Effects of Seaway Shipping Operations on Coastal Habitats with Ice Cover in the Thousands Islands Region of the St. Lawrence River

John E. Cooper and John M. Farrell
Thousand Islands Biological Station
College of Environmental Science and Forestry
State University of New York
Clayton, NY

and

Rodger M. Klindt, Scott Prindle, and Alan Fairbanks
New York State Department of Environmental Conservation
Watertown and Cape Vincent, NY

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A Report to Save The River, Inc.
Clayton, New York

Introduction

The potential effects of ice movement in wetland areas due to nearby ship passage was one area of concern in the policy statement issued by Save The River in regards to winter shipping and Seaway expansion (STR 2001). This concern was based on the results of Marshall (1978) who suggested that unstable, or free broken ice had the potential to disrupt development of fish eggs in the benthic habitat as well as increasing shoreline damage. Freeburg et al. (1990), Savino et al. (1994), and Jude et al. (1998) suggested that deleterious effects were possible on fish eggs and larvae in nearshore areas from shipping activities. There is not, however, any direct evidence of habitat changes or shoreline damage that is specific to the Thousand Islands region due to shipping activity.

Interested individuals from Save The River, NYSDEC, and SUNY-ESF met on 10 March 2005 to formulate a study plan to acquire preliminary information on the potential effects of ship transits through the Thousand Islands region while ice cover was present in the more shallow bays along the river. The Seaway was scheduled to open on 25 March so planning time was limited. It was agreed that any effort should be directed toward collection of more visible evidence of any damage as well as basic data of ice cover characteristics and water chemistry during the ice cover period. The study objectives were:

1) to determine the duration of ice cover and ice thickness in selected bays; and

2) to monitor and evaluate the chemical and physical changes to wetland habitats that may be associated with ship passage with ice cover present.

Methods

Three bays were chosen that provided a range of depth characteristics and proximity to the shipping channel: Cobb Shoal, upriver of the Thousand Islands Bridge (shallow water, close proximity to shipping channel, extensive wetland and shoreline marsh), Garlock Bay, downriver of the Bridge (deep water, close proximity to channel, limited wetland and shoreline marsh), and Millens Bay, about 6.5 km downriver of Cape Vincent (shallow water, more removed from shipping channel, limited wetland and shoreline marsh). Cobb Shoal was selected for active ship transit monitoring but ice cover would be estimated at all sites. Times of ship passage at Cobb Shoal were estimated based on ship position shown on the Great Lakes Seaway web site (www.greatlakes-seaway.com; *see Appendix*) which covers upbound and downbound transits from the Welland Canal to Montreal. Downbound transits were estimated by allowing for 10–14 hours travel time from the Welland Canal to Cape Vincent (approximately 160 miles), and 1.5 hours travel time to Cobb Shoal. Upbound transits were estimated by calculating distances among call-in points that ships use to report positions and applying an average speed of 8 mph (includes time spent in locks).

Ice cover and thickness was estimated at each site at least once per week and during monitoring of vessel transits at Cobb Shoal. Test holes were bored through the ice along a transect to measure ice thickness and distance from substrate to ice (water depth). The same test holes were used as long as ice conditions permitted. One thermograph was deployed in each bay to record water temperature at hourly intervals. Underwater video monitoring was done with a fish-cam to record the effects of ship passage. Ship speed was estimated using distance traveled over time. Potential changes in under-ice water chemistry due to ship passage were monitored using Horiba U-20 water quality monitors. The monitors recorded six parameters at 2-second intervals: water temperature (ºC), pH, dissolved-oxygen (mg/l), conductivity (S/m), turbidity (NTU), and oxidation-reduction potential (mV).

Results and Discussion

Ice duration and thickness. Monitoring began on 17 March and continued until 1 April, 2005. Ice cover was present on the monitored bays until 31 March, after which about one inch of ice remained only along the shorelines and in shallow protected areas. Maximum ice thickness was 22 inches at Cobb Shoal, 20 inches at Millens Bay, and 18 inches at Garlock Bay during the monitoring period and decreased slowly (Table 1) due to low air temperature at night. Water temperature (as measured on the bay bottom) remained at <1°C during daylight hours from 17 March to 22 March with a progressive increase to nearly 4ºC on 31 March (Fig. 1). Night water temperatures remained at <1ºC until 29 March contributing to ice retention in the bay. Melting of the ice cover started on 30 March(Fig.2).

TABLE 1.–Ice thickness (inches) by date and monitoring hole number in Cobb Shoal, Garlock, and Millens bays. NM = not measured.

	Cobb Shoal Hole number				Garlock Bay Hole number				Millens Bay Hole number					
Date	7	6	5	4	1	2	3	4	1	2	3	4	5	6
17 March	22	16	16	16	18	17	13	16	14	16	17	18	20	20
21 March	18	15.5	14	14	17	16	13.5	16	14	15	16	16	19	19
23 March	16	15	12.5	14	18	17	14	16	13	16	17	16	21	21
24 March	16	16	14	14	14	12	10.5	13	ice unsafe to measure					
28 March	14	13	12.5	NM										
29 March	10	10	NM	0										
30 March	9	9	0											
31 March	4	4												
1 April	0	0												

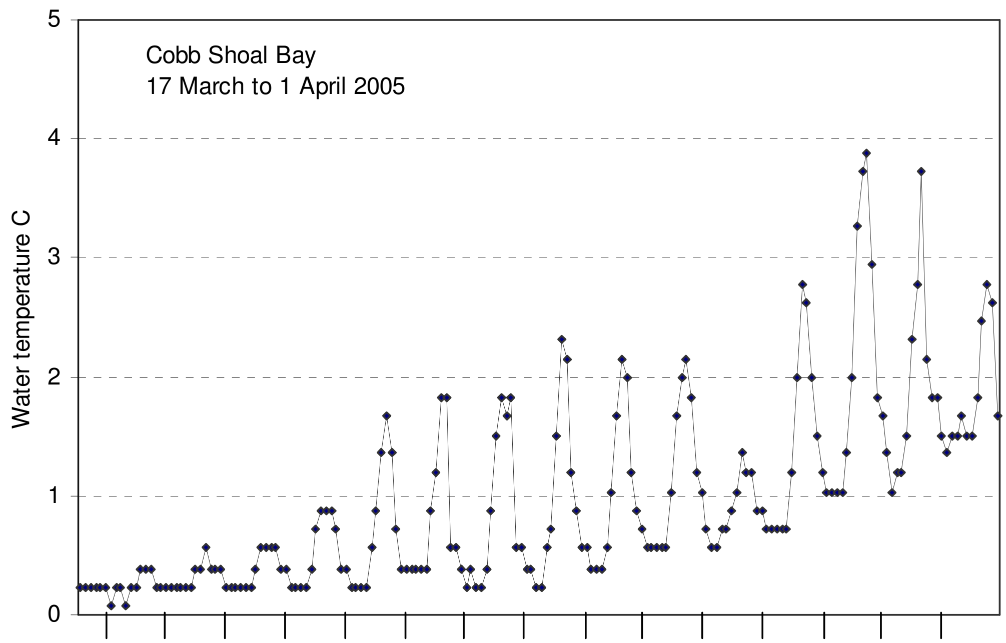


Figure 1. Water temperature on the bottom of Cobb Shoal Bay from 17 March to 1 April 2005. Data is displayed at 2 hour intervals.

Ice thickness was 14–16 inches at Cobb Shoal on 24 March, one day before the official opening of the Seaway. Ice decreased rapidly after 28 March. Ice floes were present in the river throughout the monitoring period and were present until 7 April, based on radar imaging conducted by NOAA (Fig. 2).

Video (fish-cam) monitoring. The passage of CSL Niagara was monitored on 24 March. Little evidence of the passage was detectable other than some swaying of vegetation due to water movement. Ship speed was estimated at 5.5–6.0 mph (4.8–5.2 knots). Ship speed limit from Deer Island to Bartlett Point is considerably higher than the observed speed (downbound 10.5 knots; upbound 8.5 knots).

Monitoring of under-ice water chemistry. Baseline data collections were made on 17 March (holes 4, 6, and 7; Fig. 2) and 28 March (holes 6 and 7). Evidence of water current was noticeable as the monitoring units were seen to sway about 3 inches at hole 4 with only slight movement at hole 7. The current appeared to be running from the open water of the river into the bay. Five ships were monitored as they passed Cobb Shoal during the period of 24–30 March (Table 2). Ice cracking noise was heard during the passage of each ship but no ice movement was seen. Water level in the monitoring holes rose and fell about two inches for about ten minutes after each ship had passed. Only pH showed any possible evidence of an effect from ship passage. This occurred during the monitoring of the CSL Niagara, Cedarglen, and Tadoussac: the pattern of fluctuation was consistent with what could be expected during water disturbance (Fig. 4). These fluctuations occurred only at hole 7 and could not be considered as conclusive as the amount of variation seen was within the range observed in the baseline data and there was not an expected concurrent variation in turbidity (Fig. 5). A summary of the parameters measured at holes 6 and 7 is presented in Table 3.

The lack of any measurable effect can be attributed to several factors: 1) the slow speed of the ships, 2) lack of cargo in the ships, and 3) the presence of vegetation (primarily *Chara*) in Cobb Shoal that could reduce the effect of a ship-generated wave on the sediment. The slow ship speed was noticeable near Cape Vincent (pers. observation) as well and may have been in response to the floating ice conditions present in the river. An alternative hypothesis is suggested by a press release issued on 16 April, 2004, by the Comite de Concertation Navigation in Montreal. This press release cited a 45% reduction in shoreline erosion in the Montreal–Sorel sector of the St. Lawrence River by a voluntary reduction in vessel speed initiated in 2001. There is no evidence as to why vessels speeds were reduced in the monitoring area. No evidence of ice movement was observed as a result of the transits of un-monitored ships or during the transits of monitored ships. This would suggest that ship speed would have to be increased or that the amount of cargo would have to be increased (or both) for ice movement or suspension of sediments to occur.

Previous studies have suggested that ship-generated pressure waves could result in broken ice that, in turn, could cause shoreline damage (such as uprooted plants or suspension of sediments), especially in areas near the shipping channel (Marshall 1978). Freeburg et al. (1990) suggested that ice cover may protect the eggs of lake whitefish from wind-induced waves and currents thereby increasing survival. This may suggest that ship-generated waves under the ice may decrease the survival of lake whitefish eggs but no evidence of this was presented. Savino et al. (1994) did not find any effect on lake herring eggs and larvae due to increased turbidity from vessel traffic. Similar results were reported by Jude et al. (1998) who stated that no direct effect of vessel traffic was found on lake herring and lake whitefish but that vessel traffic had the potential to cause early hatching due to agitation by waves and to cause an early break-up of ice cover resulting in dislodgement of eggs and suspension of sediments. None of these studies monitored wave strength or height during vessel passage or real-time effects from vessel movements.

Future investigations could consider monitoring sites where ship speeds may be greater, such as Chippewa Bay. Several ice fishermen stated that ship passages near this bay resulted in some water being forced out of fishing holes in 2003, but it is unlikely that any effect would be detectable if ship speeds and cargo status remain similar to those seen in 2005.

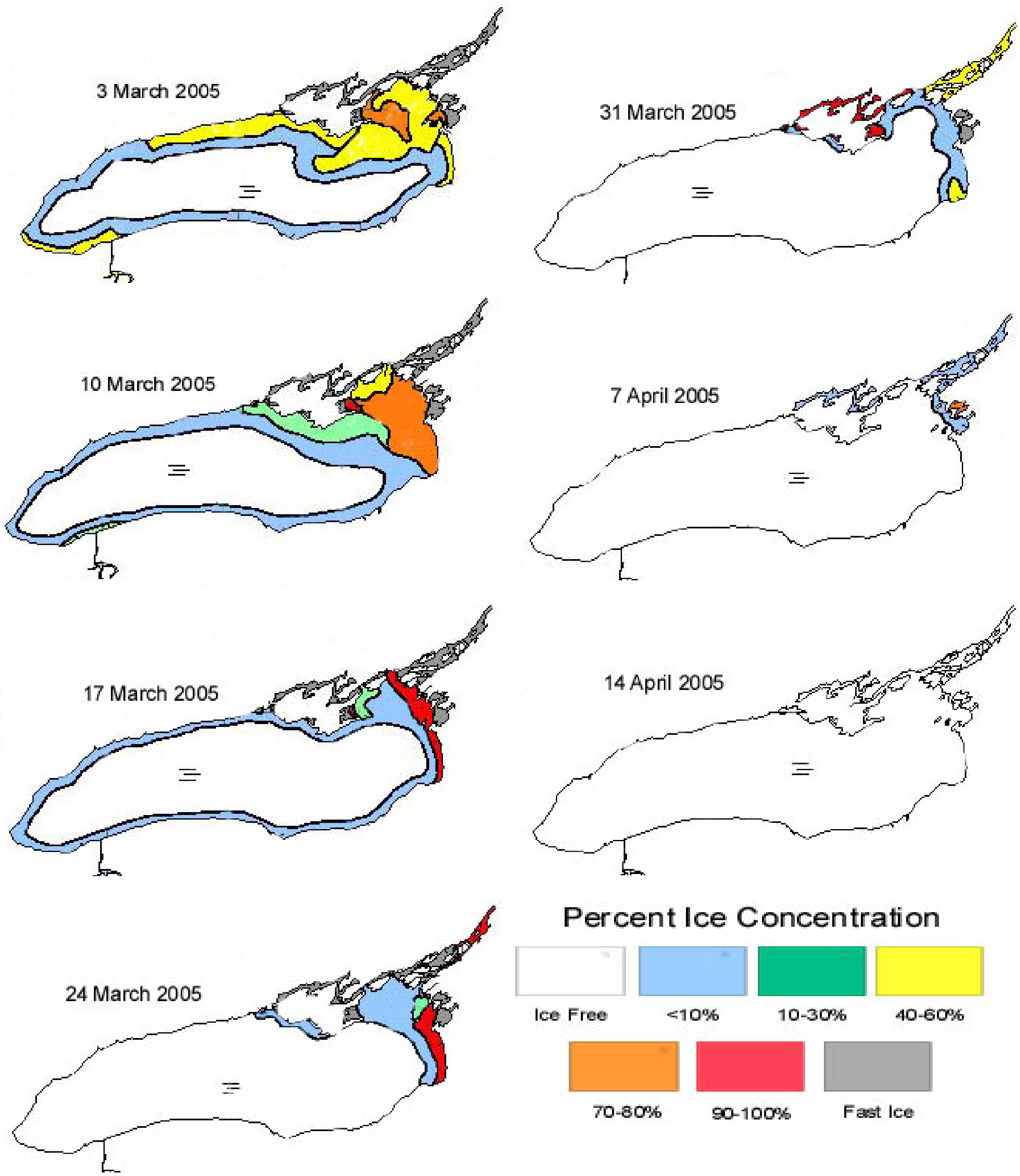


Figure 2. Percent ice concentration from 3 March to 14 April 2005. Ice concentration was simplified from the World Meteorological Organization ice chart symbology ('egg code') which relates ice thickness and concentration (www.natice.noaa.gov).

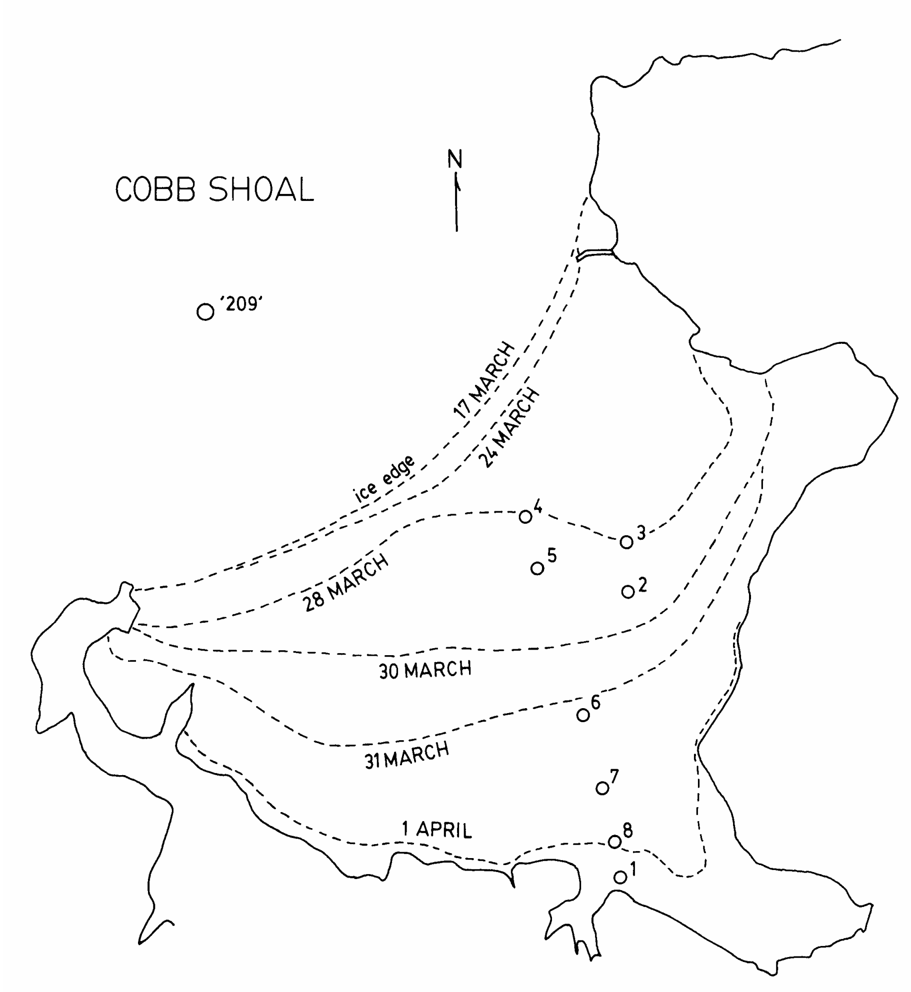


Figure 3. Location of monitoring holes and changes in ice edge position at Cobb Shoal from 17 March to 1 April 2005. River flow is from SW to NE.

TABLE 2.–Ship transits monitored at Cobb Shoal in 2005.

Date	Time	Vessel	Status	Holes used	Water depth (inches)
24 March	1130	CSL Niagara	downbound, empty	5, 6, 7	36, 20, 13
24 March	2000	Cedarglen	downbound, empty	5, 6, 7	36, 20, 13
29 March	0756	North Challenger	upbound, empty	6	20
29 March	0912	Tadoussac	downbound, empty	6, 7	20, 13
30 March	0820	RH Paul Martin	upbound, empty	6, 7	20, 13

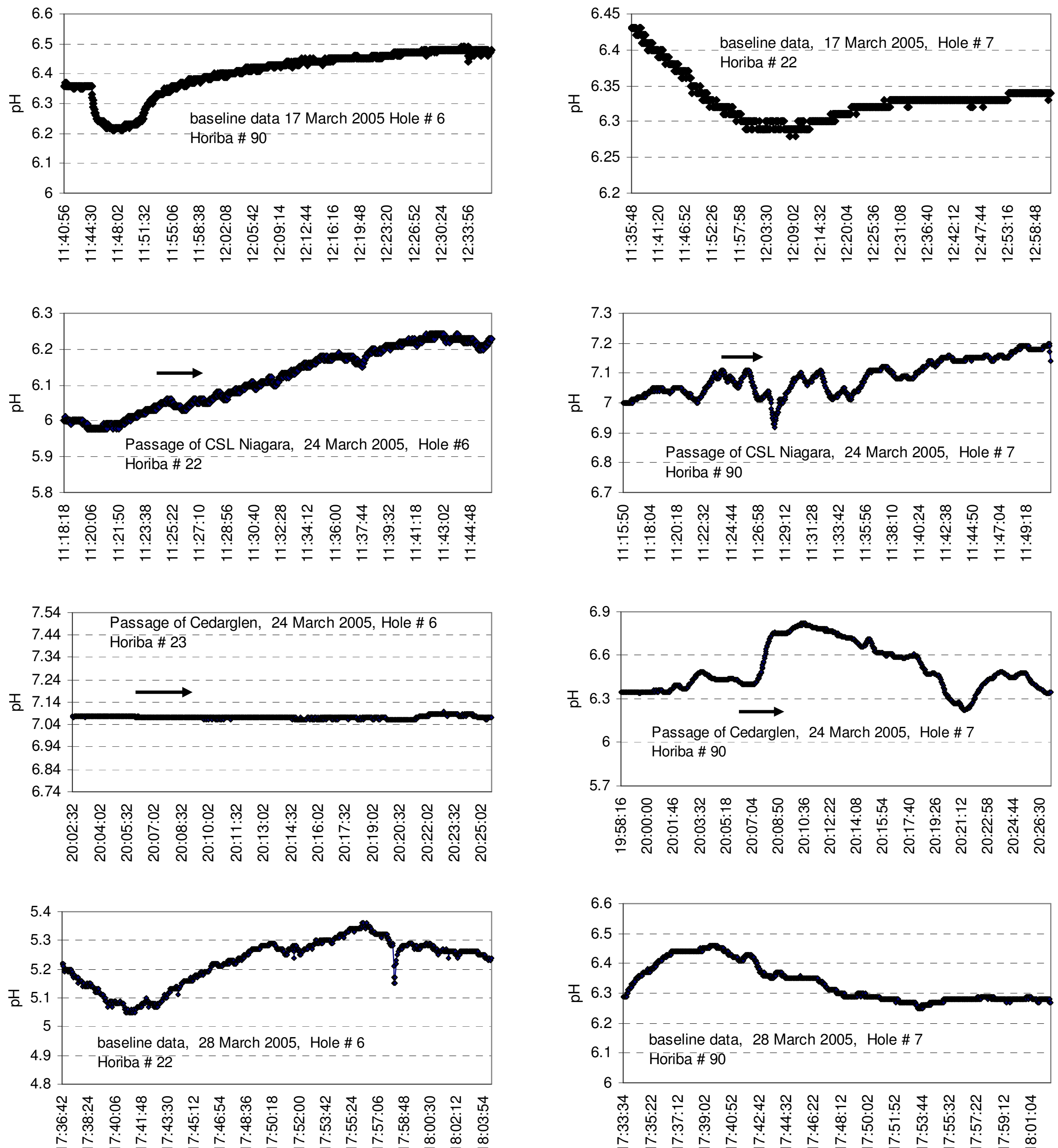
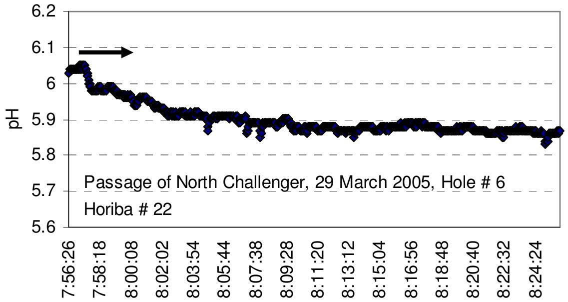


Figure 4. pH values collected during baseline and ship passage events in Cobb Shoal from 17–30 March 2005.



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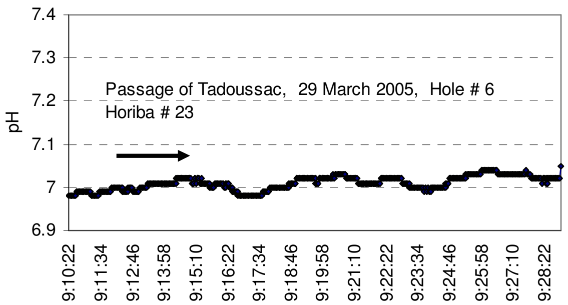

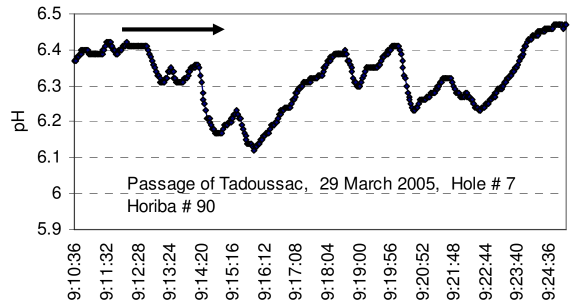

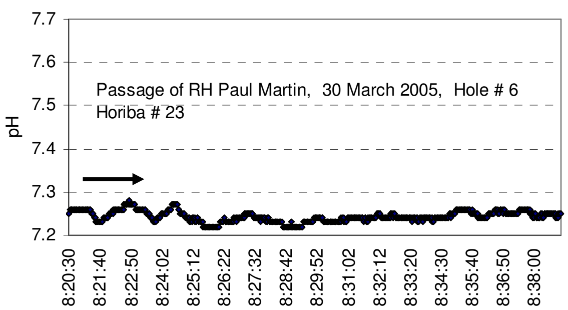

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Figure 4 *continued*. pH values collected during baseline and ship passage events in Cobb Shoal from 17 to 30 March 2005. The North Challenger was not expected as it was not listed on the web site.

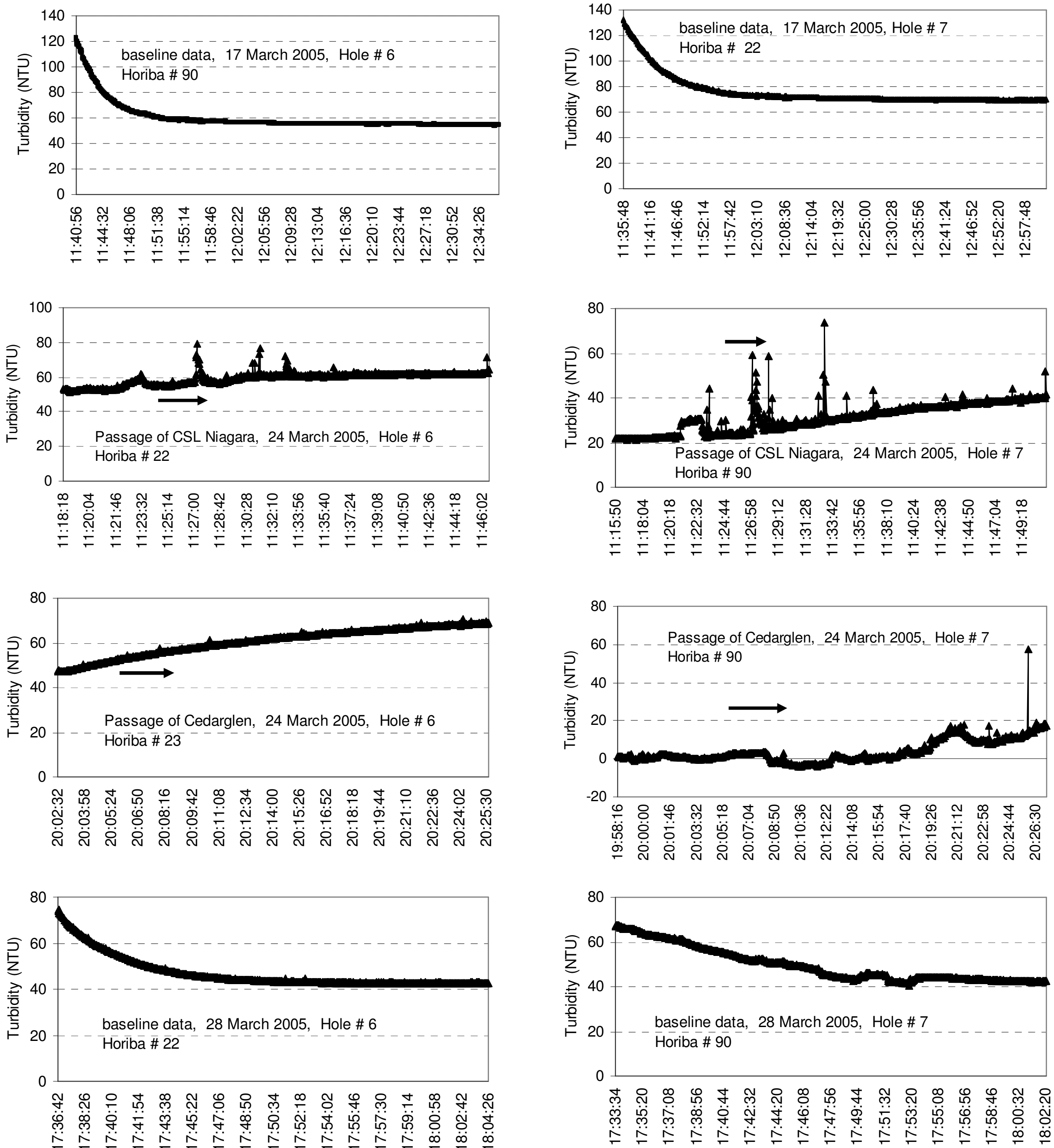
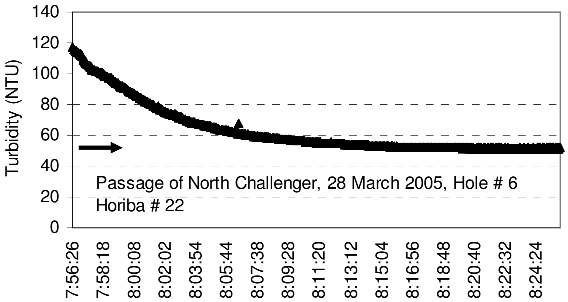


Figure 5. Turbidity values collected during baseline and ship passage events in Cobb Shoal from 17 to 30 March 2005.



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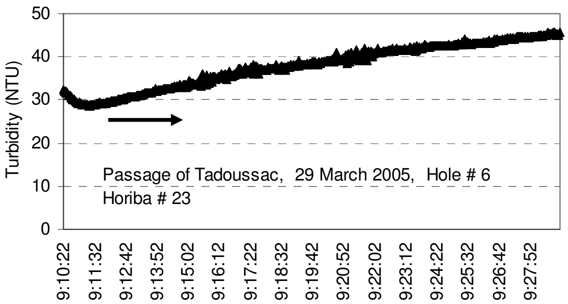

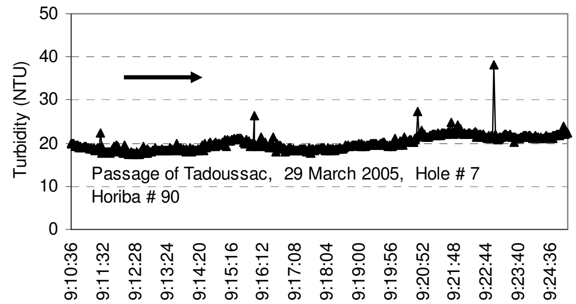

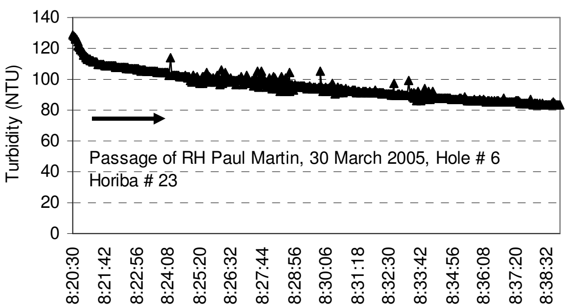

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Figure 5 *continued*. Turbidity values collected during baseline and ship passage events in Cobb Shoal from 17 to 30 March 2005. The North Challenger was not expected as it was not listed on the web site.

Table 3. Summary of water chemistry parameters recorded during monitoring of ships passing Cobb Shoal, 17 March to 1 April 2005. Each triplet contains the mean, standard error of the mean, and one standard deviation of the observations. N = number of observations.

Date	pH	Conductivity (S/m)	Turbidity (NTU)	Dissolved oxygen (mg/l)	Water temperature (ºC)	TDS (mg/l)	ORP (mV)	N
				hole # 6				
17 March,	6.40	0.035	59.99	14.28	0.42	0.228	189.12	1683
baseline	0.0019	8.78E-06	0.278	0.0039	0.001	9.26E-05	0.507	
	0.077	0.00036	11.43	0.162	0.042	0.0038	20.81	
24 March,	6.12	0.037	59.22	11.26	1.31	0.240	390.78	847
Niagara	0.003	8.046E-06	0.127	0.0099	0.004	7.03E-05	0.034	
	0.086	0.00023	3.70	0.29	0.105	0.002	0.98	
24 March,	7.07	0.033	60.60	11.98	0.2	0.21	333.8	692
Cedarglen	0.0003	0	0.235	0.009	0	1.09E-09	0.026	
	0.008	0	6.20	0.231	0	2.88E-08	0.68	
28 March,	5.22	0.036	46.96	11.56	1.21	0.24	328.52	833
baseline	0.003	1.693E-06	0.243	0.016	0.00057	0	0.101	
	0.082	0.0005	7.02	0.461	0.016	0	2.911	
29 March,	5.90	0.037	63.47	10.08	0.79	0.24	320.95	885
North	0.0015	0	0.551	0.028	0.0005	0	0.071	
Challenger	0.04	0	16.39	0.833	0.014	0	2.101	
29 March,	7.01	0.03	37.96	12.69	0.527	0.20	359.69	559
Tadoussac	0.0007	1.961E-10	0.213	0.014	0.002	9.98E-05	0.162	
	0.015	4.64E-09	5.05	0.339	0.044	0.002	3.82	
30 March,	7.24	0.03	95.81	13.64	0.915	0.20	300.2	555
Paul Martin	0.00054	2.002E-10	0.385	0.022	0.002	0	0.104	
	0.013	4.716E-09	9.075	0.521	0.05	0	2.45	
				hole # 7				
17 March,	6.33	0.033	76.04	9.36	0.295	0.214	202.0	1294
baseline	0.00087	1.172E-05	0.337	0.033	0.0011	0.00014	0.644	
	0.031	0.00062	12.11	1.182	0.039	0.005	23.18	
24 March,	7.08	0.040	31.13	14.08	1.821	0.264	242.2	1065
Niagara	0.0017	2.243E-05	0.197	0.0096	0.0005	0.0002	0.067	
	0.057	0.0007	6.43	0.314	0.162	0.005	2.18	
24 March,	6.51	0.047	3.84*	10.57	1.47	0.308	289.78	870
Cedarglen	0.0055	8.55E-05	0.196	0.0194	0.005	0.0005	0.126	
	0.163	0.0025	5.78	0.571	0.16	0.015	3.72	
28 March,	6.33	0.043	49.76	10.65	1.73	0.279	271.34	866
baseline	0.0022	5.663E-05	0.262	0.034	0.0022	0.0004	0.251	
	0.064	0.0017	7.69	0.99	0.064	0.011	7.38	
29 March,	6.32	0.039	20.01	8.04	0.965	0.258	331.16	436
Tadoussac	0.004	4.399E-05	0.086	0.019	0.0023	0.00032	0.178	
	0.084	0.0009	1.80	0.39	0.048	0.0067	3.71	

*included negative values that would make these readings inaccurate.

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Acknowledgments

We thank the St. Lawrence Bridge Authority for providing access across their property at Cobb Shoal Bay, and Karen Lago for bringing the press release to our attention.

Appendices

Appendix table 1. List of ships that passed Cobb Shoal between 17 March and 1 April 2005. Those ships marked with an asterisk were monitored.

Vessel name	status	date and time	size of ship (m)
CSL Niagara*	downbound, empty	24 March 1130	225.5 x 23.8
RH Paul Martin	downbound, empty	24 March 1445	225.5 x 23.7
Cedarglen*	downbound, empty	24 March 2000	166.4 x 22.5
Canadian Enterprise	upbound	27 March 0000	222.5 x 23.13
Atlantic Erie	upbound	28 March 0230	224.5 x 23.12
Menominee	upbound	29 March 0545	153.03 x 20.2
North Challenger*	upbound, empty	29 March 0756	unknown[1]
Tadoussac*	downbound, empty	29 March 0912	222.5 x 22.9
RH Paul Martin*	upbound, empty	30 March 0815	225.5 x 23.7
Halifax	downbound	30 March 2045	222.5 x 22.9
Algosteel	downbound	31 March 2300	222.5 x 22.9
CSL Laurentien	upbound	1 April 2100	225.5 x 23.8
Canadian Navigator	downbound	1 April 1430	222.5 x 22.5

[1]This ship did not appear on the Seaway system tracking web site

Appendix Table 2. The following is a summary of the vessel tracking log using information taken from the Great Lakes Seaway web site (www.greatlakes-seaway.com). Arrival of downbound transits at Cobb Shoal were estimated using 10-14 hours of travel time from the Welland Canal to Cape Vincent and 1.5 hours from Cape Vincent to Cobb Shoal. Arrival of upbound transits at Cobb Shoal were estimated using an average ship speed of 8 mph (includes time in locks) applied to the following distances: 48 miles from Cobb Shoal to Iroquois Lock, 12 miles from Iroquois Lock to Eisenhower Lock, 3.5 miles from Eisenhower Lock to Snell Lock, and 45 miles from Snell Lock to Beauharnois Lock.

Date	*Time*	*Ship tracking notes*
22 March	1930	tugboat Sea Eagle is only boat listed on web site
23 March	1350	CSL Niagara stopped in Welland Canal, Cedarglen delayed
	1900	Niagara is stopped, Cedarglen in transit, Paul Martin in transit at upper end: all in Welland Canal
24 March	0630	Niagara is near Sodus Point, Paul Martin at mid-lake. Niagara should reach Cape Vincent at 1000. Cedarglen is at lower end of Canal
24 March	2230	Cedarglen passed Cobb Shoal at 2000, Vigilant and Algolake at Canal, and John Leitch was at mid-lake, Frontenac entered Canal and is downbound.
25 March	0730	Vigilant, Algolake, and Gordon Leitch are in port, not heading to river
25 March	1600	Frontenac went to port, not heading to river. CSL Laurentien at mid-lake, should pass Cobb Shoal at 9PM (not monitored).
26 March	0630	Canadian Enterprise delayed at CSCL
	1015	Enterprise underway at Cote St. Catherine Lock (CSCL)
	1630	Enterprise at lock 3, Beauharnois; Atlantic Erie at CSCL
	2100	Enterprise delayed at Beauharnois, Atlantic Erie delayed at Point Fortier anchorage.
27 March	0600	Frontenac upbound in Welland Canal, Enterprise and Atlantic Erie delayed at Beauharnois.
	1030	Enterprise expected near Cornwall (C8) at 1200, Atlantic Erie expected at C6/7 at 1140, Stephen B. Roman at mid-lake-upbound, Frontenac in Welland Canal.
	1500	Enterprise expected at Eisenhower Lock (IKE) at 1415, Atlantic Erie expected at Snell Lock at 1417.
	1630	Enterprise arrived at Eisenhower Lock at 1507, Atlantic Erie arrived at Snell Lock at 1513; Enterprise expected at CIP 10/11 at 1630, needs to pass Iroquois Lock + 48 miles to Cobb Shoal, arrival estimated at 2230-2300 (not monitored).
	2130	Enterprise arrived at Iroquois Lock (IRO) at 1830, expected at Crossover Island at 2130, Atlantic Erie expected at Crossover Island at 2310, Tadoussac downbound in Welland Canal, John Leitch at mid-lake.
28 March	0640	Enterprise at mid-lake, Atlantic Erie near Sodus Point, Menominee at Beauharnois, Tadoussac in port.
	1103	Menominee near Snell Lock (about 63 miles from Cobb = 5 hrs or so), John Leitch and Gordon Leitch in Canal, Enterprise and Atlantic Erie near Canal.
	1420	Menominee at CIP 10/11, downstream of Iroquois Lock (estimated to arrive at Cobb near 2000; will be monitored). no Menominee seen at Cobb at 2130 (not monitored)
	2300	Menominee delayed by fog at Prescott anchorage, Stephen B. Roman arrived at mid-lake at 2148, expected at Sodus Point at 2345.

29 March	0545	Menominee close to Cobb Shoal, expected at Cape Vincent at 0815 (cannot reach Cobb Shoal in time to monitor), Tadoussac at Sodus Point and expected at Cape Vincent at 0815 (will be monitored; arrived at 0912), North Challenger passed Cobb at 0756 (unexpected but monitored), not listed on web site.
	1900	RH Paul Martin upriver of Beauharnois (about 83 miles + 3 locks from Cobb), possible to be near Cobb at 0700.
30 March	0430	RH Paul Martin expected at COI at 0720, Cobb around 0830 (will be monitored; arrived at 0815).
	1415	Halifax at mid-lake (MLO), Algosteel leaving Canal, CSL
	1906	Halifax at Cape Vincent, Algosteel at MLO, Niagara at Montreal, UT Viken expected at CIP 3 at 1947, will pass Cobb at 2045 (boat is only 189 m).
31 March	0720	Algosteel at Morrisburg (would have passed Cobb around 2300-0000 on 30 March), Halifax at Massena (would have passed Cobb at 2000-2100 on 30 March. English River (123 m) expected at Sodus Point at 0900, CSL Niagara arrived at Beauharnois at 0322. (Ice weak, no monitoring)
	2100	UTViken at Cornwall, CSL Niagara arrived at SZQ at 2039, CSL Laurentien at Montreal.
1 April	2030	Canadian Navigator at Massena (downbound), Algosteel upbound at Beauharnois, CSL Laurentien upbound at Chippewa Bay at 2019, Cedarglen upbound at TI Bridge at 2019, CSL Niagara upbound at MLO at 2019. (no ice at monitoring holes)