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Portland Islands Clam Flat Technical Assistance Project

Normandeau Associates, Inc.

PORTLAND ISLANDS CLAM FLAT TECHNICAL ASSISTANCE PROJECT

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1.0 INTRODUCTION

The Friends of Casco Bay (FOCB) initiated the Portland Clam Flat Technical Assistance Project as a result of public interest and as a continuation of the work done in West Bath, Yarmouth, Cumberland, Falmouth and the recruitment project conducted on Mackworth Island in association with Dr. Brian Beal of the University of Maine at Machias and the Beals Island Clam Hatchery. The goal of this project is to determine the feasibility of opening clam flats within the city limits of Portland on the city's islands. The opening of a clam flat for harvesting requires several steps:

- a shoreline survey to identify potential sources of pollution.
- water quality testing under normal and adverse conditions to assure there is no threat of fecal contamination
- chemical testing of clam meats to ensure there is no risk to human consumption
- resource surveys to document the levels of harvestable clams.

The report summarizes results of these studies on Portland's Great and Little Diamond Islands, Cliff Island, and Peaks Island.

2.0 HISTORICAL INFORMATION

There is very little historical data concerning the clam flats on the islands within the city limits of Portland. According to Dana Wallace, Maine Department of Marine Resources (MDMR), retired, shoreline surveys and resource surveys were never conducted on the Portland Islands, because the water quality was so poor that the flats could not be opened for harvesting. John Hurst also of the MDMR has stated that the flats have been closed since at least 1951 when he began working for the Department. According to Brad Sterl, former MDMR biologist, clams were last harvested in Lamson Cove just before and during WWII. Incidental information from various island residents has provided evidence that some recreational digging has occurred over the years, but that little if any commercial digging ever took place. Obvious visible signs of pollution and poor water quality were perhaps the biggest deterrents to shellfish harvesting. The major sources of pollution into the Bay have been eliminated, and water quality has greatly improved prompting renewed interest in clamming on the islands.

The Department of Marine Resources requires water quality data to consider the opening of shellfish beds. Water quality samples must produce acceptable results meeting National Shellfish Sanitation Program (NSSP) criteria from thirty samples randomly collected over a period of five years or fifteen samples collected over a three-year period under adverse conditions. Water quality data are reviewed annually by the MDMR and must remain current for shellfish beds to remain open. FOCB has collected water quality samples from Centennial Beach on Peaks Island and at Lamson Cove between Great and Little Diamond Islands since 1993 and from Cliff Island off Northeast Beach since April of 1997 (Appendix A). Data from each of these stations indicated that fecal coliform counts were well within acceptable limits.

A shoreline survey is also required by the MDMR to consider opening a closed shellfish area. Shoreline surveys involve walking the shoreline and inspecting septic systems, identifying potential pollution sources

that could have negative impacts on the water quality of the area. Straight pipes, overboard discharges, land drains, malfunctioning septic systems and farm land usage are a few examples of potential sources of pollution. Any identified problems must be corrected before a flat can be opened. In addition, hydrological features of the surrounding landscape are taken into consideration, as tides, rainfall and wind are factors that can also affect water quality.

Clam tissue samples are also analyzed by the MDMR for fecal bacteria and must meet their criteria to be considered safe for human consumption.

3.0 FIELD METHODS

3.1 SHORELINE SURVEYS

Shoreline surveys were conducted along Centennial Beach on Peaks Island, on Northeast Beach on Cliff Island and along Lamson Cove between Great and Little Diamond Islands by Laura Livingston of the MDMR and staff from Friends of Casco Bay and Normandeau Associates. A 1996 survey of Lamson Cove by staff of FOCB revealed no significant sources of pollution from malfunctioning septic systems, discharge pipes or streams. Centennial Beach was surveyed in August 1997. Two pollution source samples were collected, one sample from a street drain, the other from a source originating from a questionable septic system. Both had fecal counts of 240 mpn, which are within acceptable limits. The presence of a overboard discharge (OBD) pipe near the Trefethern Evergreen Improvement Association building would keep that end of the beach closed to harvesting of shellfish. No other pipes were found during the survey. Northeast Beach on Cliff Island was surveyed September 4, 1997. No violations were observed. A survey of South Beach encountered several OBD's, which would keep this shoreline closed.

3.2 RESOURCE SURVEYS

Normandeau Associates, Inc. with assistance from staff and volunteers from Friends of Casco Bay conducted soft-shell clam, *Mya arenaria*, resource surveys on three islands. Each area was surveyed using a stratified random method, locating sample plots in areas where there were at least 4 - 5 clam holes or, 2 - 3 in areas of very low densities such as on Cliff Island and some areas of Peaks Island. The upper, mid and lower intertidal zones were examined for the presence of clams, and representative plots were sampled in each zone. The 100 ft. grid method often used by the Maine Department of Marine Resources was not appropriate to this survey as densities in most areas were very low. Two-foot-square sample plots were dug to 12 inches where possible and all clams found were measured in 5mm increments (Tables 1,2,3). Additional clams were dug from Centennial Beach and Lamson Cove for contaminant analysis. Collected clams were transported to the office laboratory of the Friends of Casco Bay where they were drained, shucked and frozen in appropriate containers for metals and organics analyses. Samples were shipped via overnight carrier to the Water Research Institute at the University of Maine at Orono.

Chemical constituents were selected for analysis in consultation with Paul Anderson, MDMR, and Andrew Smith, Maine Department of Public Health. A review of DEP's contaminant testing of mussels and clams in Casco Bay along with recently-collected clam data from Searsport suggested that metals, poly-

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Table 1. Density (per 2 ft. sq.) of clams in each length class collected on Cliff Island on August 18, 1997.

	STATION														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SIZE CLASS															
<5mm			0			0								0	
5–10mm															
11–15mm															
16–20mm															
21–25mm															
26–30mm															
31–35mm															
36–40mm															
41–45mm															
46–50mm															
51–55mm				1											
56–60mm		2		1											
61–65mm	1										1				
66–70mm															
71–75mm															
76–80mm															
81–85mm															
86–90mm															
91–95mm															
96–100mm															
101–105mm															
>105mm															
SUM	1	2	0	2	0	0	0	0	0	0	1	0	0	0	0

Table 1. Cliff Island (continued).

	STATION													Harvest.
	16	17	18	19	20	21	22	23	24	25	Ave.	CF*	Bu/Ac**	Bu/Ac
SIZE CLASS											0.0			
<5mm	0				0						0.0			
5–10mm											0.0			
11–15mm											0.0			
16–20mm											0.0	0.55	0.00	
21–25mm											0.0	1.2	0.00	
26–30mm											0.0	2.21	0.00	
31–35mm											0.0	3.68	0.00	
36–40mm											0.0	5.69	0.00	
41–45mm											0.0	8.33	0.00	
46–50mm											0.0	11.67	0.00	
51–55mm											0.1	15.8	1.05	
56–60mm											0.2	20.82	4.16	
61–65mm											0.1	26.8	3.57	
66–70mm											0.0	33.78	0.00	
71–75mm											0.0	41.98	0.00	
76–80mm											0.0	51.36	0.00	
81–85mm											0.0	61.88	0.00	
86–90mm											0.0	74.12	0.00	
91–95mm											0.0	87.6	0.00	
96–100mm											0.0	102.72	0.00	
101–105mm											0.0	119.03	0.00	
>105mm											0.0	137.65	0.00	
SUM	0	0	0	0	0	0	0	0	0	0	0.4		8.79***	8.79****

* Conversion factor for no. of bushels for one clam in that length interval.
** Bushels per acre of average density density of clams
***Total bushels per acre of all clams, all lengths
**** Total bushels per acre of legal–sized clams

Table 2. Density (per 2 ft. sq.) of clams in each length class collected at Centennial Beach, Peaks Island on August 20, 1997.

	STATION																						Harvest.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Ave.	CF*	Bu/Ac	Bu/Ac
SIZE CLASS																								
<5mm	0			0			0							0						0	0.0			
5–10mm																					0.0			
11–15mm													1								0.1			
16–20mm																					0.0	0.55	0.00	
21–25mm																					0.0	1.2	0.00	
26–30mm																					0.0	2.21	0.00	
31–35mm																					0.0	3.68	0.00	
36–40mm					1							1									0.1	5.69	0.57	
41–45mm																					0.0	8.33	0.00	
46–50mm		1			5						1			1						1	0.5	11.67	5.25	
51–55mm		2		1	9			1			4	2								1	1.0	15.8	15.80	
56–60mm	2	1		1	3				1					1							0.5	20.82	9.37	
61–65mm					4			1												1	0.3	26.8	8.04	
66–70mm				3	1						2			1						1	0.4	33.78	13.51	
71–75mm																					0.0	41.98	0.00	
76–80mm																					0.0	51.36	0.00	
81–85mm																					0.0	61.88	0.00	
86–90mm																					0.0	74.12	0.00	
91–95mm																					0.0	87.6	0.00	
96–100mm																					0.0	102.7	0.00	
101–105mm																					0.0	119	0.00	
>105mm																					0.0	137.7	0.00	
Sum	2	4	0	5	23	0	0	2	1	0	7	3	1	3	0	0	0	0	0	4	2.8		52.54	46.72***

*CF=conversion factor for no. of bushels for one clam in that length interval
**Bushels per acre of average density of clams
***Total bushels per acre of all clams, all lengths
****Total bushels per acre of legal–sized clams

Table 3. Density (per 2 ft. sq.) of clams in each length class collected in Lamson Cove on August 20, 1997.

	STATION													Harvest.
	1	2	3	4	5	6	7	8	9	10	Ave.	CF*	Bu/Ac**	Bu/Ac****
SIZE CLASS														
<5mm	0			0			0				0.0		0.00	
5–10mm											0.0		0.00	
11–15mm											0.0		0.00	
16–20mm											0.0	0.55	0.00	
21–25mm											0.0	1.2	0.00	
26–30mm											0.0	2.21	0.00	
31–35mm						1				1	0.2	3.68	0.74	
36–40mm		2		4		1					0.7	5.69	3.98	
41–45mm	3	1		9		3					1.6	8.33	13.33	
46–50mm	1	9	2	4	4	2					2.2	11.7	25.67	
51–55mm	6	5	3	7	5	5				1	3.2	15.8	50.56	
56–60mm	3	1	1	1	5	4					1.5	20.8	31.23	
61–65mm	1	1			3	2				1	0.8	26.8	21.44	
66–70mm						3				1	0.4	33.8	13.51	
71–75mm						1		1			0.2	42	8.40	
76–80mm	1							1	1		0.3	51.4	15.41	
81–85mm											0.0	61.9	0.00	
86–90mm									1		0.0	74.1	0.00	
91–95mm											0.0	87.6	0.00	
96–100mm											0.0	103	0.00	
101–105mm											0.0	119	0.00	
>105mm											0.0	138	0.00	
Sum	15	19	6	25	17	22	0	2	1	4	11.1		184.27**	140.55

*CF= conversion factor for no. of bushels for one clam in that length interval
**Bushels per acre of average density of clams in each length interval
*** total bushels per acre of all clams, all lengths
**** Total bushels per acre of legal–sized clams

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chlorinated biphenols (PCB's), poly-nuclear aromatic hydrocarbons (PAH's) and pesticides were suitable analyses because of the potential for exposure from Casco Bay sediments and their presence in mussel meats. Tributyl tin (TBT) was included because its toxicity level is relatively low. The methods and detection limits are shown in Appendix B.

4.0 RESULTS

4.1 RESOURCE SURVEY

Northeast Beach on Cliff Island is approximately 2500 ft. long and 250 ft. wide at mean low water. Substrate grades from cobble and coarse sand in the upper most intertidal to fine sand/silt in the lower intertidal zone scattered with boulders throughout, providing about 7-8 acres of suitable clam habitat. Mid-way across the beach is a *Fucus* sp.-covered ledge extending perpendicular to the beach in a northerly direction from the upper mid intertidal into the subtidal zone. Eel grass, *Zostera marina*, predominates just below mean low water. Several holes observed and dug assumed to be *Mya arenaria*, were actually *Ensis directus*, or razor clams. Few soft-shell clams were found during this survey as documented in Table 1. A total of 25 samples were dug yielding a total of 6 clams from 4 of those stations, all ranging in size from 55mm to 65mm.

Centennial Beach on the western shore of Peaks Island has coarse to medium sand in the upper beach giving way to fine sand/silt substrate in the lower intertidal, similar to Northeast Beach on Cliff Island but with less ledge and fewer cobbles and boulders. The beach is approximately 2500 feet long and 250 feet wide at mean low water, roughly 16 acres. Extensive eel grass beds occur subtidally. Twenty two-foot-square sample plots were dug. Eleven stations yielded 55 clams, ranging from 15mm to 70mm (Table 2). Most clams were found in the mid-tidal zone in fine to medium sand.

Lamson Cove lies between Great Diamond and Little Diamond Islands on the east side of the causeway connecting the two islands. Our sampling area encompassed the entire cove, but most clams were found on the Great Diamond shore in fine silty muck. The substrate on the Great Diamond side is composed of several types, including ledge near to the Casco Bay Ferry dock, low salt marsh (*Spartina alterniflora*), fine sandy-silt and, *Fucus* sp./mussel beds. Habitats along the causeway include *Spartina*, medium/fine sand/shell hash and small cobble mix, and *Fucus* sp./mussels. Little Diamond Island supports a small coarse to medium sand beach, which then gives way to a silty/mussel bed, and ledge with *Fucus* sp. The southern-most area of Lamson Cove combines *Spartina*, medium sand, shell hash and debris with few clam or worm holes. Ten samples were dug yielding 110 clams from nine stations, which ranged in size from 35mm to 90mm (Table 3).

4.2 CLAM PRODUCTION

Clam densities can be converted to a volumetric estimate using conversion factors developed by Belding (1930) and updated by Newell et al. 1985 in Increasing Clam Harvests in Maine/New Hampshire: A Practical Guide (Table 4). Clam productivity was highest at Lamson Cove, moderate at Peaks Island, and

lowest at Cliff Island. All of the clams collected at Cliff Island were of legal size (>50mm); 89% of the clams were of legal size at Peaks Island and 76% were legal-sized in Lamson Cove.

Table 4. Bushels and harvestable bushels per acre collected at Cliff and Peaks Islands and Lamson Cove in August 1997.

	Bushels/Acre	Harvestable Bushels/Acre
Cliff Island	8.79	8.79
Peaks Island	52.54	46.72
Lamson Cove	184.27	140.55

4.3 CHEMICAL ANALYESES

Preliminary chemical analysis results are presented in Appendix C. None of the tributyl tin compounds were detectable in clam meats. At the request of MDMR, Dr. Andrew Smith, Maine Bureau of Health (BOH) assessed the potential human health risks from clam consumption (Appendix D). The BOH and U.S. Environmental Protection Agency establish "action levels" of chemical constituents in clam tissue that would allow the consumption of one clam meal (8 oz.) per week over a lifetime (70 years) with an incremental lifetime cancer risk of no more than 1-in-a-100,000. Several metals had levels below the fish tissue action level as described by Dr. Smith in his August 14, 1997 review of clams collected at Searsport. These include silver, chromium, cadmium, mercury, selenium, zinc, and nickle. Three parameters exceeded the action level; lead, arsenic, and polycyclic aromatic hydrocarbons (PAHs). Of these, lead was a concern because of the potential for multiple sources of exposure for young children, the most vulnerable to lead effects. The BOH recommends additional sampling to determine spatial and temporal variability. In addition, the BOH recommends an evaluation of the effects of the cooking process, which may alter the concentration levels.

Arsenic levels exceeded the action level, which assumes the inorganic (and more toxic) form composes 5% of the total. However, the BOH indicates it is likely that inorganic arsenic in actuality composes at most 1% of the total arsenic, which would reduce the health risk from consumption. BOH recommends further testing to confirm this.

The PAH levels in clam tissue slightly exceeded the action level, which resulted in a 2-in-a-100,000 incremental lifetime risk. The BOH recommends measurement of PAHs in clams collected from "clean" sites for comparative purposes.

4.4 SEEDING

Given that suitable substrate/habitat is available on all three of the islands, enhancement of the soft-shell fishery in Portland could prove successful. There are several options and methods for seeding clam flats

ranging from very labor intensive to low effort. Dr. Brian Beal, University of Maine at Machias has offered the following suggestions:

1) obtain 250,000 to 500,000 seed clams, 8 - 12mm size
2) broadcast seed at densities of up to 40 clams per square foot
3) protect with netting
4) establish a maintenance program with volunteers

Or

5) start with 1.5 - 3mm clams in April, grow them out in trays until June or July
6) then seed the flat as described above (clams should be ≥15mm by then).

He indicates that survivability of clams improves with increased clam size.
Any method used would require some degree of maintenance.

Costs:

8-12mm seed clams =	$25.00/1000	250,000 clams =	$625.00
1.5 - 3mm seed clams	6.00/1000	250,000 clams	150.00
Netting	.05/ft^2	11,000 ft^2 (¼ac)	545.00

Densities:

250,000 clams at 25 ft^2 = ¼ acre coverage (10,890 ft^2)
Densities can be 5 - 40/ft^2 and broadcast in the sand/mud but not near rock and seaweed
If seeded at densities of 2 - 3 / square foot then netting probably not necessary

5.0 SUMMARY

Shellfish resources were most abundant at Lamson Cove; densities of harvestable clams were moderate on Peaks Island and lowest on Cliff Island. Based on the shoreline and resource surveys, Lamson Cove could be suitable for clam harvest, as could portions of Peaks Island. Resident interest is another important consideration. Seeding could be used to augment existing clam stocks, and would be most effective if volunteers can assist with tending seed clams, broadcasting clams, and installing protective netting. Shoreline surveys revealed no significant sources of pollution on Lamson Cove on Great/Little Diamond Island. Centennial Beach on Peaks Island had two sources of pollution that would necessitate partial closure. Northeast Beach on Cliff Island showed no sources of pollution, but South Beach had several OBD's that would keep that area closed. Water quality samples by FOCB showed no violations of the NSSP criteria. However, the lead levels in clam tissues at Peaks Island and Lamson Cove may pose a potential health risk if consumed, especially for young children. PAH and arsenic levels were also of some concern. The Maine Bureau of Health recommends the following:

1) Issuing a consumption advisory for clams collected from Peaks Island and Lamson Cove, Diamond Islands should DMR choose to open the flats for recreational harvesting. The advisory should recommend that children less than five years of age limit intake of clams to one meal per month.

2) Obtaining additional clam samples from these flats to confirm lead levels, provide information concerning spatial and temporal variability, and to evaluate the effect of typical cooking methods on contaminate concentrations.

3) Conducting the necessary laboratory analyses to speciate arsenic and determine the percent inorganic arsenic in clam tissue.

4) Conducting sampling of "clean sites" to obtain data on background levels of PAHs in clam tissue.

Misc3\portclam

APPENDICES

APPENDIX A. WATER QUALITY DATA

FOCB Fecal Station Report 93-96

		05/18/93			05/19/93			06/16/93			07/21/93			08/18/93			09/15/93			10/20/93			11/17/93	
STATION NAME	STATION #	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL
Peaks Isl., Ferry Term	101.1				HF	28	15	HF	30	2.9	F	30	3.6	HF	30	3.6	F	32	3.6	L	28	3.6	F	30	43
Peaks Isl., Dolphins	101				HF	28	3.6	HF	29	2.9	F	29	3.6	HF	29	1100	F	31	3.6	L	28	3.6	F	30	9.1
Little Diamond Isl., Flats	102				HF	28	3.6	HF	28	2.9	F	27	3.6	HF	30	3.6	HF	31	3.6	L	28	3.6	F	32	3.6
	98				H	30	2.9	HF	26	2.9	F	28	2.9	HF	28	150	HF	31	3.6	L	28	2.9	F	32	3.6
	38	L	29	2.9				HE	31.5	2.9	HF	31	2.9	H	29	93	H	31	9.1	LF	28	9.1	F	32	2.9
	37	L	30	2.9				HE	28	3.6	HF	30	2.9	H	28	240	H	31	3.6	LF	27	2.9	F	32	2.9
	29	LE	29	2.9				HE	30	2.9	HF	32	2.9	HE	29	3.6	H	31	2.9	LF	28	2.9	F	32	3.6
	27.5	LE	30	2.9				E	30	2.9	HF	30	2.9	HE	31	2.9	HE	31	2.9	LF	26	2.9	F	32	2.9
	26	L	30	93				E	27	43	H	23	2.9	HE	17	240	HE	24	93	F	28	93	F	31	2.9
	107				H	26	2.9	E	28	2.9	H	32	9.1	E	29	2.9	E	30	3.6	F	28	2.9	HF	30	240
	41	E	28	2.9				HE	28	2.9	F	30	9.1	E	29	93	H	33	43	F	29	9.1			

		04/14/94			05/12/94			06/09/94			07/07/94			08/18/94			09/08/94			10/06/94			11/03/94	
STATION NAME	STATION #	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL	TIDE	SALINITY	A1COL
Peaks Isl., Ferry Term	101.1	LF	24	23	F	26	2.9	F	30	2.9	F	27	3.6	H	30	240	F	31	3.6	F	32	15	H	32	23
Peaks Isl., Dolphins	101	LF	25	23	F	27	3.6	F	30	2.9	HF	28	2.9	H	30	43	F	31	2.9	F	32	15	H	32	23
Little Diamond Isl., Flats	102	LF	24.5	9.1	F	27	2.9	F	28	2.9	HF	32	3.6	H	29	3.6	F	31	3.6	F	32	23	H	32	43
Diamond Cove, GDI	105	LF	28	2.9	F	28	2.9	F	30	2.9	HF	31	3.6	H	31	3.6	F	31	2.9	F	31	2.9	H	32	9.1
Great Diamond Isl., North End	106	LF	26	2.9	F	25	3.6	HF	29	3.6	HF	28	3	HE	31	2.9	F	31	2.9	F	29	15	H	32	23
	107	LF	22	43	F	26	9.1	HF	28	2.9	H	24	3.6	HE	30	43	F	31	7.3	HF	29	9.1	HE	31	43
Mackworth Isl., South West	10	F	2	1100	F	26	3.6	HF	25	2.9	H	28	9.1	HE	28	43	F	25	23	HF	27	93	HE	31	23
Mackworth Isl., North East	13	F	28	2.9	F	26	2.9	HF	29	2.9	H	29	2.9	HE	26	23	F	31	2.9	HF	30	2.9	HE	31	9.1
Falmouth across from Brothers	15	F	27	2.9	F	24	9.1	HF	30	23	HE	28	2.9	E	28	43	F	31	2.9	HF	31	2.9	HE	30	2.9
Prince Point	17	F	28	3.6	F	26	3.6	H	30	2.9	HE	30	23	E	25	460	F	31	2.9	HF	29	2.9	HE	31	2.9
Bartlett Point (Mussel Cove)	19	F	27	2.9	F	27	2.9	H	30	2.9	HE	30	2.9	E	27	23	F	29	3	HF	29	3.6	HE	32	23
Mill Creek (Mussel Cove)	20	F	25	3.6	HF	26	2.9	H	29	2.9	HE	30	3	E	27	1100	F	31	2.9	HF	32	2.9	E	31	2.9
Handy Boat	24	F	25	3.6	HF	27	3.6	HE	30	2.9	E	30	2.9	E	25	1100	F	31	2.9	HF	32	2.9	E	32	3.6
Falmouth Town Landing	25	F	28	2.9	HF	26	3.6	HE	30	2.9	E	26	3.6	E	27	43	F	31	2.9	H	32	9.1	E	32	21
Underwood	26	F	27	2.9	HF	26	3.6	HE	30	2.9	E	25	1100	E	27	93	F	31	9.1	H	32	43	E	32	9.1

93-96.WK4

08/12/97

STATION NAME	STATION #	TIDE	04/27/95 SALINITY	A1COL	TIDE	05/25/95 SALINITY	A1COL	TIDE	06/29/95 SALINITY	A1COL	TIDE	07/27/95 SALINITY	A1COL	TIDE	08/24/95 SALINITY	A1COL	TIDE	09/28/95 SALINITY	A1COL	TIDE	10/12/95 SALINITY	A1COL	TIDE	11/27/95 SALINITY	A1COL
Peaks Isl., Ferry Term	101.1	F	31	3.6	H	31	2.9	F	32	2.9	F	30	43	HF	31	3.6	LF	32	2.9	F	31	3.6	F	26.3	2.9
Peaks Isl., Dolphins	101	HF	31	1100	H	31	2.9	F	32	2.9	F	30	9.1	HF	31	2.9	F	32	3.6	F	31	2.9	F	26.5	3.6
Little Diamond Isl., Flats	102	HF	31	3.6	H	31	2.9	F	32	3.6	F	30	2.9	H	31	4.3	F	32	2.9	F	31	2.9	F	27	2.9
Diamond Cove, GDI	105	HF	31	2.9	H	32	2.9	F	32	2.9	F	30	9.1	H	32	2.9	F	32	2.9	F	32	3.6	F	28.5	2.9
Great Diamond Isl., North End	106	HF	31	3.6	H	31	2.9	F	32	2.9	HF	29	7.3	H	31	2.9	F	32	2.9	F	31	2.9	F	28.3	7.3
Mackworth Isl., South West	10	HF	28	9.1	HE	31	2.9	F	32	9.1	HF	27	93	HE	30	23	F	30	23	F	26	9.1	F	13.6	23
Mackworth Isl., North East	13	H	31	2.9	HE	31	2.9	F	32	2.9	HF	29	3.6	HE	30	2.9	F	32	3.6	F	31	2.9	F	28.5	7.3
Mackworth Dolphins	12	H	31	2.9	HE	30	2.9	HF	31	9.1	HF	29	9.1	HE	31	2.9	F	32	11	F	31	7.3	F	26.8	23
Dock at Mackworth flats	14	H	31	9.1	HE	32	7.3	HF	31	2.9	HF	31	2.9	HE	27	2.9	F	32	9.1	F	32	2.9	F	28	2.9
Falmouth across from Brothers	15	H	31	2.9	HE	32	2.9	HF	31	2.9	HF	30	2.9	HE	31	2.9	F	32	3	F	31	2.9	F	28.2	2.9
Clapboard	24.5	H	31	2.9	E	32	2.9	HF	31	3.6	HF	30	2.9	E	31	2.9	F	32	9.1	F	31	2.9	F	28.3	43
Prince Point	17	HE	31	2.9	E	32	3	HF	31	2.9	H	29	150	E	31	3.6	F	32	2.9	F	30	2.9	F	28	2.9
Bartlett Point (Mussel Cove)	19	HE	31	2.9	E	31	9.1	HF	32	2.9	H	30	11	E	31	2.9	F	32	2.9	F	31	2.9	F	28.6	23
Mill Creek (Mussel Cove)	20	HE	31	2.9	E	31	3.6	H	32	2.9	H	30	23	E	31	2.9	F	32	2.9	F	31	2.9	F	28.6	3.6
Handy Boat	24	HE	31	2.9	E	31	2.9	H	32	2.9	H	30	23	E	31	2.9	HF	32	2.9	HF	31	2.9	HF	28.1	43
Falmouth Town Landing	25	HE	31	2.9	E	32	2.9	H	32	2.9	H	31	2.9	E	31	2.9	HF	32	3.6	HF	31	3.6	HF	28.2	7.3
Underwood	26	HE	31	2.9	E	31	9.1	H	32	2.9	H	30	15	E	31	3.6	HF	32	75	HF	30	7.3	HF	28	7.3

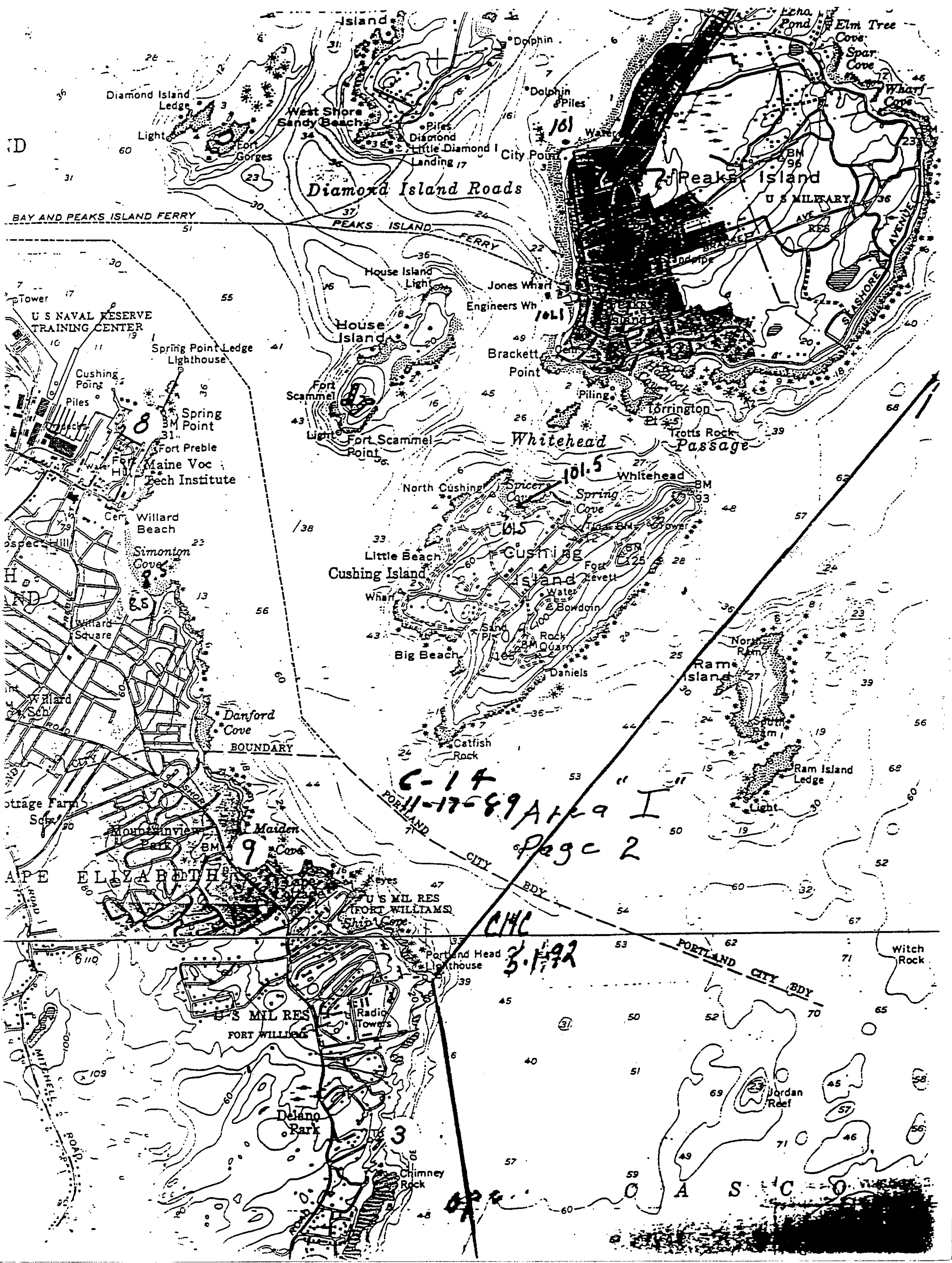
STATION NAME	STATION #	TIDE	05/15/96 SALINITY	A1COL	TIDE	05/30/96 SALINITY	A1COL	TIDE	06/27/96 SALINITY	A1COL	TIDE	08/13/96 SALINITY	A1COL	TIDE	08/27/96 SALINITY	A1COL	TIDE	09/24/96 SALINITY	A1COL	TIDE	10/15/96 SALINITY	A1COL	TIDE	11/07/96 SALINITY	A1COL
Simonton Cove	8.5	HF	28.2		HF	30	3.6	H	29.5	3.6	F	29.6	43	F	29.9	75	H	30.4	2.9	F	31	2.9	HE	29.4	3.6
Cushing Isl., Spicers Cove	101.5	HF	28.6		H	31	3.6	HE	33	2.9	F	29.9	3.6	F	29.8	43	H	30.4	2.9	F	31	3.6	HE	30.9	23
Peaks Isl., Ferry Term.	101.1	HF	27.7	3.6	H	30	3.6	HE	32.9	2.9	F	29.9	15	F	30.4	23	HE	30.1	2.9	F	31	2.9	HE	30.4	3.6
Peaks Isl., Dolphins	101	H	27.1	3.6	H	30	3.6	HE	32.6	2.9	F	29.4	2.9	F	30	43	HE	30.1	2.9	F	31.2	2.9	HE	29.9	9.1
Little Diamond Isl., flats	102	H	27	2.9	H	30	2.9	HE	33.5	3.6	F	29.9	3.6	F	29.1	23	HE	29.4	3.6	F	31.2	3.6	HE	29.2	9.1
Diamond Cove, GDI	105	H	28.6	2.9	H	30	3.6	HE	33.3	2.9	HF	29.4	3.6	HF	30.7	2.9	HE	30.6	2.9	F	31.2	2.9	HE	31	3.6
Great Diamond Isl., North End	106	H	26.2	2.9	H	30	2.9	HE	32.2	2.9	HF	28.4	7.3	HF	29.9	9.1	HE	29.9	9.1	F	31	2.9	HE	29.8	3.6
Mackworth Isl., South West	10	H	18.5	23	HE	25	15	HE	20.5	9.1	HF	27.6	23	HF	28.8	43	HE	27.3	2.9	F	28.4	3.6	E	22.2	23
Mackworth Isl., North East	13	HE	27.9	2.9	HE	26	9.1	E	31.9	2.9	HF	28.8	2.9	HF	29.4	9.1	E	29.7	9.1	F	31	3.6	E	28.2	43
Mackworth Dolphins	12	HE	23.8	9.1	HE	28	23	E	30.5	3.6	HF	29	2.9	HF	29	3.6	E	29.9	9.1	F	31	3.6	E	29.4	43
Dock at Mackworth flats	14	HE	24	36	E	29	3.6	E	32.1	2.9	H	29	3.6	HF	29.8	3.6	E	30.1	3.6	F	30.8	3.6	E	28.3	21
Falmouth across from Brothers	15	HE	26.2	2.9	E	29	2.9	E	32.5	3.6	H	27.4	2.9	HF	30.1	2.9	E	30.2	3.6	F	31.2	2.9	E	28.8	15
Clapboard	24.5	HE	28	2.9	E	30	23	E	32.2	23	H	29.6	2.9	H	29.9	9.1	E	30.6	9.1	F	31	2.9	E	30.2	9.1
Prince Point	17	E	27.8	9.1	E	30	93	E	32	43	H	29.6	2.9	H	30.1	3.6	E	30	93	F	30.8	2.9	E	28.2	7.3
Bartlett Point (Mussel Cove)	19	E	28.3	2.9	E	30	210	E	32.1	2.9	H	29.2	2.9	H	29.7	1100	E	27.3	15	F	30.8	3.6	E	30	9.1
Mill Creek (Mussel Cove)	20	E	23.2	2.9	E	30	3	E	31.9	9.1	H	29.4	2.9	H	30.2	2.9	E	30.3	2.9	HF	31.8	2.9	E	29.2	2.9
Handy Boat	24	E	31	2.9	E	30	23	E	32	3.6	HE	29.4	7.3	H	30	43	E	30.8	43	HF	31.2	2.9	E	29.9	9.1
Falmouth Town Landing	25	E	31	2.9	E	30	43	E	32.2	3.6	HE	29.2	9.1	HE	30	3.6	E	30.8	3.6	HF	31	2.9	E	30	2.9
Underwood	26	E	29	43	E	30	15	E	31.3	2.9	HE	27.8	9.1	HE	30	240	E	28.7	9.1	HF	30.8	2.9	E	29.4	3.6

FOCB Fecal Station Report 97

STATION NAME	STATION #	TIDE	04/08/97 SALINITY	A1COL	TIDE	05/08/97 SALINITY	A1COL	TIDE	06/17/97 SALINITY	A1COL	TIDE	07/22/97 SALINITY	A1COL
Willard Beach	8.5	F	*	*	F	30	2.9	H	29	23	F	20	3.6
Cushing Isl., Spicers Cove	101.5	F	32	2.9	F	30	3.6	H	30	9.1	F	31	2.9
Peaks Isl., Ferry Term.	101.1	F	31	3.6	F	31	2.9	H	30	3.6	F	31	2.9
Peaks Isl. Dolphins	101	F	30	3.6	F	30	3.6	H	29	2.9	F	31	3.6
Little Diamond Isl. flats	102	F	31	23	F	30	2.9	H	28	23	F	31	3.6
Peaks Isl., Trefethen	103	F	31	3.6	F	30	2.9	H	29	2.9	F	31	2.9
Diamond Cove, GDI	105	F	32	2.9	F	31	2.9	HE	29	7.3	F	31	2.9
Great Diamond Isl., North End	106	F	30	3.6	F	30	2.9	HE	28	2.9	F	31	2.9
Cliff Isl., SW End	110	F	33	2.9	F	31	2.9	HE	29	2.9	F	32	2.9
Cliff Isl., Mid Island West Side	109	F	32	2.9	F	31	2.9	HE	29	2.9	F	32	2.9
Cliff Isl., NE End (Sand Isl. side)	108	F	33	2.9	F	30	2.9	HE	29	2.9	F	32	2.9
Cliff Isl., NE End (Bates Isl. side)	113	F	33	2.9	F	31	2.9	HE	29	2.9	HF	32	2.9
Jewell Isl., Coctail Cove	115	F	33	3.6	F	30	2.9	E	29	2.9	HF	32	2.9
Cliff Isl., Boat Cove	112	F	*	*	HF	31	3.6	E	*	*	HF	32	3.6
Cliff Isl., SE End	111	F	*	*	HF	31	2.9	E	*	*	HF	32	2.9
Jewell Isl., SW End (Tower)	114	N/A	N/A	N/A	HF	31	2.9	E	*	*	HF	32	2.9
Clapboard	24.5	HF	32	16	HF	30	240.0	E	29	2.9	H	32	2.9

4/8/97 SITE # 114 NO SAMPLE DUE TO BAD WEATHER

* = NO DATA RECEIVED FROM LAURA AS OF 8/14/97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Light
Fort Gorges
West Shore Sandy Beach
Dolphin
Dolphin Piles
Piles
Diamond
Little Diamond I
Landing
City Point
Diamond Island Roads
Peaks Island
U S MILITARY RES
SEASHORE AVENUE
Echo Pond
Elm Tree Cove
Spar Cove
Wharf Cove
BAY AND PEAKS ISLAND FERRY
PEAKS ISLAND FERRY
House Island Light
House Island
Jones Wharf
Engineers Wh
Fort Scammel
Light
Fort Scammel Point
Brackett Point
Piling
Torrington Pt
Trotts Rock
Whitehead Passage
Whitehead
U S NAVAL RESERVE TRAINING CENTER
Tower
Spring Point Ledge Lighthouse
Cushing Point
Piles
Spring Point
Fort Preble
Maine Voc Tech Institute
Willard Beach
Simonton Cove
Willard Square
North Cushing
Spicer Cove
Spring Cove
Cushing Island
Fort Levett
Little Beach
Wharf
Sand Pit
Rock Quarry
Big Beach
Daniels
North Ram
Ram Island
South Ram
Catfish Rock
Ram Island Ledge
Light
Danford Cove
BOUNDARY
Maiden Cove
Mountainview Park
CAPE ELIZABETH
Keyes
U S MIL RES (FORT WILLIAMS)
Ship Cove
Portland Head Lighthouse
PORTLAND CITY BDY
Witch Rock
U S MIL RES
FORT WILLIAMS
Radio Towers
Jordan Reef
Delano Park
Chimney Rock
MITCHELL ROAD
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11-17-49 Area I
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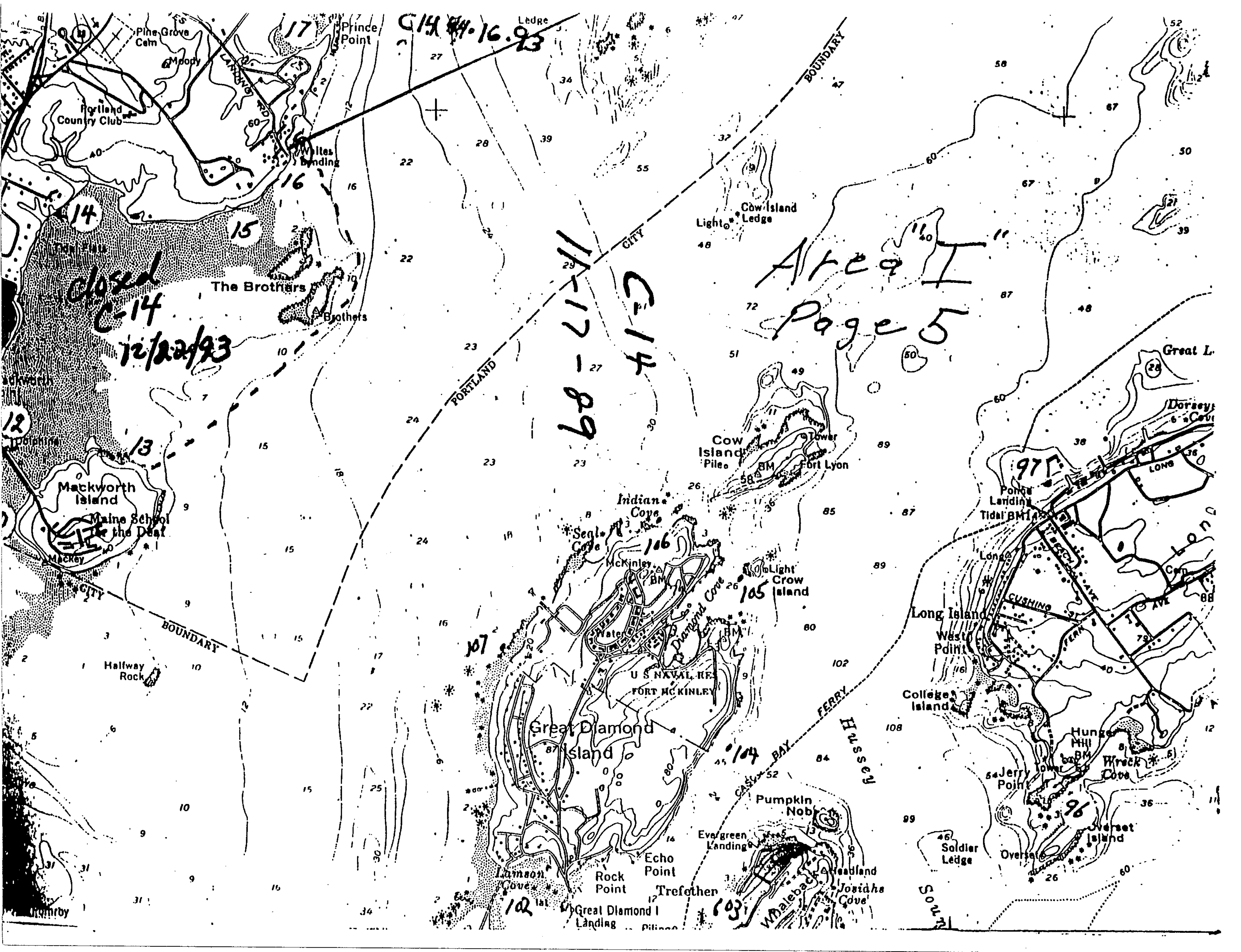

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Area I
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Closed
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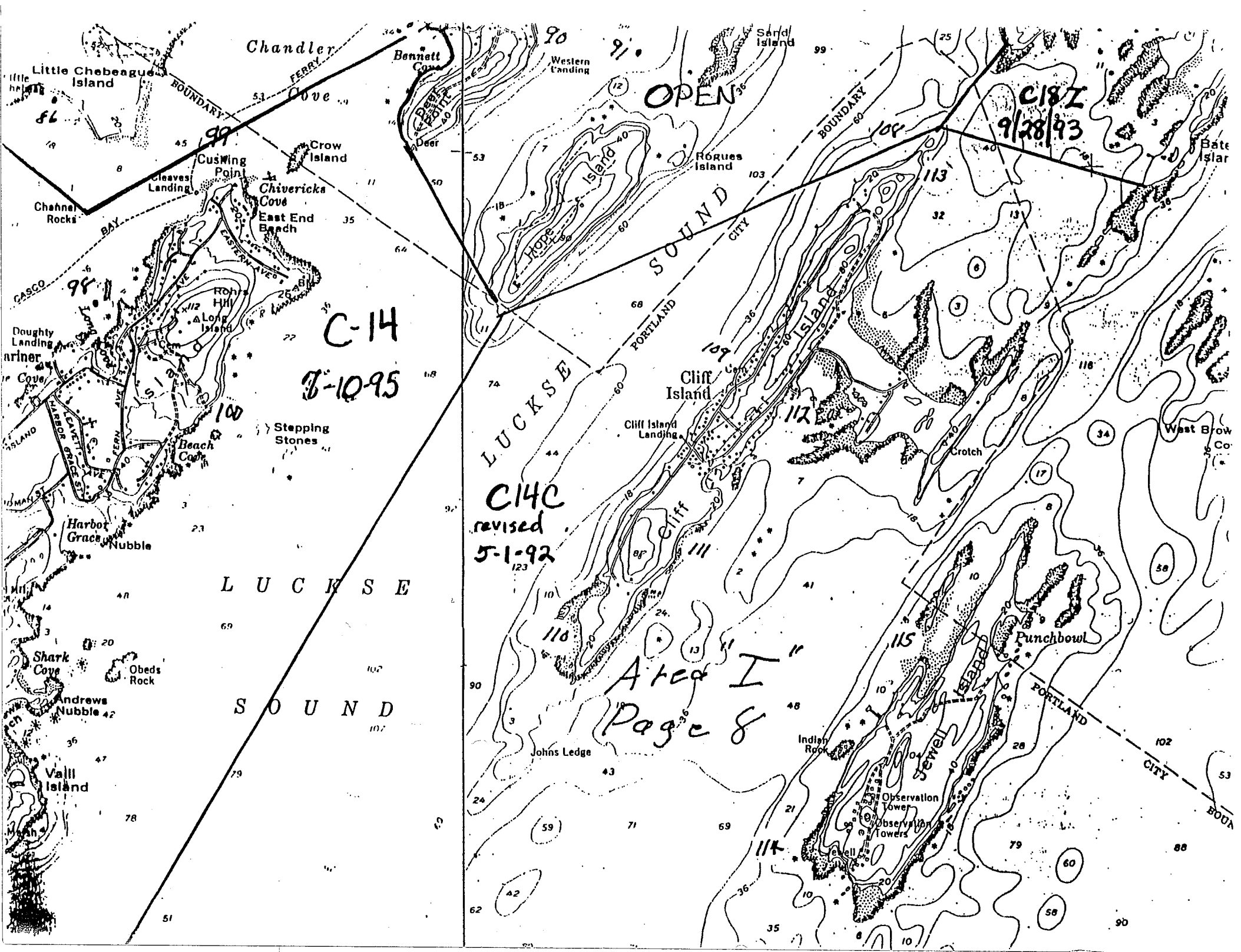
Pine Grove Cem
Moody
Portland Country Club
Landing Rd
Prince Point
Whites Landing
Ledge
The Brothers
Brothers
Tidal Flats
Mackworth Island
Maine School for the Deaf
Mackey
Dolphins
Halfway Rock
Portland City Boundary
Cow Island Ledge
Light
Cow Island
Pile
Tower
Fort Lyon
Indian Cove
Seal Cove
McKinley
Crow Island
Light
Diamond Cove
U S NAVAL RES
FORT MC KINLEY
Great Diamond Island
Lamson Cove
Rock Point
Echo Point
Trefethen
Great Diamond I Landing
Pilings
Evergreen Landing
Pumpkin Nob
Headland
Josiahs Cove
Whaleback
Casco Bay Ferry
Hussey
Great L.
Dorseys Cove
Long
Ponce Landing
Tidal BM
Cushing
Beach Ave
Fern
Long Island
West Point
College Island
Hunger Hill
Wreck Cove
Jerry Point
Tower
Overset Island
Overset
Soldier Ledge
South


Chandler
Little Chebeague Island
BOUNDARY
FERRY
Bennett Co
Deer Point
Deer
Crow Island
Cushing Point
Cleaves Landing
Chivericks Cove
East End Beach
Channel Rocks
BAY
CASCO
EASTERN AVE
Rohr Hill
Long Island
Doughty Landing
Cove
HARBOR GRACE ST
Stepping Stones
Beach Cove
Harbor Grace Nubble
LUCKSE
SOUND
Shark Cove
Obeds Rock
Andrews Nubble
Vaill Island
Western Landing
OPEN
Sand Island
Rogues Island
Hope Island
CITY
PORTLAND
Cliff Island
Cliff Island Landing
Cliff
Crotch
Johns Ledge
Indian Rock
Jewell Island
Observation Tower
Observation Towers
Punchbowl
West Brow
C-14
B-10-95
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Area I
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APPENDIX B. CHEMICAL METHODS AND DETECTION LIMITS

Organic Analysis Methods

The following table lists the procedures used and detection limits for analyzing organic compounds in tissues.

Analytes	EPA Method	Description	Detection limits
PAHs	8270B/C[2]	GCMS	50 ng/g (ppb) all compounds
PCBs			
Low resolution	8082[2]	GC/GCMS	1 ng/g (ppb) all congeners
High resolution (coplanars)	1668[4]	HRGC/HRMS	1 pg/g (ppt) all congeners
Pesticides			
	8081A/8270B/C[2]	GC/GCMS	
Hexachlorobenzene			1 ng/g (ppb)
Lindane			1 ng/g (ppb)
Heptachlor			1 ng/g (ppb)
Aldrin			1 ng/g (ppb)
Heptachlor Epoxide			1 ng/g (ppb)
Gamma-chlordane			1 ng/g (ppb)
Alpha-chlordane			1 ng/g (ppb)
Trans-nonachlor			1 ng/g (ppb)
Dieldrin			1 ng/g (ppb)
Endosulfan I and II			1 ng/g (ppb)
Mirex			5 ng/g (ppb)
DDD, both isomers			5 ng/g (ppb)
DDE, both isomers			5 ng/g (ppb)
DDT, both isomers			5 ng/g (ppb)
Dioxin/Furans	1613B(mod)[3]	HRGC/HRMS	
TCDD/TCDF			0.1 pg/g (ppt)
PeCDD/PeCDF			0.5 pg/g (ppt)
HxCDD/HxCDF			0.5 pg/g (ppt)
HpCDD/HpCDF			0.5 pg/g (ppt)
OCDD/OCDF			1.0 pg/g (ppt)
Butyltin			5 ng/g (ppb) each compound
4BT			
TBT			
DBT			
MBT			

Butyltin to be subcontracted to West Coast Analytical Services Santa Fe Springs CA or equivalent.

Trace Metal Analysis

Methods

The following table lists the procedures used and detection limits for analyzing trace metals in fish tissue.

Analyte	Method	Description	Detection Limit (mg/Kg)
Ag	7761[2]	GFAAS	0.06
Al	7040[2]	GFAAS	0.25
As	7060A[2]	GFAAS	0.05
Cd	7131A[2]	GFAAS	0.012
Cr	7191[2]	GFAAS	0.06
Cu	7211[2]	GFAAS	0.25
Fe	7381[2]	GFAAS	0.25
Pb	7421[2]	GFAAS	0.05
Hg	245.6[1]	CVAAS	0.0025
Ni	7521[2]	GFAAS	0.10
Se	7740[2]	GFAAS	0.05
Zn	7951[2]	GFAAS	1.25
Digestion	3050B[2]	Metals digestion	NA

Notes:
Trace metals are analyzed on a THGA furnace as a result furnace temperatures and modifiers may be changed from the method to the manufacturers recommended conditions.
Flame AA may be used if analyte concentration exceeds the appropriate range for graphite furnace analysis.

Organic Analysis

Methods

The following table lists the procedures used and detection limits for analyzing organic compounds in tissues.

Analytes	EPA Method	Description	Detection limits
PAHs	8270B/C[2]	GCMS	50 ng/g (ppb) all compounds
PCBs			
Low resolution	8082[2]	GC/GCMS	1 ng/g (ppb) all congeners
High resolution (coplanars)	1668[4]	HRGC/HRMS	1 pg/g (ppt) all congeners
Pesticides			
	8081A/8270B/C[2]	GC/GCMS	
Hexachlorobenzene			1 ng/g (ppb)
Lindane			1 ng/g (ppb)
Heptachlor			1 ng/g (ppb)
Aldrin			1 ng/g (ppb)
Heptachlor Epoxide			1 ng/g (ppb)
Gamma-chlordane			1 ng/g (ppb)
Alpha-chlordane			1 ng/g (ppb)
Trans-nonachlor			1 ng/g (ppb)
Dieldrin			1 ng/g (ppb)
Endosulfan I and II			1 ng/g (ppb)
Mirex			5 ng/g (ppb)
DDD, both isomers			5 ng/g (ppb)
DDE, both isomers			5 ng/g (ppb)
DDT, both isomers			5 ng/g (ppb)
Dioxin/Furans	1613B(mod)[3]	HRGC/HRMS	
TCDD/TCDF			0.1 pg/g (ppt)
PeCDD/PeCDF			0.5 pg/g (ppt)
HxCDD/HxCDF			0.5 pg/g (ppt)
HpCDD/HpCDF			0.5 pg/g (ppt)
OCDD/OCDF			1.0 pg/g (ppt)
Butyltin			5 ng/g (ppb) each compound
4BT			
TBT			
DBT			
MBT			

Butyltin to be subcontracted to West Coast Analytical Services Santa Fe Springs CA or equivalent.

APPENDIX C. PRELIMINARY CHEMICAL RESULTS

UNIVERSITY OF MAINE

Water Research Institute

5764 Sawyer Research Center
Orono, Maine 04469-5764
Tel: 207 581-3244
Fax: 207 581-3290
e-mail: wrilines@maine.maine.edu

Data for Normandeau Associates Inc. Clam tissue project.
Each Sample was homogenized prior to analysis.

Peaks Island 12.3 % solids
Lamson Cove 19.6 % solids

Samples reported on a wet weight basis.

Analyte	Lamson Cove (mg/Kg)	Peak's Island (mg/Kg)
Ag	0.17	0.07
Al	250	159
As	1.98	1.22
Cd	0.03	<0.012
Cr	1.56	1.75
Cu	3.54	2.66
Fe	345	1150
Hg	0.066	0.065
Ni	2.04	1.18
Pb	0.81	1.02
Se	0.47	0.36
Zn	13.1	14.9

Samples reported as received on a dry weight basis.

Analyte	Lamson Cove (mg/Kg)	Peak's Island (mg/Kg)
Ag	0.88	0.58
Al	1276	1293
As	10.1	9.9
Cd	0.15	<0.098
Cr	8.0	14.2
Cu	18.1	21.6
Fe	1760	9350
Hg	0.34	0.53
Ni	10.4	9.6
Pb	4.1	8.3
Se	2.4	2.9
Zn	66.8	121

UNIVERSITY OF MAINE

Water Research Institute

5764 Sawyer Research Center
Orono, Maine 04469-5764
Tel: 207/581-3244
Fax: 207/581-3290
e-mail: wrilines@maine.maine.edu

Method Detection Limits for analytes. Detection limits are listed on an as received basis and calculated for % solids for each site.

Analyte	Detection Limit as received mg/Kg	Detection Limit dry wt Lamson Cove mg/Kg	Detection Limit dry wt Peaks Island mg/Kg
Ag	0.03	0.15	0.24
Al	0.25	1.28	2.03
As	0.05	0.26	0.41
Cd	0.012	0.061	0.098
Cr	0.06	0.31	0.49
Cu	0.25	1.28	2.03
Fe	0.25	1.28	20.3
hg	0.0025	0.0128	0.0203
Ni	0.1	0.51	0.8
Pb	0.05	0.26	0.41
Se	0.05	0.26	0.41
Zn	1.25	6.38	10.2

Organotin Data for Normandeau Associates Clam Tissue Samples
ug/Kg wet weight

	monobutyl tin	Dibutyl tin	Tributyl tin	Tetrabutyl tin
Lamson Cove	ND	ND	ND	ND
Peaks Island	ND	ND	ND	ND

ND= not detected at a detection limit of 5 ug/Kg

APPENDIX D. HUMAN HEALTH ASSESSMENT OF CLAM TISSUE

Table 1. Shellfish tissue levels and clam tissue monitoring data (wet weight)

Toxicant	Action Level	Lamson Cove	Peaks Island	Units (wet wt)
Organics				
Total PCBs	11	0.9	0.63	ug/kg
Carcinogenic PAHs	3	6.4	4.4	ug/kg
Anthracene	656	18.4	0.5*	ug/kg
Acenapthene	131	5.6	0.5*	ug/kg
Fluoranthene	88	14.9	9.92	ug/kg
Fluorene	88	8.2	0.5	ug/kg
Napthalene	88	15.6	1.4	ug/kg
Pyrene	66	8.4	10.1	ug/kg
Hexachlorobenzene	13.7	0.5*	0.5*	ug/kg
Heptachlor	4.9	0.5*	0.5*	ug/kg
Aldrin	1.3	0.5*	0.5*	ug/kg
Mirex	12.2	0.5*	0.5*	ug/kg
Lindane	16.8	0.5*	0.5*	ug/kg
Heptachlor Epoxide	2.4	0.5*	0.5*	ug/kg
Chlordane/Nonachlor	16.8	0.5*	0.5*	ug/kg
Dieldrin	1.4	0.5*	0.5*	ug/kg
Endosulfan	13.1	0.5*	0.5*	ug/kg
Metals				
Arsenic [a]	0.02	0.1	0.06	mg/kg
Aluminum	NA	2.5	1.59	mg/kg
Cadmium	2.2	0.03	0.006	mg/kg
Chromium [b]	10.9	1.56	1.75	mg/kg
Copper	NA	3.54	2.66	mg/kg
Lead [c]	0.6	0.81	1.02	mg/kg
Mercury	0.2	0.066	0.065	mg/kg
Nickel	43.8	2.04	1.18	mg/kg
Silver	10.9	0.17	0.07	mg/kg
Selenium	10.9	0.47	0.36	mg/kg
Tributyltin**	0.66	0.0025*	0.0025*	mg/kg
Zinc	656	13.1	14.9	mg/kg

* 1/2 Det. Limit **RfD for Tributyltin oxide

[a] Arsenic RsD is for inorganic form. Seafood tends to have an organic arsenic form. . Estimates are that <5% of total seafood As is inorganic

[b] Chromium RfD is for most toxic form, Cr VI.

[c] Lead fish tissue action level derived using EPA's biokinetic model, that accounts for exposure to other sources (e.g. diet, water, soil, air).

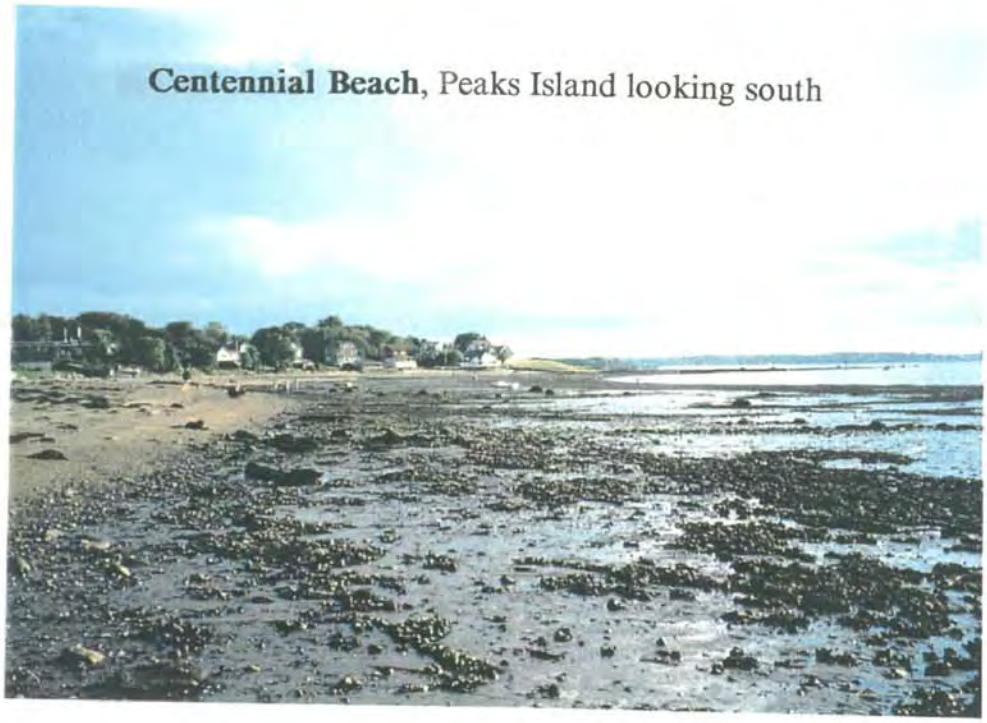
Table 2. Age Specific Results from IEUBK Modeling of Blood Lead When Consuming One Meal per Week of Clams

AGE (years)	Percent Population with Blood Lead Greater Than 10 µg/dL		
	Baseline	Lamson Cove	Peaks Island
1 to 2 years	4%	11%	13%
2 to 3 years	3%	10%	12%
3 to 4 years	3%	9%	11%
4 to 5 years	1%	5%	7%
5 to 6 years	0.5%	4%	5%
6 to 7 years	0.3%	3%	4%

APPENDIX E - PHOTOS


GREAT DIAMOND ISLAND
PEAKS ISLAND
Lamson Cove
Centennial Beach
LITTLE DIAMOND ISLAND

Centennial Beach, Peaks Island looking south

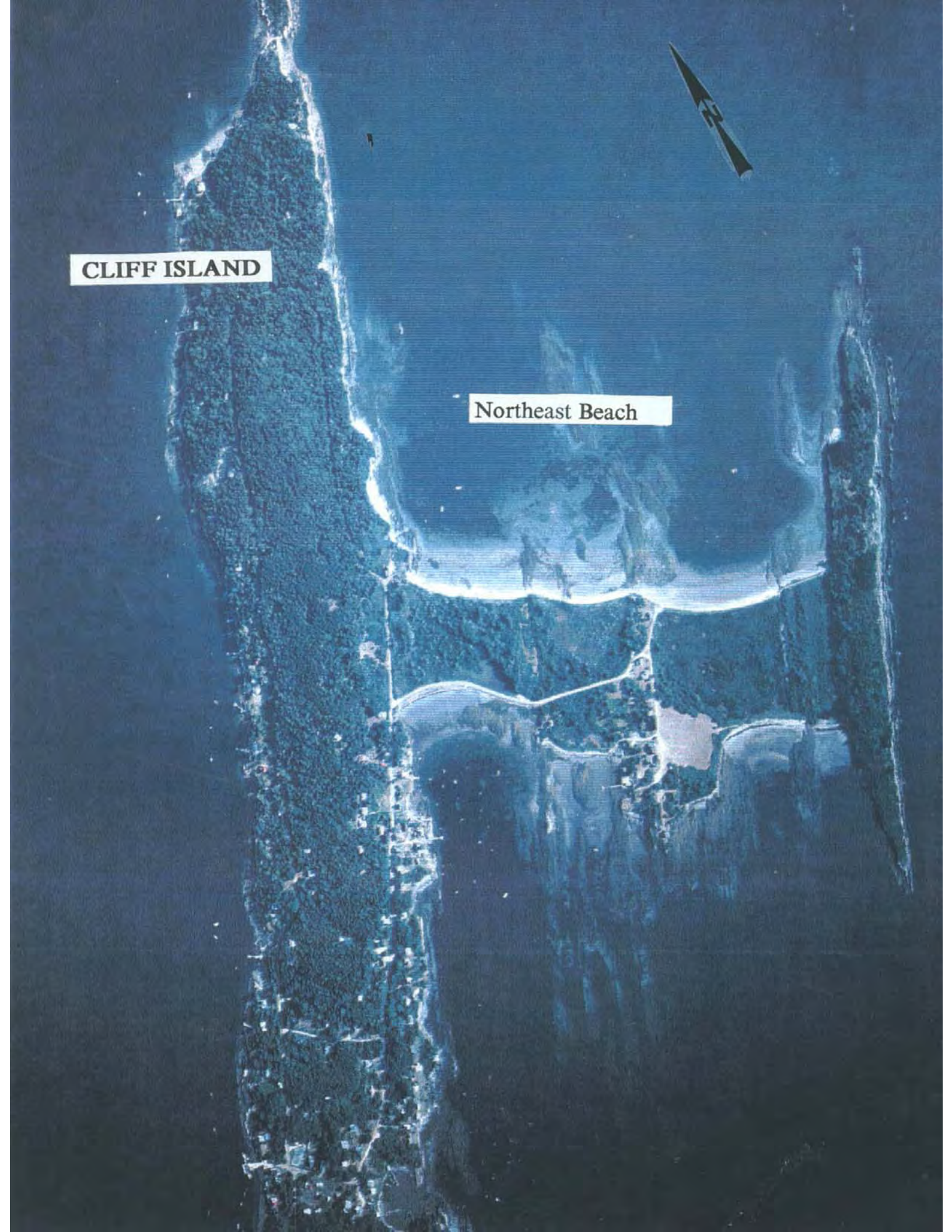


Lamson Cove, between Great Diamond and Little Diamond, from the causeway, looking towards Peaks Island

Staff from Friends of Casco Bay and Normandeau Associates, island residents and volunteers

Peaks Island

Cliff Island


CLIFF ISLAND
Northeast Beach