fish were observed immediately to the west of the proposed cap and west of Skin Island in relatively deep water with no macrophytes. The limited data available for Peninsula Harbour, suggests that aquatic macrophytes although present outside Jellicoe Cove, may be less abundant. The deep, clear waters of Lake Superior are oligotrophic, and shallow protected bays such as Peninsula Harbour are typically more productive and support greater development of aquatic macrophytes. These macrophytes provide cover for adult and young fish, as well as their invertebrate prey that feed on macrophytes and attached algae. No YOY northern pike were found during sampling in Peninsula Harbour, which is not surprising since no suitable spawning habitat for this species appears to be present. Adult fish likely moved in from adjacent areas of Lake Superior.

4.2.3 Forage / Cover Habitat

Jellicoe Cove and the proposed cap area provide cover and habitat for adult fish whose YOY and juveniles have used Jellicoe Cove such as round whitefish. Jellicoe Cove may also provide habitat for adult fish that spawned and spent early life stages elsewhere in Peninsula Harbour or Lake Superior, such as lake trout (discussed earlier) and northern pike. Adult alewives have also been caught in Jellicoe Cove, but no younger life stages. There is no suitable spawning habitat for Threatened lake sturgeon in Peninsula harbour (they typically spawn over coarse substrates in rapids of large rivers) and no juvenile sturgeon were caught during sampling. However, they are known to spawn in the Pic River and adult sturgeon have been recorded making long distance trips in Lake Superior so it is conceivable that adults could potentially forage in Peninsula Harbour and the proposed cap area, if only sporadically.

Jellicoe Cove could potentially provide good cover for adult fish of many species due to the abundant aquatic macrophytes and logs, at least in the eastern portion of the proposed cap. The limited data available suggests that suitable foraging and cover habitat is likely widespread Peninsula Harbour however. The proposed cap would cover only 25 ha, or about ¼ of Jellicoe

Cove and only 2.5% of Peninsula Harbour. Elsewhere in Jellico Cove and Peninsula Harbour, rocky areas, logs, and at least some submergents (systematic data are lacking) provide cover for foraging and overwintering fish.

In addition, the heavily contaminated sediments of the proposed cap area are not ideal foraging habitat for fish due to mercury and PCB contamination. The benthic invertebrate community in Jellicoe Cove and Peninsula Harbour are dominated by midge larvae (Chironomidae), oligochaete worms (Tubificidae and Naididae), fingernail clams (Sphaeriidae), isopods (Asellidae), and snails (Valvatidae), with other taxa such as amphipods and oligochaetes, comprising less than 10% (Milani et al. 2002). Benthic invertebrates (midges and amphipods) from Jellicoe Cove have significantly elevated concentrations of bioavailable mercury due to exposure to contaminated sediments (Grapentine *et al.* 2005). Existing mercury concentrations have the potential to negatively impact reproductive activities of sportfish and bottom fish throughout Peninsula Harbour and there is the potential for population level effects from mercury and PCB levels on longnose suckers, the most abundant large benthivore (Sommerfreund et al. 2005).

Similar effects could potentially impact long-lived lake sturgeon if they foraged regularly in the contaminated sediments of Jellicoe Cove. As a benthivore like longnose sucker, lake sturgeon are often exposed to high contaminant loads (COSEWIC 2006b), and exposed individuals can have lower retinoids compared to sturgeon in unimpaired systems (Ndayibagira et al. 1995). Elsewhere in the Great Lakes (e.g., Lake St. Clair), tissue levels of mercury and PCBs in lake sturgeon tissue have been enough to lead to fishery closures (Baldwin et al. 1978; Hart 1987). There is no evidence however that lake sturgeon use Peninsula Harbour despite their presence in the nearby Pic River.

4.2.4 Overwintering Habitat

Depending on the species, fish could use the proposed cap area and Jellicoe Cove in egg, larval, or adult stages. Seasonal movements are known for many species such as YOY coho salmon, Chinook salmon, rainbow trout, and lake trout which use waters less than 2 m deep in the spring but move into deeper water in the fall (Lane et al. 1996b). In Lake Michigan, yellow perch move into nearshore areas <15 m deep in the spring and early summer, but move deeper in the fall, presumably following warmer water (Schaefer 1977; Wells 1968). Conversely some adult salmonids e.g., lake trout and coho salmon, will avoid warmer shallow waters less than 5 m deep during summer months but will use these areas in the winter when the water is isothermal (Lane et al. 1996a).

4.3 Assessment of Significance of Fish Habitat

Expected degree of use for the proposed cap area for spawning, nursery, and adult fish species confirmed from Peninsula Harbour is presented in Table 5. Fish habitat use is broken down by water depth, substrate type, and presence of submerged aquatic vegetation (there are no emergents) to be consistent with classes used by Fisheries and Oceans Canada (DFO) Habitat Alteration Assessment Tool (HAAT). Shallow water classes (0-1 m and 1-2 m) were pooled due to the lack of detailed bathymetric data in very shallow water. This table also provides a breakdown of area (m^2) derived from GIS for each habitat combination (e.g., vegetated silt in 5-10 m of water) present within the proposed cap area. Since there are limited field data for the proposed cap area, expected habitat use was largely derived from habitat preferences derived from the literature (e.g., Lane et al. 1996a,b,c; Table 5) while taking into consideration habitat features assessed in the current review.

The most abundant fish species in Jellicoe Cove, based on the limited sampling to date, are longnose sucker and round whitefish. The proposed cap area provides no spawning habitat for longnose suckers, since they likely spawned in Shack Creek and less than 2% (3600 m^2) of the cap is shallow water (<2 m). However, the proposed cap does provide suitable habitat for adult longnose suckers, which prefer to forage over sand and silt, often in the presence of submergents and logs in waters greater than 2 m deep. Seven adult longnose suckers were gill-netted by Beak (2001) in the proposed cap area. Data are lacking (no sampling for YOY fish was done in the proposed cap area), but YOY longnose suckers could potentially forage in the cap as well. Round whitefish prefer to spawn rubble and gravel so the cap provides little or no spawning habitat due to the lack of coarse substrate, but it provides nursery and adult foraging habitat in deeper water over bare or partially vegetated sand or silt.

Yellow perch are typically strongly associated with vegetation for spawning, nursery, and adult stages and the proposed cap may provide habitat for all life stages of yellow perch. However, actual use of the proposed cap by yellow perch has not been confirmed; no adult yellow perch were gill-netted (1.5-5" mesh) in Jellicoe Cove and only 3 YOY were seined from the small bay (JS1) to the east of the proposed cap. The proposed cap potentially provides considerable habitat for other species that use soft sediments (sand or silt) in moderate to deep water, particularly those with an affinity for submergents (e.g., emerald shiner, spottail shiner, sticklebacks), although there are also abundant bare sediments preferred by lake whitefish or cisco.

The cap provides little spawning or nursery habitat for trout or salmon that prefer shallow water areas with coarse substrates (most spawn in Shack Creek), and vegetation in deeper waters likely reduces its suitability for adults as well due to predation risk from northern pike.

Table 5. Expected degree of use (L=low; M=moderate; H=high) for spawning (S), nursery (N), and adults (A) of the proposed cap area based on water depth, submerged aquatic vegetation (SAV) presence, and substrate for fish species confirmed from Peninsula Harbour.

Depth Class (m)	**0-2**			**2-5**				**5-10**					**10+**			
SAV	**Y**			**N**	**Y**			**N**		**Y**			**N**		**Y**	
Substrate	**boulder**	**gravel**	**sand**	**silt**	**gravel**	**sand**	**silt**	**sand**	**silt**	**gravel**	**sand**	**silt**	**sand**	**silt**	**sand**	**silt**
Area (m2)	**42**	**65**	**3,536**	**2,987**	**338**	**17,942**	**4,989**	**7**	**14,703**	**1,454**	**12,282**	**37,358**	**24,687**	**114,826**	**2,324**	**18,646**
	S N A	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**	**S N A**
Alewife	M,M,L	M,M,M	M, M,M	H,H,M	M, M,M	M,M,M	M,M,L	H	M	M	M	L	H	M	M	L
Emerald Shiner	L,M	M	M,H	M	M	M,H	H	H,M	M	M	M,H	H	H,M	M	M,H	H
Lake Chub	L L	M,M,M	M,M		M					M						
Longnose Dace	L,L,L	M,L,M	L,M,M													
Spottail Shiner	L L	M,H,M	M,H,M	M,M	M,H,M	M,H,M	M,L	M,H	L,M	H,M	H,M	M,L	M,H	L,M	H,M	M,L
Longnose Sucker			H	H	M	H	H	H	H	M	H	H	M	M	H	H
White Sucker	L	M	M,M	M,L	M	M,M	L	H	L	M	M		H	L	M	
Northern Pike			M				H									
Rainbow Smelt		M	M		M	M		H		M	M		H		M	
Pink Salmon	L															
Coho Salmon	M,P	P	L,P	P		L		M,P	P		L		M,P	P	L	
Chinook Salmon	P	M,P	M,P	P	L	L		P	P				P	P		
Rainbow Trout		M	M	H,P	M	M	M	P	P							
Brook Trout	M,M	M,M	M,M	M,L	M,L	M,L	L,L	H	M	M	M	L				
Lake Trout	L,M	L,M	L,L	L,P	L,M	L		L,M,P	L,P	M	L		L,M,P	L,P	L	
Lake Whitefish	L,L	L,M	L,M		L,M	L,M		M,H,H		M,L	M,L		M,H,H		L,M,M	
Cisco	L,L,P	L,L,P	L, P	M P	M,L	M,L	L	H,L	M P	M,L	M	L	H,L,P	M P	M	L
Round Whitefish	M	M,M	M		M	M		H,H	H	M,L	M,M	M	H,H	H	M,M	M
Burbot	M	M	L	M	M	L	L	H	H	M	M	M	H	H	M	M
3-sp. Stickleback		M,M,M	H,H, H	H	M	H	H	M	M	M	H	H	M	M	H	H
Sticklebacks		M,H	H,H,H	H	H	H	H	M	M	H	H	H	M	M	H	H
Mottled Sculpin	M	M,M,H	M,M,H	H	H	H	M									
Slimy Sculpin	M L	M,M,M	L,M,M	L M	L,L,M	L,L,M	L L	L,M,H	L M	L,L,M	M	L	L,M,H	M	L,L,M	L
Johnny Darter	L	M, H,H	M, H,H	M,H	H,H	H,H	H,H	M	M	H	H	H	M	M	H	H
Walleye		M,H	M,H	M	M,H	M,H	M	M,H	M	M,H	M,H	M				
Yellow Perch	L L	H, H,M	H, H,M	M, M,H	H, H,M	H, H,H	M, H,H	M, H,M	L, H,M	H, H,M	H, H,H	M, H,H	M, M,M	L, M,M	H, H,H	M, H,H

In summary, the proposed cap area is probably most significant for adult longnose sucker and yellow perch (in all stages) due to its submergent cover. It may also be preferred by northern pike due to the cover and prey base, but this species can also forage in a wide variety of other habitats. The proposed cap has limited value for species preferring coarse substrates, and since open sandy/silty substrates in moderate to deep water are abundant elsewhere in Peninsula Harbour, the proposed cap is not significant for those species preferring this habitat type.

4.4 Data Gaps

Despite the attention paid to the Peninsula Harbour AOC of the past few decades and numerous studies that have been conducted, there still remain significant information gaps, particularly related to the fish community and fish use of the AOC in general, and Jellicoe Cove in particular. In part, this is due to a relative lack of targeted and systematic fisheries studies in the proposed cap area. In particular, the following data gaps are identified:

- There are limited data on the abundance of aquatic macrophytes elsewhere in Peninsula Harbour, which would help determine the significance of the submergents within the proposed cap area.
- The limited video available indicated that the historical lake trout spawning habitat along Ypres Point and west of Beatty Cove is in relatively good condition. Targeted surveys could confirm if the habitat is indeed suitable and if it is currently used by spawning lake trout, lake whitefish, cisco, or other species.
- The status of fish habitat in Beatty Cove, particularly with respect to woody debris and the need/potential for rehabilitation, is poorly known.
- There is little information available on the status of fish habitat in shallow (<2 m) nearshore areas adjacent to the proposed cap area, although sampling (beach seining/electrofishing) has demonstrated that areas are used as nursery habitat. Habitat and additional fish community surveys would provide information that could be used to identify appropriate habitat remediation for these potentially important areas.
- There are limited data on actual fish use in the proposed area, particularly for spawning and nursery habitat. Most of the existing information was derived from limited gill-netting of adults. Additional surveys could confirm use and help assess significance.

Additional data from other studies would be beneficial, particularly for helping guide any additional remediation efforts or potential fish habitat compensation. However, the existing habitat and fisheries information, combined with known fish habitat preferences derived from other studies, is sufficient identify potential impacts of the proposed capping, and recommend compensation if required.

5 Potential Impacts of Proposed Capping

Discussion of impacts will be restricted to potential habitat-related impacts on fish habitat rather than direct impacts on fish during the actual capping from turbidity or other construction-related impacts. Those impacts and potential impacts on benthic invertebrates are beyond the scope of this report and will be addressed separately by AECOM in the EA screening report.

5.1 Aquatic Macrophytes

The proposed capping would cover approximately 99,000 m^2 (~10 ha) of aquatic macrophytes, primarily *Chara* but also some Canada waterweed and pondweeds, with a layer of approximately 10-15 cm of sand (Table 5). Of this, only 3600 m^2 are in waters less than 2 m deep. Submerged aquatic vegetation typically does not occur below 10 m water depth, but *Chara* is known to grow to depths of 12 m and other macroalgae are found down to depths of 30 m or more (Ciborowski et al. 2009; Wehr and Sheath 2003). Canada waterweed typically grows in a wide range of water depths, typically between 4 to 8 m deep, but as deep as 12 m (Sheldon and Boylen 1977).

The cap will initially smother at least some of the submergents, although some may be tall enough not to be covered by the cap, particular in areas with coarse woody debris which might disrupt the evenness of the cap. Among submerged macrophytes, charophytes such as *Chara* are s fast colonizers and often occur in temporary or disturbed habitats (Wade 1990; Beltman and Allegrini 1997). Reproduction in *Chara* is primarily sexual using oospores, although there is also a limited amount of fragmentation, particularly near the rhizoid (root-like structure). *Chara* oospores (propagules) can accumulate in large numbers in the upper sediment, and persist for many years, possibly decades (Proctor 1967). In The Netherlands, Van den Berg et al. (2001) reported gradual colonization of approximately 1/3 of a small lake by *Chara* (mainly *C. aspera*) after improvement in water quality created suitable conditions. Within 9 years, *Chara* spread from adjacent areas of the lake and colonized (at >50% cover) approximately 30 ha of previously unoccupied lake bottom. Although not directly comparable to the Peninsula Harbour case, it suggests that recolonization of the sediments of the proposed cap would take less than a decade, and perhaps considerably sooner.

Recolonization rates for aquatic macrophytes, particularly for the oligotrophic waters of Lake Superior, are poorly understood. Canada waterweed is a perennial that vegetatively propagates readily from unspecialized stem fragments (Nichols and Shaw 1986); sexual reproduction with seed formation is rare (St. John 1965). It has been observed in the leafy condition under snow-covered ice and can overwinter as entire plants (Stuckey et al. 1978). The dormant apices of Canada waterweed grow quickly as the water warms and light intensity increases in the spring. It is unknown to what extent, if any, it might die back under the low light conditions experienced in Peninsula Harbour during winter. *Elodea* rapidly invades areas that have been disturbed by natural or anthropogenic causes, including subtle disturbances such as accelerated eutrophication (Nichols and Shaw 1986). *Elodea* can utilize nutrients from both soil and water and does not appear to be nitrogen or phosphorus limited. Haag (1976) estimated a growing season net productivity for elodea of 160-203 g/m2 for Lake Wabmun, Alberta. In Europe, Canada waterweed is an invasive exotic with very high growth rates (Barrat-Segretain et al. 2002).

Canada waterweed is found on a wide variety of sediment types but grows best on fine sediments where organic matter is 10-25% (Nichols and Shaw 1986 and reference therein). Substrates that are too coarse don't provide good anchorage and may be nutrient-poor; conversely, fine bottom sediments can be too soft and flocculent to support smartweed growth (Nichols and Shaw 1986).

Like *Chara*, Canada waterweed is tolerant of varied water chemistry but is most common in hard, nutrient-rich, alkaline waters (Nichols and Shaw 1986). Canada waterweed does well in eutrophic conditions (Lind and Cottam 1969), but is also one of the most common submergent species along the north shore of Lake Superior (pers. obs.). Oligotrophic conditions generally prevail in Lake Superior, including Peninsula Harbour. Point source nutrients are major variable in determining the distribution of benthic macroalgae in Lake Huron, and phosphorous may be a limiting factor (Sheath et al. 1988). *Chara* and *Elodea* are not common submergents along Lake Superior shorelines due to the oligotrophic conditions and typically coarse substrates. Benthic macroalgae can be an indicator localized pollution inputs (Sheath et al. 1988) such as in Thunder Bay harbour (Harris et al. 2009), and the abundance of *Chara* in Jellicoe Cove may partly reflect greater nutrient availability in the sediment resulting from past contamination and accumulation of organics.

Nutrients such as phosphorus and nitrogen are recycled primarily through death and decay of the *Elodea* and other submergents (Nicols and Shaw 1986) and fall senescence of *Elodea* has been observed to release soluble nitrogen (Peverly and Johnson 1979). Burial of *Elodea* in the proposed capping may release nutrients of the upper layers of the substrate in Jellicoe Cove and could help promote growth of remaining plants. This may help mitigate potentially reduced availability of nutrients in existing sediments if the additional depth of the cap puts nutrients in the existing sediments beyond the rooting zone of submergents. Submergents are groing on approximately 7 ha of predominately silty substrate within the proposed cap area, with the remainder mainly on sand. Although submergents are growing on sandy sediments in the proposed cap, the sand of the proposed cap may be less suitable for submergent growth since it will lack the silts and finer sediments that are mixed in with the existing silt substrate which might slow recolonization somewhat.

Submergents in the proposed cap area are expected to regenerate in the short to medium term because:

- Not all existing plants are likely to be smothered by the 15-20 cm layer of the sand in the proposed cap;
- The proposed cap substrate appears to be a suitable growing medium for submergent species present in Jellicoe Cove (although the impacts on SAV recolonization of the loss of organics in the rooting zone and capping of silt with sand are unknown);
- Dominant submergents i.e., *Chara* and Canada waterweed in Jellicoe Cove are known to rapidly colonizing bare substrates, and
- Potential nutrients input from smothered submergents may stimulate growth of regenerating individuals if they are accessible to the rooting zone of submergents.

5.2 Fish

Potential impacts on the fish community from the proposed capping are particularly difficult to predict due to paucity of existing fisheries assessment data and the number of other factors that may influence fish distribution and abundance including other environmental variables (e.g., weather, water levels), harvest, and interspecific relationships (e.g., predation, competition), as well as the uncertainty regarding the aquatic macrophytes response to the proposed capping.

The proposed cap area does not provide significant spawning, nursery, or foraging habitat for fish species that prefer cobble and other coarse substrates and, while there will be a reduction in silt substrates, the amount of potential spawning, nursery, and other habitat over sand will increase concomitantly. Furthermore, silty substrate is abundant elsewhere in Peninsula Harbour in similar water depths. The proposed capping should benefit fish species that prefer to forage on sandy substrate compared to siltier and flocculent substrates.

The reduction in submergents may have some impacts on species that spawn over vegetation, at least in the short term. However, a short-term reduction in vegetation density may not have a significant negative impact on fish populations in Jellicoe Cove, including longnose sucker and yellow perch. Yellow perch is the sportfish species most likely to be impacted in terms of spawning habitat, but yellow perch egg masses float and will adhere to logs or sand in the proposed cap (as well as on any remaining or regenerating macrophytes). On waveswept Great Lakes shorelines, yellow perch will spawn over sand and cobble where preferred submergent vegetation or woody debris is absent (Robillard and Marsden 2001).

Reduced submergent density may negatively impact nursery, foraging habitat, and overwintering habitat for some species (e.g., yellow perch, longnose sucker, northern pike) in the short to medium term. Crowder and Cooper (1979, 1982) found that medium macrophyte densities support abundant macroinvertebrates while allowing room for fish to forage. Therefore, a reduction in submergent density in portions of the proposed cap could potentially improve foraging conditions for some fish species.
Most of the fish species found in Jellicoe Cove are found in a variety of habitats and are not dependent on submergents. For example, even though juvenile yellow perch commonly use submergents, age-0 perch in Lake Michigan showed a preference for rocky habitat (Janssen and Luebke 2004) and YOY perch were seined along the shoreline in Jellicoe Cove outside the proposed cap area.

5.3 Conclusions

Recognizing the limitations of the existing data, the proposed cap area does not appear to be critical fish habitat. Less than 2% of the cap is in shallow (<2 m) water preferred by many YOY fish including salmonids and suckers, and relatively similar littoral habitat is abundant elsewhere in Peninsula Harbour along more natural shorelines. The unvegetated portion of the proposed cap in deep water over fine-textured substrate is likely used by adult longnose suckers and round whitefish in particular. The proposed capping will cover silt substrate with sand; this may benefit slightly species that prefer sand compared to silt and vice versa, but will probably not have a significant effect on fish habitat use. Furthermore, deepwater silt habitat is common in elsewhere in Peninsula Harbour.

Available evidence suggests that the most significant impact will be the potential reduction in aquatic macrophyte abundance in the proposed cap area, which could reduce the habitat suitability for foraging adult longnose suckers and northern pike. Although data are lacking, yellow perch and small fish species in various life stages could also be affected by a reduction in submergent density. The response of submergents to disturbances such as the proposed capping is poorly understood for oligotrophic systems like Peninsula Harbour. Various lines of evidence suggest however that the plant species present in Jellico Cove are will be able to recover in the short to medium term.

Finally, the long-term benefit of reducing exposure to contaminated sediments by capping it with a layer of sand probably outweighs the any potential short-term negative impacts to fish habitat.

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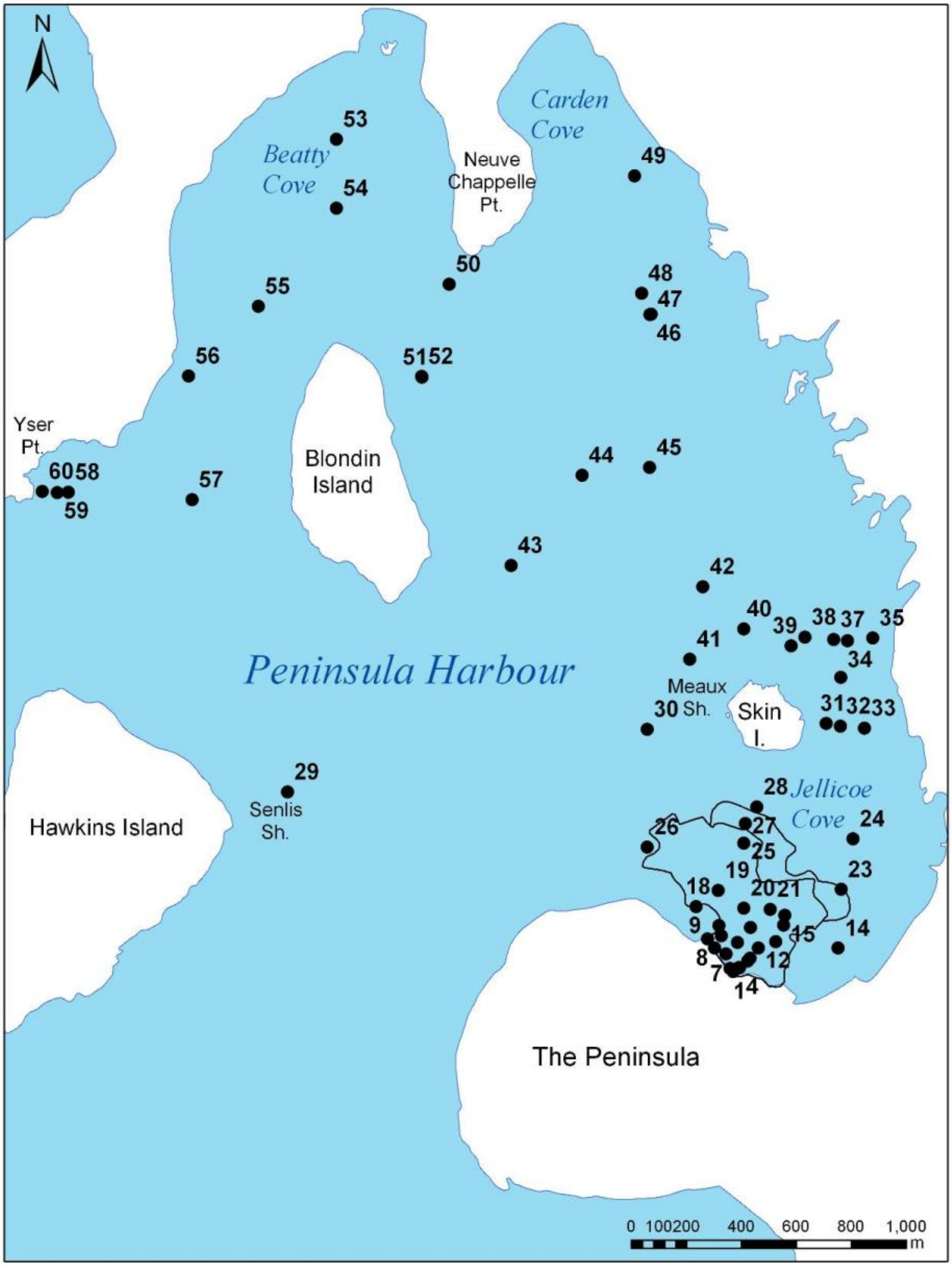
Appendix 1. Particle size* analysis from sediment grabs in Peninsula Harbour by Grapentine et al. (2005) and Milani et al. (2001). See Figure 15 and Figure 26 for locations.

Source	Site	Dominant Substrate	Sand	Silt	Clay	Gravel	Depth	Northing	Easting
Grapentine et al. (2005)	JC2A	Clay	7	19	74	0	7.5	5396712	544367
Grapentine et al. (2005)	PH20	Clay	33	14	53	0	26.2	5403155	498041
Grapentine et al. (2005)	PH17	Clay	5	46	49	0	41.0	5410755	457816
Grapentine et al. (2005)	JC3A	Clay	18	35	47	0	7.7	5396702	544382
Grapentine et al. (2005)	JC1B	Sand	84	1	0	14	9.0	5396753	544291
Grapentine et al. (2005)	JC1D	Sand	90	5	0	6	15.0	5396883	544216
Grapentine et al. (2005)	JC1C	Sand	92	4	0	4	10.0	5396832	544248
Grapentine et al. (2005)	JC7A	Sand	93	6	0	2	6.8	5396628	544454
Grapentine et al. (2005)	PH13	Sand	90	5	3	1	13.2	5402907	526305
Grapentine et al. (2005)	PH15	Sand	67	13	19	1	8.4	5399005	544152
Grapentine et al. (2005)	PH26	Sand	53	31	16	1	38.4	5398319	534292
Grapentine et al. (2005)	JC2C	Sand	44	42	14	0	15.0	5396851	544326
Grapentine et al. (2005)	JC4A	Sand	62	26	12	0	10.6	5396710	544412
Grapentine et al. (2005)	JC3B	Sand	55	31	14	0	0.0	5396780	544389
Grapentine et al. (2005)	JC5A	Sand	54	33	13	0	7.5	5396681	544432
Grapentine et al. (2005)	JC2D	Sand	46	42	12	0	16.9	5396921	544310
Grapentine et al. (2005)	JC2B	Sand	63	25	12	0	12.2	5396787	544343
Grapentine et al. (2005)	PH2	Sand	56	34	9	0	1.2	5385168	549731
Grapentine et al. (2005)	JC7B	Sand	75	17	8	0	4.8	5396640	544527
Grapentine et al. (2005)	PH18	Silt	8	53	39	0	23.3	5406082	444807
Grapentine et al. (2005)	PH16	Silt	11	52	36	0	27.4	5408595	461938
Grapentine et al. (2005)	PH22	Silt	7	67	26	0	64.8	5400026	540285
Grapentine et al. (2005)	PH14	Silt	20	58	22	0	43.6	5403841	520730
Grapentine et al. (2005)	PH21	Silt	39	45	16	0	29.4	5401241	540354
Grapentine et al. (2005)	PH11	Silt	15	70	15	0	26.9	5387649	548785
Grapentine et al. (2005)	JC7C	Silt	36	49	15	0	5.3	5396655	544603
Grapentine et al. (2005)	PH1	Silt	36	50	14	0	2.7	5385705	548946
Grapentine et al. (2005)	JC4D	Silt	12	73	14	0	13.5	5396893	544511
Grapentine et al. (2005)	JC6B	Silt	39	47	14	0	7.5	5396688	544516
Grapentine et al. (2005)	JC5D	Silt	15	71	14	0	11.8	5396833	544599
Grapentine et al. (2005)	JC5B	Silt	26	60	14	0	11.0	5396734	544485
Grapentine et al. (2005)	JC3D	Silt	28	59	14	0	14.6	5396925	544415
Grapentine et al. (2005)	JC5C	Silt	22	65	13	0	11.2	5396780	544539
Grapentine et al. (2005)	JC4C	Silt	31	56	13	0	12.6	5396830	544478
Grapentine et al. (2005)	JC6C	Silt	24	64	13	0	8.0	5396711	544590
Grapentine et al. (2005)	JC3C	Silt	35	52	12	0	13.6	5396855	544403

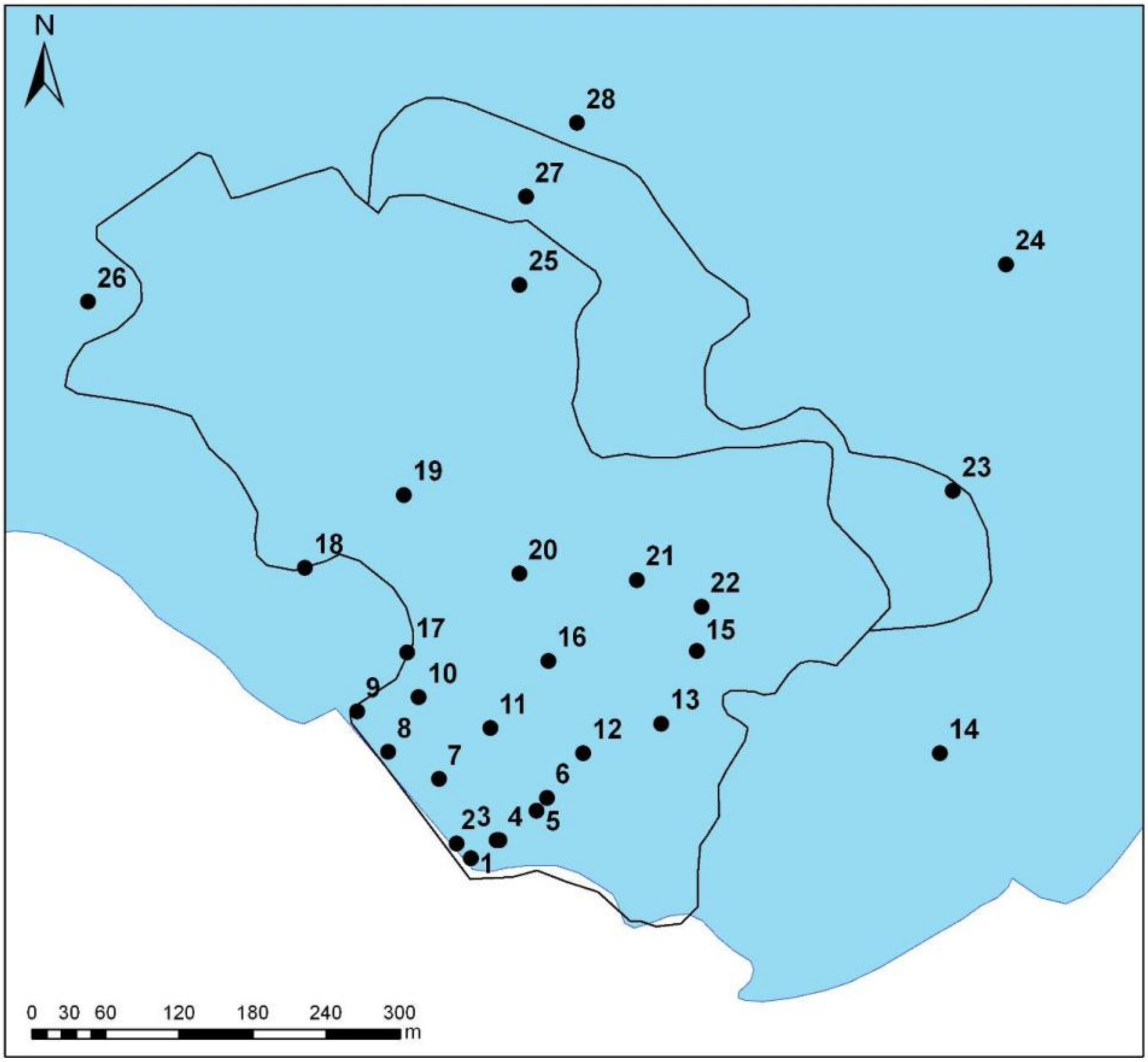
Source	Site	Dominant Substrate	Sand	Silt	Clay	Gravel	Depth	Northing	Easting
Grapentine et al. (2005)	JC4B	Silt	37	52	10	0	12.0	5396767	544445
Milani et al. (2002)	60	Clay	12	16	72	1	26.0	5397852	542605
Milani et al. (2002)	A1	Clay	2	16	82	0	12.7	5397330	544421
Milani et al. (2002)	57	Sand	83	16	0	1	1.3	5396508	544744
Milani et al. (2002)	71	Sand	82	18	0	0	4.0	5399461	543891
Milani et al. (2002)	A2	Sand	97	2	0	0	18.9	5397248	544353
Milani et al. (2002)	B5	Sand	53	40	8	0	20.3	5396990	544243
Milani et al. (2002)	C6	Sand	87	9	4	0	13.3	5396865	544240
Milani et al. (2002)	F2	Sand	53	36	11	0	8.8	5396945	544669
Milani et al. (2002)	G6	Sand	86	11	0	3	5.1	5396639	544488
Milani et al. (2002)	I5	Sand	91	9	0	0	2.3	5396576	544688
Milani et al. (2002)	58	Silt	41	48	11	0	17.0	5396937	544311
Milani et al. (2002)	59	Silt	25	63	12	0	70.5	5396138	542400
Milani et al. (2002)	61	Silt	2	76	21	0	83.6	5399337	540173
Milani et al. (2002)	62	Silt	21	67	11	0	43.1	5397343	543358
Milani et al. (2002)	64	Silt	10	78	12	0	77.2	5395566	542281
Milani et al. (2002)	65	Silt	18	66	16	0	95.2	5394937	541308
Milani et al. (2002)	66	Silt	32	56	11	0	72.7	5395830	541450
Milani et al. (2002)	67	Silt	24	67	9	0	61.6	5396555	542721
Milani et al. (2002)	68	Silt	7	76	17	0	38.6	5397392	542672
Milani et al. (2002)	70	Silt	40	51	9	0	33.0	5397105	543874
Milani et al. (2002)	289	Silt	25	61	14	0	21.5	5399162	542807
Milani et al. (2002)	A5	Silt	21	70	9	0	25.1	5397102	544179
Milani et al. (2002)	C3	Silt	23	69	8	0	15.8	5397078	544438
Milani et al. (2002)	D1	Silt	40	52	8	0	13.3	5397126	544636
Milani et al. (2002)	D4	Silt	39	54	7	0	13.9	5396937	544417
Milani et al. (2002)	D5	Silt	24	67	9	0	15.0	5396935	544366
Milani et al. (2002)	E3	Silt	38	53	9	0	12.5	5396952	544556
Milani et al. (2002)	E5	Silt	35	55	10	0	12.3	5396828	544437
Milani et al. (2002)	F4	Silt	23	68	10	0	10.0	5396814	544533
Milani et al. (2002)	G3	Silt	8	80	11	0	9.1	5396825	544678
Milani et al. (2002)	G5	Silt	42	49	10	0	6.7	5396685	544552
Milani et al. (2002)	H3	Silt	18	69	13	0	6.5	5396762	544734
Milani et al. (2002)	H5	Silt	40	49	11	0	4.5	5396639	544608

*particle size diameter classes not given, but according to Denholm and Schut (1993)
clay <.0002 mm; silt 0.002- 0.05 mm; sand 0.05-2.0 mm; gravel >2.0 mm

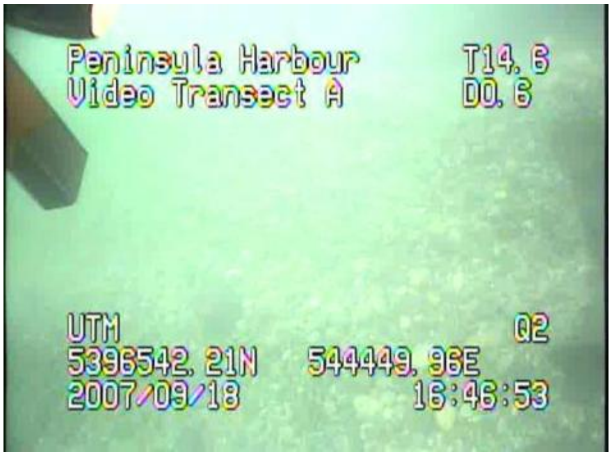
Appendix 2. Selected underwater video images for Peninsula Harbour.



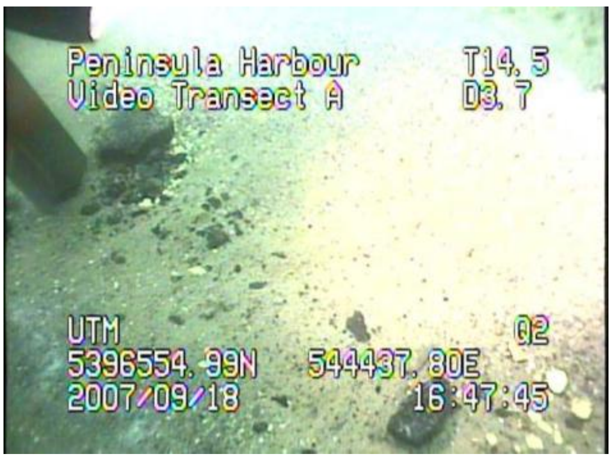
Location of Selected images from underwater video with proposed cap area (black outline).



Inset of proposed cap area with location of images from underwater video.



#1 Cobble and Rip rap in shallow water along shoreline of southern portion of proposed cap.



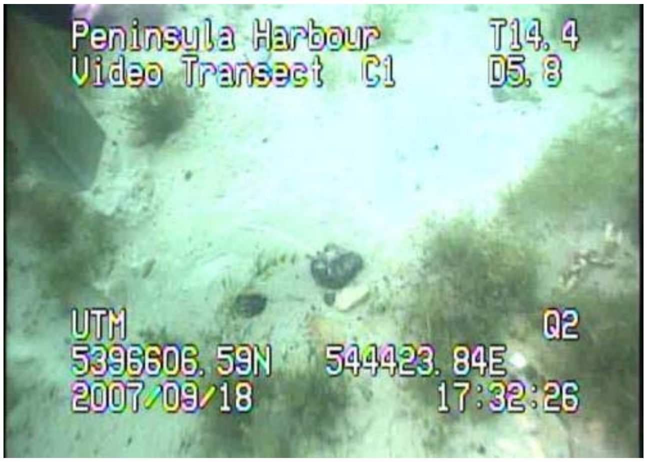
#2 Mixed substrate in shallow water along shoreline of southern portion of proposed cap.

#3 Sand adjacent in shallow water of proposed cap.

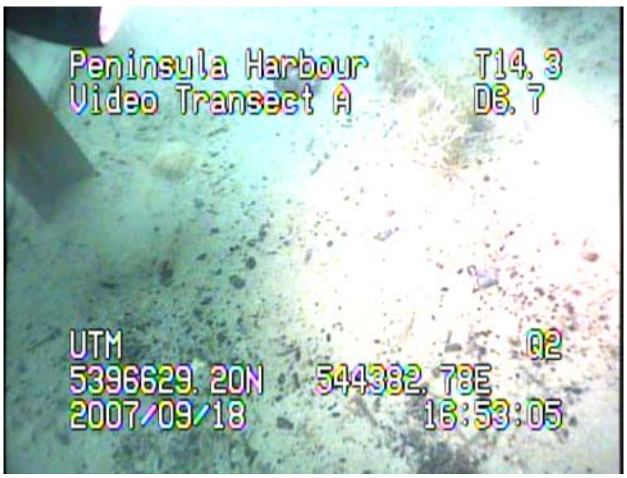
#4 Tires, rip rap, and soft sediment at southern edge of proposed cap.

#5 Sand and sparse stonewort at southeastern edge of proposed cap.

#6 Sparse Canada smartweed in proposed cap.



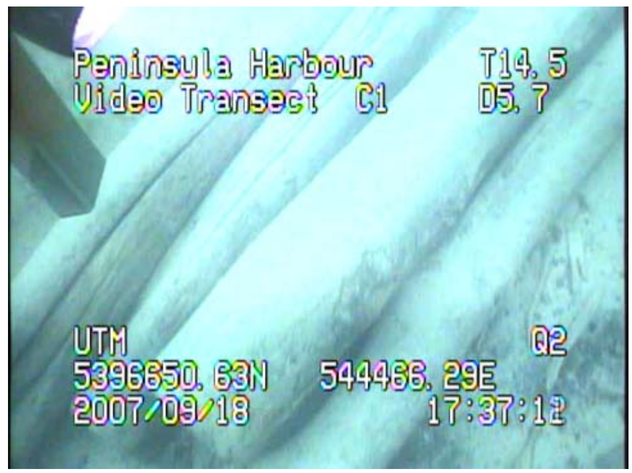
#7 "Mixed substrate" of occasional cobble and gravel over silty sand with stonewort in cap area.



#8 Mixed substrate of gravel, fragmented bark, and silty sand in shallow water of proposed cap.

#9 "Cobble" rip rap in shallow water on northwest part of proposed cap.

#10 Silty substrate with sparse stonewort in proposed cap area.



#11 Logs on silty substrate in proposed cap area.

#12 Moderate stonewort and a narrow-leavd poindweed (Potamogeton spl.)on silty substrate at the southern edge of the cap.

#13 Dense submergents at southern edge of proposed cap area.

#14 Bare sandy substrate southeast of proposed cap in shallow water mapped as submerged aquatic vegetation in AECOM.

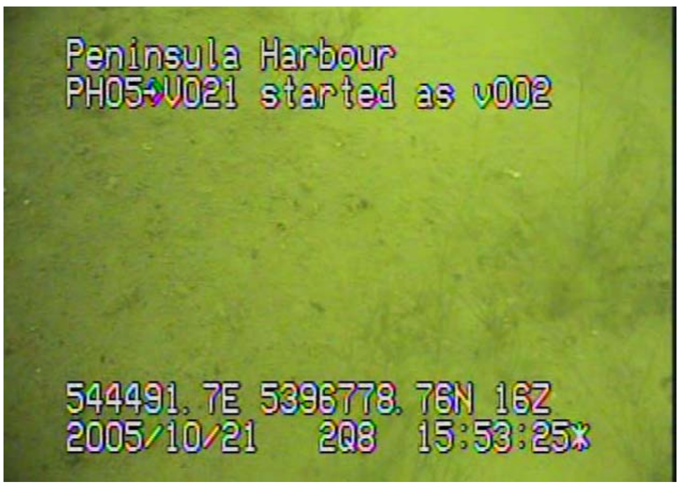
#15 Dense stonewort in middle of cobble polygon mapped as cobble by AECOM (2009) and sand by BioSonics (2011).

#16 Logs and stonewort on silty substrate in proposed cap area.

#17 Soft substrate on southest side of proposed cap in shallow water.

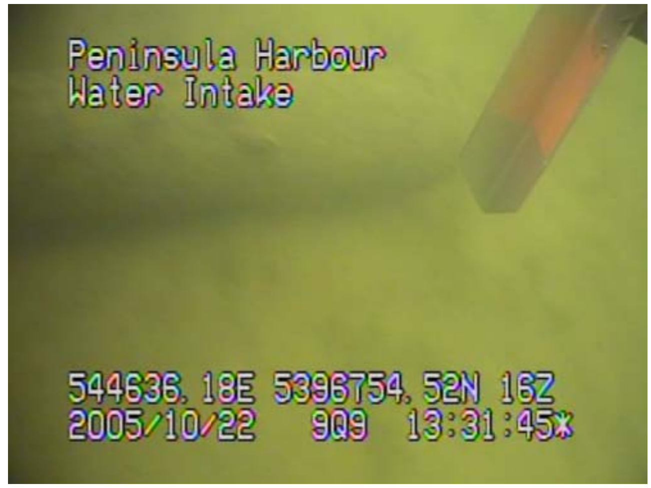
#18 Gravel, cobble and bark chips overlying sand at southwest margin of proposed cap.

#19 Soft sediments in middle of proposed cap area.)



#20 Centre of proposed cap area with silt, some gravel and sparse macrophytes.

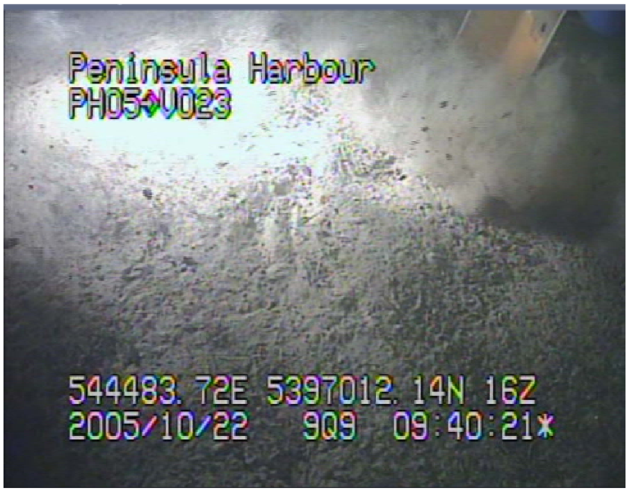
#21 Sparse macrophytes in AECOM detritus polygon.



#22 Log and silty in AECOM “cobble” polygon (Photo 13).

#23 Silty sand at northeast edge of proposed cap.

#24 Rippled sand with thin layer of silt east of proposed cap in approximately 4 m of water.



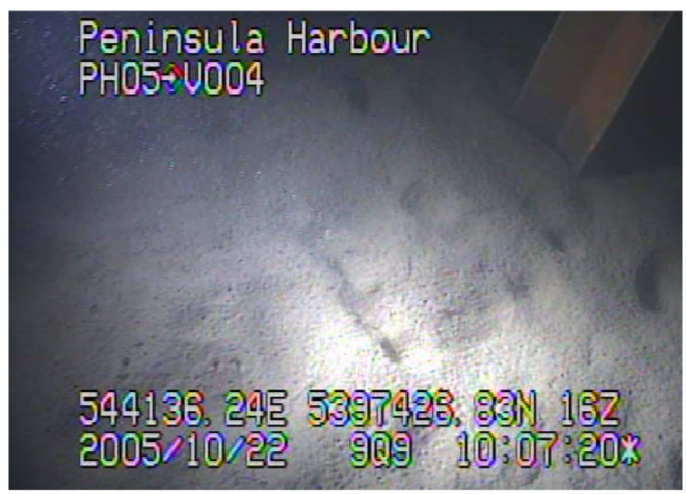
#25 Bark overlying silty substrates at north end of proposed cap.

#28 Silty bottom in new polygon mapped as silt by AECOM.

#26 Silty substrate on northwest edge of proposed cap.

#29 Bedrock with thin layer of silt and algae off east side of Hawkins Island at Senlis Shoal.

#27 Soft bark deposits at edge of AECOM silt polygon mapped by AECOM.



#30 Soft sediment west of Skin Island.

#31 East side of Skin Island.

#32 East side of Skin Island with bark.

#33 East side of Skin Island with logs.

#34 Northeast side of Skin Island, silty? with bark deposits and pulp logs.

#35 Bark (misidentified in Envt Can shapefile) overlying sand east of Skin Island that.

#36 Bark deposits 300 m northeast of Skin Island.

#37 Bedrock shoal with thin layer of silt northeast of Skin Island in 5 m of water.

#40 Thin layer of silt over bedrock 200 m north of Skin Island in 15-16 m of water.

#38 Silty sediments northeast of Skin Island showing plume of silt from contact of camera apparatus with substrate.

#41 Bedrock on west side of Skin Island at Meaux Shoal.

#39 Cobble northeast of Skin Island.

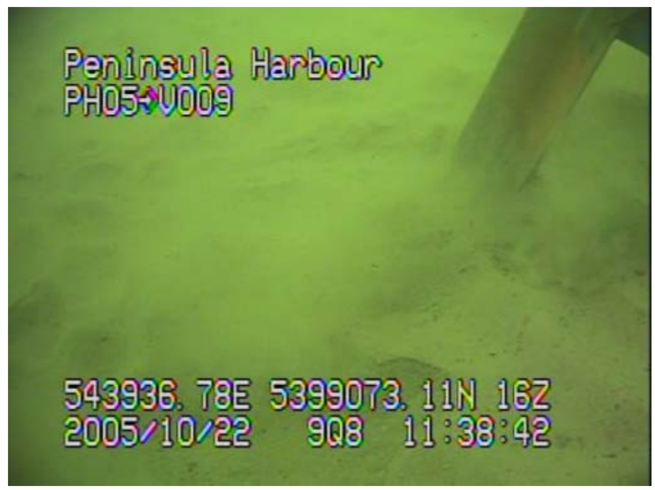
#42 Soft sand north of Skin Island with the occasional cobble.

#43 Silty substrate 280 m southeast of Blondin Island in 24 m of water.

#44 Silty sand in middle of harbour east of Blondin Island.

#45 Silty sand at 14 m depth approximate 900 m due east of Blondin Island in middle of Peninsula Harbour.

#46 Gravel overlaying fairly clean sand; not much silt compared to other sites with wave ridges.



#47 Deeper water immediately adjacent and siltier and siltier in deeper part of bay opposite Carden Cove.

#48 Scalloped silty sand at mouth of Carden cove in approximately 8 m of water.

#49 Smooth bedrock in Carden Cove.

#52 Sparse submergent in silty substrate approximately 120 m off the northeast side of Blondin Island.

#50 Silty sand off Neuve Chappelle Pt in approximately 6 m of water.

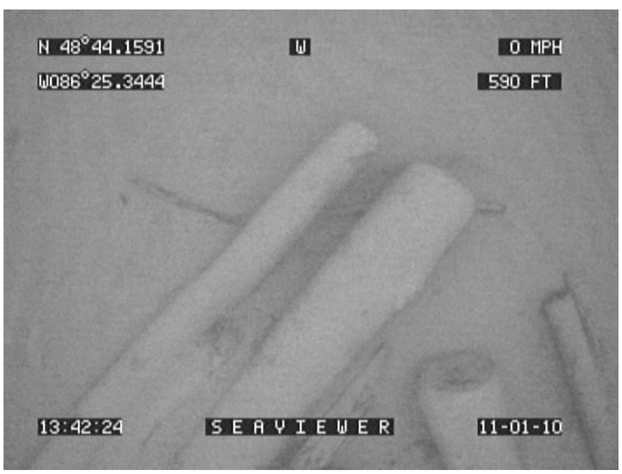
#53 Silty substrate and logs in Beatty Cove Photo 58

#51 Silty substrate with bark debris east of Blondin Island (Photo 24).

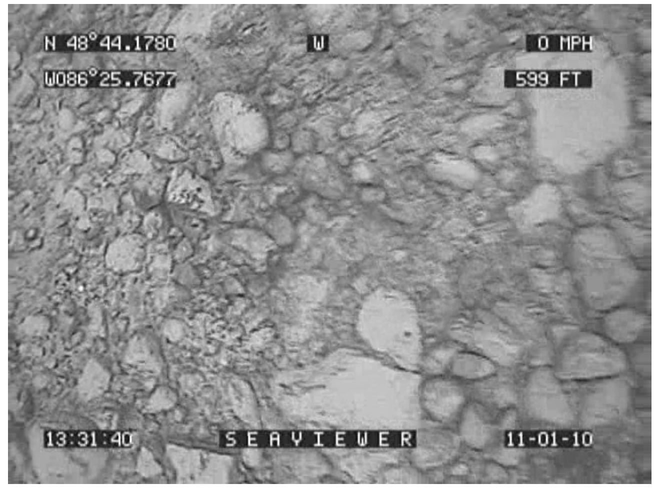
#54 Silty, flocculent substrate at mouth of Beatty Cove in approximately 18 m of water.

#55 Silty substrate in 23 m of water approximately 300 m northwest of Blondin Island.

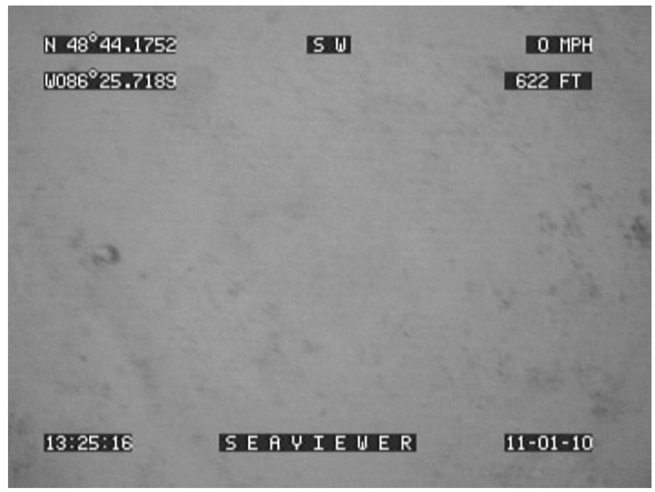
#56 Fairly clean cobble and gravel on bedrock off mainland west of Blondin Island.



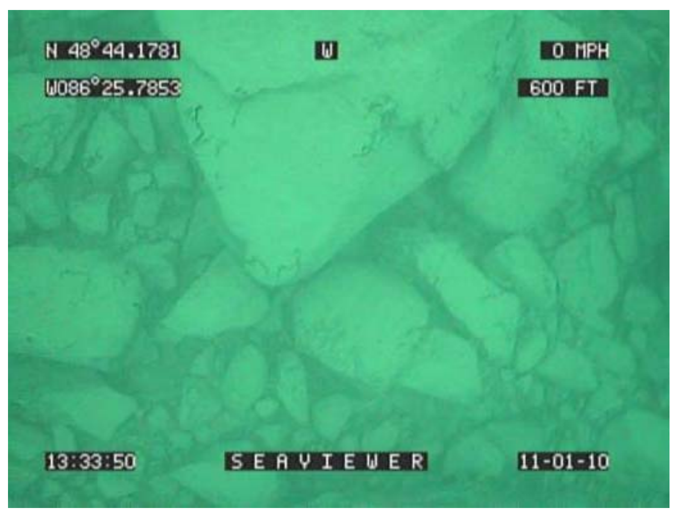
#57 Sand and logs between Blondin Island and Yser point in 34 m of water.



#58 Silty cobble on Yser Point.



#59 Silty sediments in deeper water off Yser Point.



#60 Rock and cobble inshallow water off Yser Point.