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A SURVEY OF THE DISTRIBUTION AND ABUNDANCE OF IRISH MOSS (*Chondrus crispus*) ON THE SOUTH SHORE OF NOVA SCOTIA. PORT MEDWAY, SHELBURNE CO. TO PENNANT POINT, HALIFAX CO.

by

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ABSTRACT

The harvesting of *Chondrus crispus* Stackhouse has been active for over 60 years in Southwestern Nova Scotia. Landings peaked in the early 1970's above 10000 wet tons per year. However, a decline in the 1980's continued to below 2500 wet t in 2000. Recently an increase in demand has lead to the exploration of non-traditional areas along the south shore (Halifax to Shelburne county). Conflict between local harvesters and harvesters from traditional areas has lead to the demand for an assessment of harvestable standing crop for this part of the coast. Biomass was estimated with a combination of remote sensing methods and ground truthing. Minimum sustainable harvests from Halifax to Port Medway were estimated to be 387 wet t $year^{-1}$; maximum harvest was estimated at 580 wet t $year^{-1}$. Due to the wave exposure in many areas where this resource occurs, it was concluded that the Halifax to Peggy's Cove portion of the coast held the most promise for resource accessibility and economic potential.

RÉSUMÉ

La récolte du *Chondrus crispus* Stackhouse, ou mousse d'Irlande, se pratique depuis plus de 60 ans dans le sud-ouest de la Nouvelle-Écosse. Les quantités récoltées ont atteint des sommets au début des années 1970, se chiffrant à plus de 10 000 tonnes brutes par année, toutefois, un déclin amorcé dans les années 1980 s'est poursuivi et les quantités récoltées étaient inférieures à 2 500 tonnes brutes en 2000. Récemment, en raison d'une augmentation de la demande, on a entrepris l'exploration de nouveaux secteurs de la côte sud (entre Halifax et le comté de Shelburne). Un conflit entre les ramasseurs de ces secteurs et les ramasseurs des secteurs exploités de longue date a débouché sur une demande d'évaluation du stock récoltable dans les nouveaux secteurs visés. On a estimé la biomasse en combinant des méthodes de télédétection et des vérifications sur le terrain. On a estimé à 387 tonnes brutes par année la quantité minimale récoltable, et à 580 tonnes brutes par année la limite maximale permettant d'assurer la viabilité de l'activité, entre Halifax et Port Medway. Compte tenu de la forte exposition aux vagues

de nombreux endroits du secteur où se trouve la ressource, on a conclu que la partie du littoral située entre Halifax et Peggy's Cove était la plus prometteuse en matière d'accessibilité de la ressource et de potentiel économique.

1.0 INTRODUCTION

The Irish Moss (*Chondrus crispus*) harvest in Nova Scotia began in the 1940's centered on the southwestern coast. Harvesting of this resource has remained artisanal with the use of hand rakes from outboard powered skiffs (5 to 6 m). The lack of mechanization in this harvest is to a large degree a reflection of the difficult circumstances and accessibility of the resource. The prime harvesting zone is the lowest portion of the intertidal and the shallow subtidal (Pringle and Mathieson 1986) and access to this zone with a rake is approximately 4 hours per day on the most extreme low tide series of each month (Sharp and Roddick 1982). The bottom is typically one of high relief, either of ledges or drumlin boulders. Despite many attempts and a great deal of money expended no reasonable economic method of mechanically harvesting this resource has developed over its 60 year history. The rake is designed to remove only the largest fronds of the plant while leaving behind the immature fronds for recovery of biomass and the vital holdfast for regeneration of new fronds (Pringle and Sharp 1986). The regulations do not limit effort but restrict licenses to geographic units, gear type and seasons (Fig. 1).

Figure 1. Marine Plants Harvesting districts of the Maritimes as described in the Atlantic Coast Marine Plant Regulations in the Fisheries Act.

In the early years of the industry, companies explored other parts of the coastline for more resource when demand increased for carrageenan. The Nova Scotia government provided exclusive concessions for buying Irish Moss to companies for sections of the coastline under the provincial Seaplants Harvesting Act, 1959. These Irish Moss concessions did not extend into the 1970's despite being retained for rockweed. During the 1960's companies brought experienced harvesters from south western N.S. to the eastern shore to demonstrate the techniques to local fishers. Three buying stations were provided; one on the southern coast of Nova Scotia in Prospect near Halifax, and two on the eastern shore in Murphy's Cove and East Jeddore (Ffrench 1970). Landings for the eastern shore are reported between 200 t and 400 t for 1970. There were 15 "full time" harvesters however there were also a large number of part time high school children who contributed to the landings.

Once the buying stations closed in the 1970's harvesters on the south shore and eastern shore had to dry their harvests and transport them to Yarmouth for sale. By the mid 1970's there were 6 companies buying Irish Moss in the Maritimes and the harvest had reached its peak of landings and infrastructure development (Fig. 2).

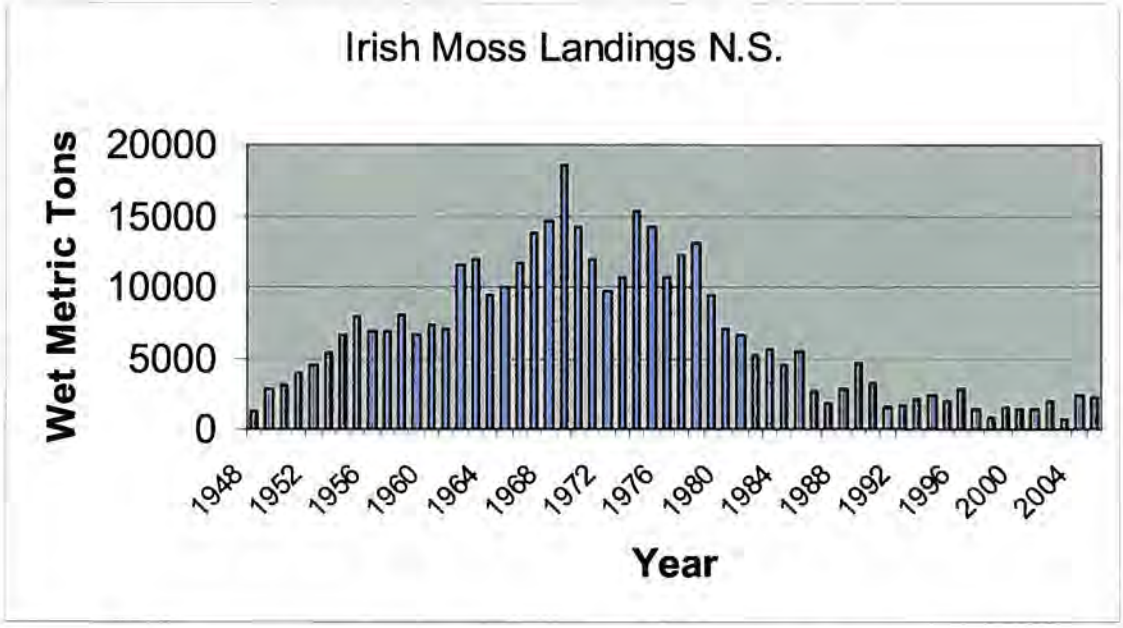


Figure 2. Irish Moss (*Chondrus crispus*) landings 1948 to 2004 (Atlantic shores only).

There was both a decline in demand for Irish Moss and a decline in participation in the harvest during the 1980's (Fig. 2, Sharp and Roddick 1982). At the turn of the 20th century there was an increase in demand for Irish Moss with a corresponding price increase. This stimulated more interest in harvesting Irish Moss. Unfortunately there has been a significant change in the composition of commercial Irish Moss beds in south western N.S. Beds that were essentially pure stands of Irish Moss are observed to have very high percentages of other seaweeds now, particularly coralline species (G. Sharp. P.O. Box 1006, Dartmouth, NS. B2Y 4A2, unpublished data.). It is not surprising that harvesters began to look for other "better" harvest areas. First, they moved to areas adjacent to the traditional harvest region, particularly the Shelburne to Lockeport area. They traveled daily with trucks, boats and trailers bringing their harvest to regular buying stations on wharves in south western N.S. However, when some harvesters from District 12 went beyond Port Medway and crossed into District 11 (Fig. 1), in conflict with the regulations, it became a legal and social issue for resource managers. Companies have assisted this new harvest by establishing buying stations on the south coast including one at Port La Tour.

The argument by district 12 harvesters and processors for the transfer of harvesting effort was there were not enough "local" harvesters to harvest the resource on this coastline. The locals from district 11 who had entered the harvest stated their resource base was not sufficient to support a larger harvest force. Companies have very actively recruited harvesters from this coast with only limited success and the lack of local effort in district 11 prevented the buying companies from reaching a minimum economic tonnage per buying site.

The basic question that has arisen from this issue is how many harvesters can this resource support? This cannot be answered without knowledge of the abundance, distribution and accessibility of Irish Moss biomass using traditional harvesting methods. District 11 extends from the Medway River to Chedabucto Bay, but the major area of contention that is considered accessible to harvesters from District 12 is from Medway River to Halifax. The goal of this study is to provide an estimate for the total rakeable

biomass of Irish Moss from Medway River to Pennant Point. It was also designed to address the issues of access to the resource regarding wave exposure, landing sites and characteristics of the shoreline.

2.0 METHODS

2.1 WAVE EXPOSURE

The prevailing wind directions, velocity, wave direction and height by month were derived from available oceanographic data compiled in the Wind and Wave Atlas (MacLaren Plansearch Ltd, 1991). Recent 2007 wave height data was obtained from the archive data base of Halifax entrance oceanographic buoy C44258 for June through September 2007.

The wave exposure that is most optimal for the presence of Irish Moss is a semi exposed to exposed shoreline. We examined 57 sections of the shoreline from Pennant Point to Port Medway that were chosen based on the observations of a ground survey plus the experience of the lead author. A mid point on each section of the shore was chosen to determine the open angles to wave action. The fetch was measured to the nearest land or if over 10 km as unlimited (Fig. 3, Table 1).

Figure 3. Open angles to wave action with a range of fetch at a raking site near West Dover, Nova Scotia.

Table 1. Classification system for Exposure index on the south coast of Nova Scotia.

Open Angle degrees	Fetch	Wave exposure
> 100	unlimited	EE (extreme exposure)
> 50 ≤100	unlimited	E (exposed)
> 100	< 10 km	SE (semi exposed)
< 50	unlimited	SE (semi exposed)
≥ 50	< 10 km	SS (semi sheltered)
0 - < 100	≤ 5 km	S (sheltered)

Each segment of the coast is made up of a composite of open angles; some offer shelter due to an island, shoal or main land (Fig. 3). This means that even exposed sites can be sheltered from certain wind and wave directions, resulting in a variety of wave exposures at different open angles. To derive an overall index of exposure the total angles in the EE to E wave exposure were divided by the total open angle. This percentage does not take into account wind direction which prevails from the south in the summer. However, the shoreline of the south shore runs mainly southwest; therefore the only truly protected angles are those facing north to north east.

2.2 IRISH MOSS AREA COVERAGE

To determine the area of Irish Moss beds we used three sources of remote sensing data: Google earth satellite images, Nova Scotia Department of Natural Resources (GeoNova) 1:10000 aerial photos 1980 – 2002 series and oblique aerial photos taken at low level (100 m to 300 m) (Fig. 4).

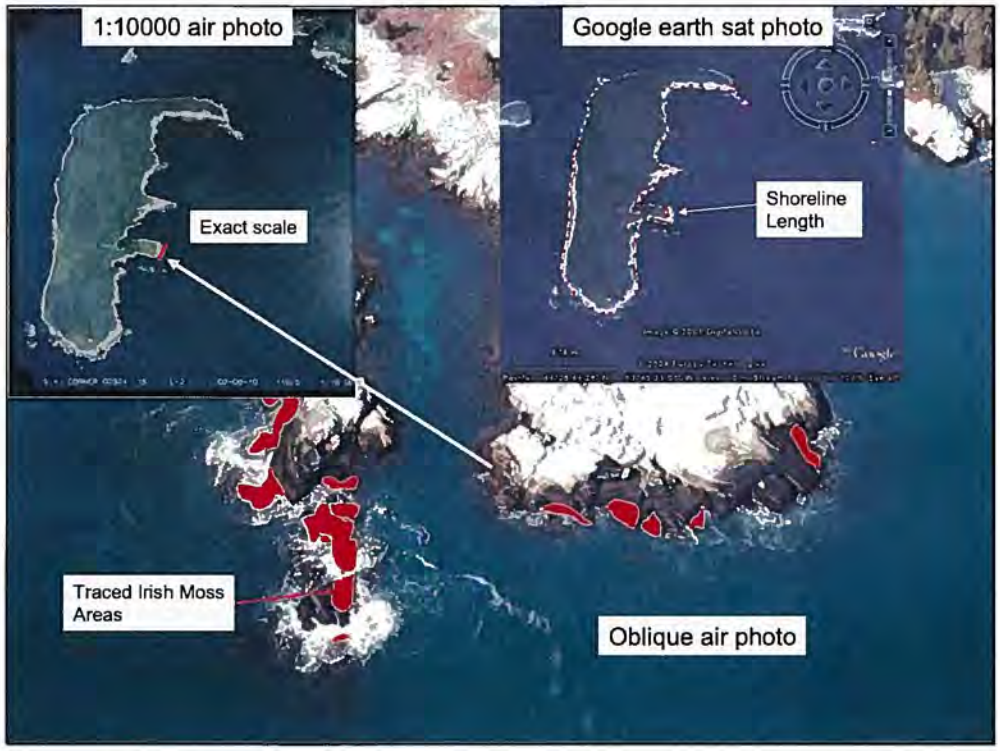


Figure 4. The integration of three types of remote sensing data; satellite, vertical air photos (1:10000), and oblique air photos.

The satellite photos were used to determine the shoreline distance by using the path function of Google Earth. Photos were enlarged to a minimum of 1:20000 and the outline of the major land forms were traced to 0.1 km. This result was compared to a more detailed tracing of a 1:10000 air photo to determine the effects of scale.

The 1:10000 air photos were used to scale the oblique air photo interpretation of Irish Moss cover. Land marks on the 1:10000 photos were used to match with land marks on the oblique photos and these were then used to place a scale on the interpreted Irish Moss areas.

Oblique air photos were taken to identify the areas of the coast with the most coverage of Irish Moss. Three flights were made; June 07, September 07 and February 08. It was not possible to provide continuous coverage of the entire coast but photos were samples of the coast line. A total of 885 photos were taken of which 99 were suitable for analysis.

The digitized photos taken with a Nikon D70 camera were located by using both the time checks on the flight and land marks. These photos were taken into Adobe Photoshop and the areas, determined to be Irish Moss by the colour (yellow in the summer and early fall flights; red – purple in the winter flights), were outlined and filled. This section of the photo was removed as a JPEG to NIH image analysis software and the total area calculated with the scale obtained from corresponding 1:10000 air photos (Fig. 4).

2.3 GROUND TRUTHING

Seventeen sites from Betty Island (Prospect Area to Medway River) were chosen to measure the biomass of Irish Moss. At each site 4 to 10 quadrats (2.5 m long by 1 m wide) were placed haphazardly within a 15 m to 30 m section of shoreline with a minimum of 50% Irish Moss cover. The quadrat was raked with a 5 mm tine spaced standard Irish Moss rake until only a few fronds of Irish Moss were removed on each rake pull (Fig. 5).

Figure 5. Raking Irish Moss at West Ironbound Island, La Have, Nova Scotia using a 5 mm tine spaced Irish Moss rake and a 2.5 m^2 quadrat.

If the zone was 2.5 m wide or more the quadrat was placed perpendicular to the shoreline. However, if the zone was narrow less than 2.5 m wide the quadrat was placed parallel to the shoreline. By this procedure we were raking in the optimal part of the Irish Moss bed. The entire quadrat was raked length wise as it provided the best angle to remove the moss. The yield from each quadrat was placed in a separate mesh bag to allow draining in transport to the shore. If the material still held external water the bag was spun 10 times over the head prior to measuring the total weight to 1 g within 2 hours of harvest. If the sample was not pure (99% Irish Moss) it was separated into Irish Moss and major associated species and these components were weighed to 1 g on a top loading scale.

2.4 CALCULATION OF RAKEABLE STANDING CROP (RSC)

The ground truth survey data was available for 17 sites from Betty Island to Medway Harbour. To expand this data to the total area we made several assumptions and used the data from the aerial surveys to test these assumptions. The most subjective component of the aerial expansion of the data was the determination of what type of shoreline would support commercial quantities of Irish Moss. This was based to a large extent on the shoreline wave exposure and the presence of suitable substrate. In general it was assumed that for pure stands of Irish Moss to develop vigorous water movement is needed. Irish Moss can exist in quiescent waters but it will be a small component of the seaweed community (Pringle and Mathieson, 1986). The acceptable shoreline was in areas classified with an open angle that was semi exposed to extremely exposed to wave action. The linear extent of these shorelines was measured with the path function in Google Earth at a 1:20000 scale. No attempt was made to delineate every semi submerged ledge or irregularity in the shoreline, therefore this is a conservative measure of lineal shoreline.

We did not have continuous photographs of the entire shoreline; the best photos with Irish Moss cover were used to calculate the average width of the Irish Moss zone. For example if we measured an island with 2 km of shoreline and we had photos that covered 500 m of that shoreline we would calculate the area of the beds. This area was then

divided by 500 to determine the average width of the Irish Moss bed and then the value was compared to the value based on the ground truth data for the sample sites in the region. The average bed width was multiplied by the shoreline length represented by the air photos to obtain square meters of Irish Moss beds. To obtain the total rakeable biomass for each shoreline segment the average biomass per square meter was multiplied by the bed area.

RESULTS

3.1 PREVAILING WIND DIRECTION, VELOCITY AND WAVE HEIGHT

The southern shore of Nova Scotia runs in a southwesterly direction; the predominant direction of winds and waves in the summer months (Table 2).

Table 2. Predominant wind and wave directions on the south shore of Nova Scotia in the summer (MacLaren Plansearch 1991).

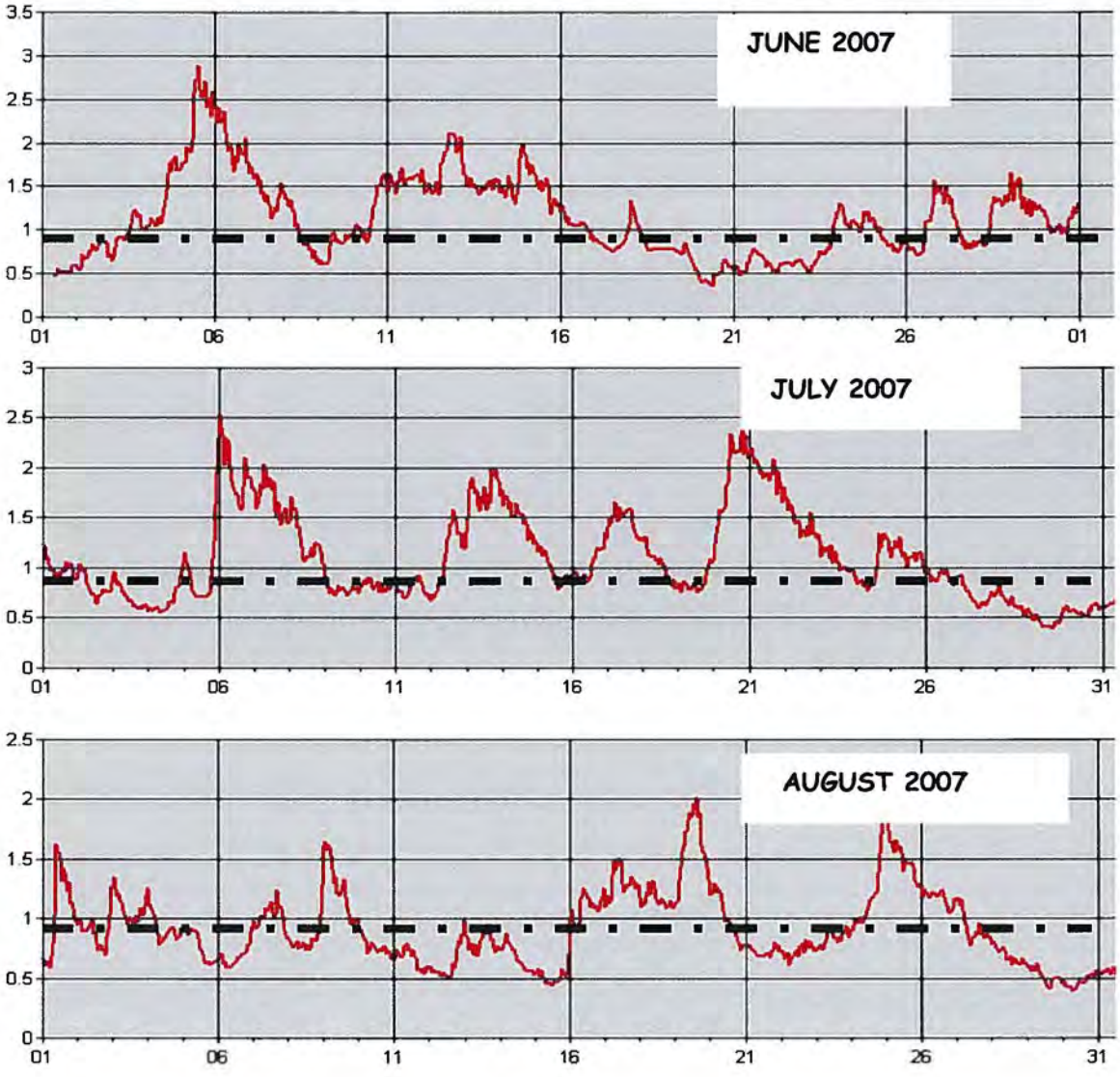
Month	Wind Direction % Southerly	Wave Direction % Southerly
June	55	65
July	68	66
August	50	40
September	35	35

The maximum wind velocity that it is possible to rake Irish Moss is related to the wave exposure of the raking site. The most wave exposed sites need a very low wind velocity plus a very low wave height. These "calm" conditions are defined as winds below 10 knots and wave heights below 0.5 m. Calm conditions exist for a small portion of the time available in the summer (Table 3, Fig. 6). The window for swells below 0.5m occurs only 8% of the time and the window for winds below 10 knots occurs about 20% of the time. If we consider less wave exposed sites we could raise the wind to about 16 knots (considers crossing open waters from sheltered areas) and wave height to 1 m, consequently expanding the potential raking window to between 50 and 60% of the time. This does not deal with the coincidence of tide and weather. Access to Irish Moss at low tide is restricted to 4 hours of the day at the most. If the wind and waves are calm in the

afternoon but the low tide is in the morning raking will not be possible. Therefore these percentages are optimistic and require a coincidence between the low tide and the best raking conditions.

Table 3. The portion of time there are conditions suitable for raking semi sheltered to semi exposed Irish Moss beds on the south shore of Nova Scotia

Month	Wind Below 10 knots % of the time	Waves below 0.5 m % of the time	Wind Below 16 knots % of the time	Waves less than 1m % of the time
June	20	8	57	54
July	28	8	58	52
August	20	8	62	62
September	19	8	52	54



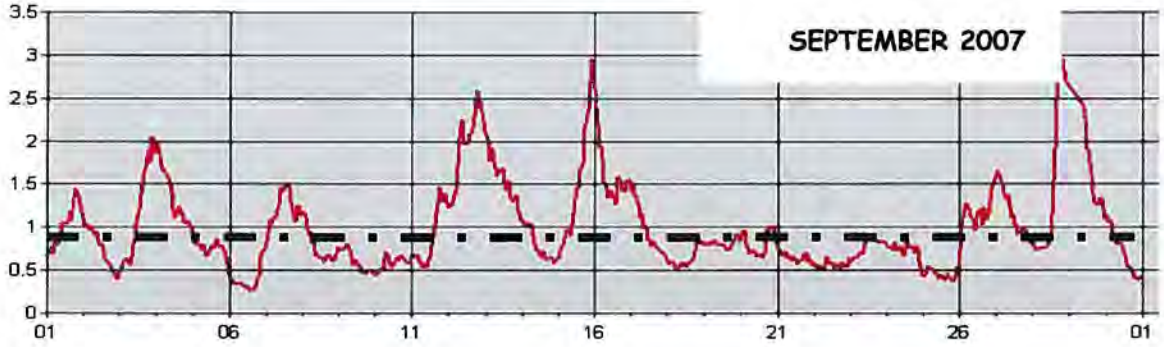


Figure 6. Significant Wave Height in meters at the Halifax entrance measured at oceanographic buoy C44259. The dashed line (— • —) is the 1 m wave height limit for access to wave exposed sites summer 2007. The red line (—) is the Significant Wave Height (VCAR).

3.2 WAVE EXPOSURE

The average wave exposure index (open to unlimited fetch/total open angle) for all sectors was 66 %. Only 15 of the 78 sites had the entire open angle exposed to the unlimited fetch of the waves (Table 1 & Maps, Appendix I) and all other sites had some shelter from open water depending on the direction of the wind and waves. This does not include the possibility of an outer ledge breaking the action of the swell in a very exposed site. For example we were able to rake a very exposed site at Pollack Point during building south westerly winds and swell by choosing a ledge that was the last one in a parallel series toward shore. The outer ledges broke up the heavier swells and enabled us to sample the site with some difficulty. Sites with very low wave exposure were found to have either a low biomass of Irish Moss or a great deal of extraneous species as by catch. On the most extreme wave exposed sites, such as West Ironbound, the cover of the plant was very high but the plants were short and not easily raked. This is due the loss of heavier bushier plants that contribute greatly to the catch per unit effort. The most ideal sites were those with a semi exposed situation, such as Taylor Island; although they were in the 100% category they still included islets and shoals that were protected from the major impact of the swell with ample water movement.

3.2 BIOMASS ESTIMATES

The average yield of pure Irish Moss was 0.9 + 0.5 wet kg m^{-2} for 151 samples (Fig. 7). The majority of yield from a 2.5 m^2 area (90%) was below 2 wet kg m^{-2} (Fig. 7).

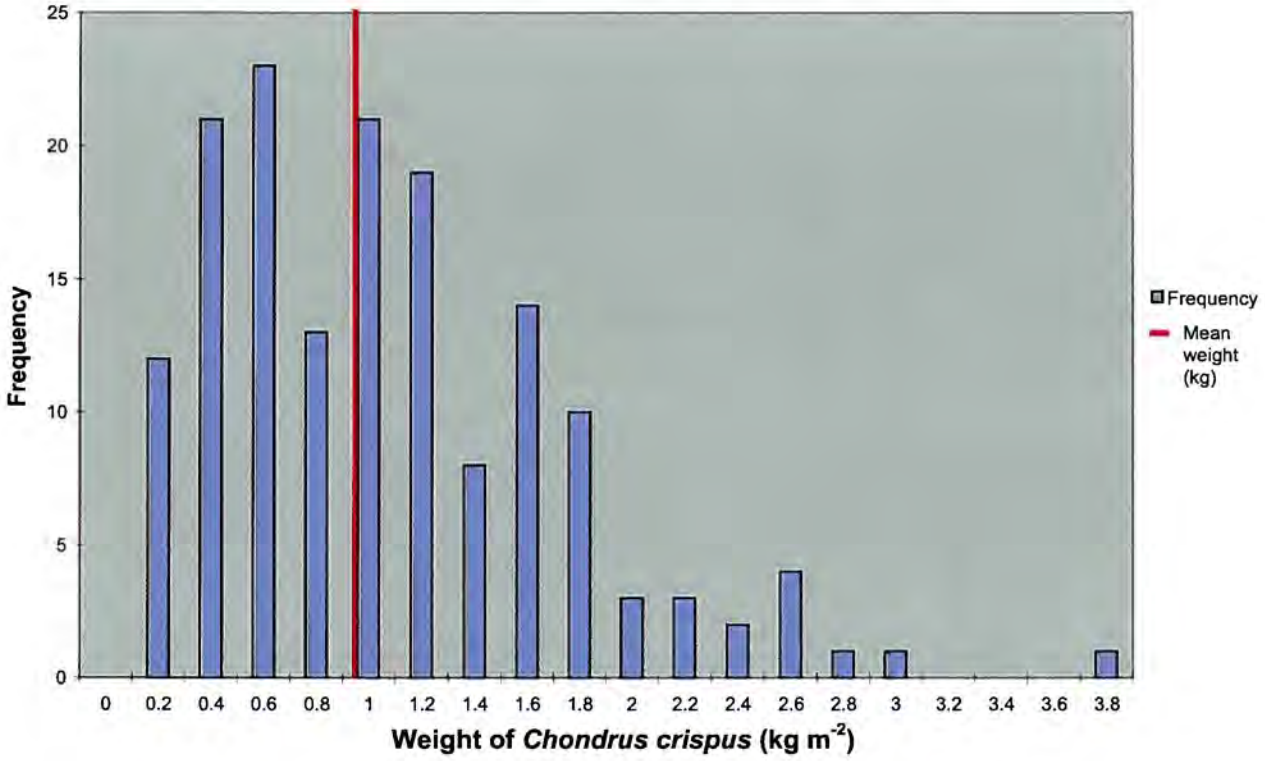


Figure 7. The frequency distribution biomass (kg m^{-2}) of the 151 raking samples from survey sites between Pennant Point and Medway Harbour.

The highest average yield of Irish Moss was from Betty Island, near Prospect, and lowest was at Little Tancook Island, at the entrance to Mahone Bay (Fig. 8, Maps Appendix I). The purity of the samples was above 80% at all sites with the exception of Toby Island, near Medway River, and on the Westside of Cape La Have Island. This reflects our bias for "pure" stands. Despite this, yield could vary greatly within the same bay or island (i.e. Blandford and Little Tancook Island) (Fig. 8). Overall, the Mahone Bay and La Have sites had significantly lower yields than the two ends of the survey area. This to some degree relates to the type of substrate and the difficulty of raking in rocks that are striated or have a regular parallel relief (Fig. 9).

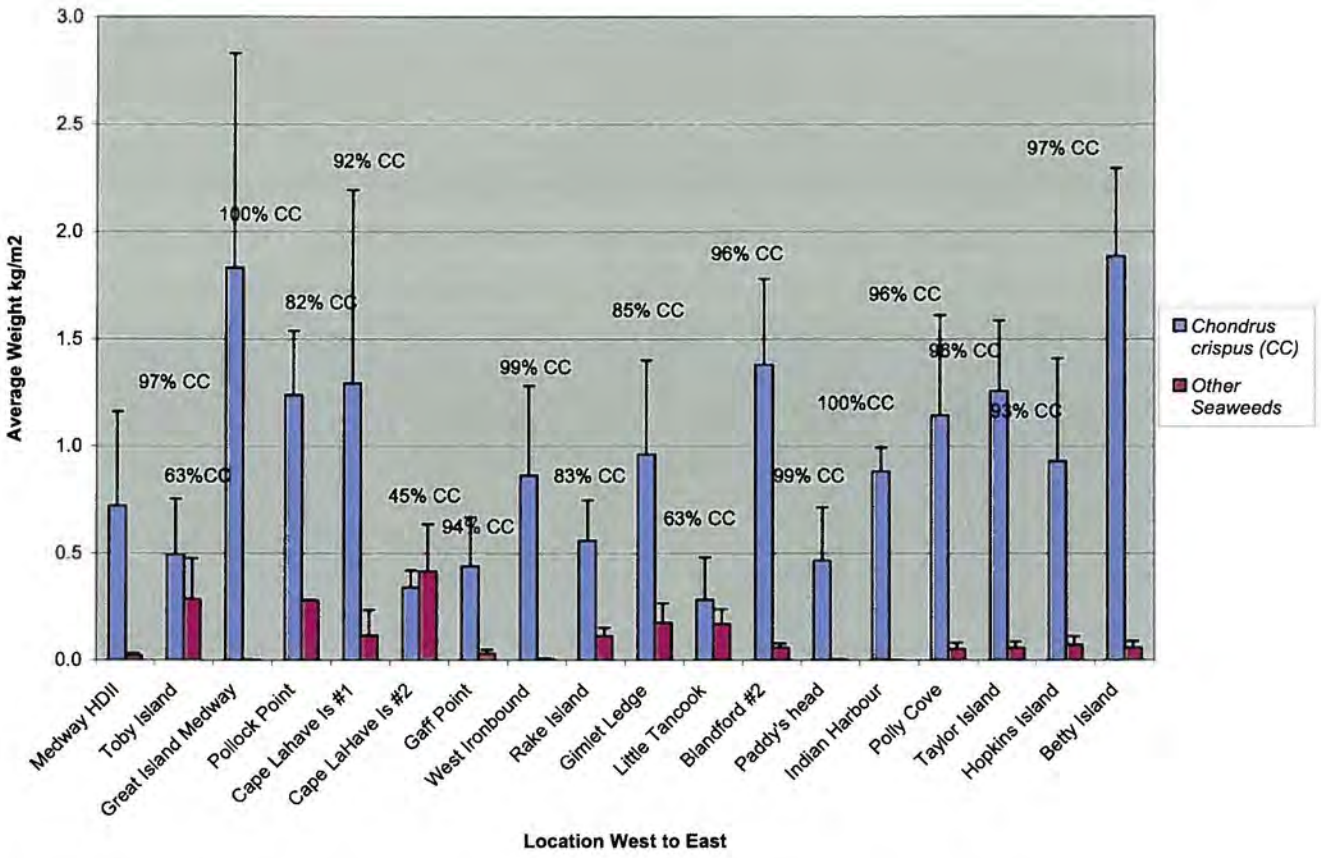


Figure 8. The mean wet weight and standard deviation of Irish Moss (*Chondrus crispus*) raking yield, other seaweeds and percent purity from sites between Pennant Point and Medway Harbour June to September 2007 (n = 4-10).

Figure 9. Striated bedrock with exposed Irish Moss West Iron Bound Island, La Have area.

The combination of coastline measurements with the area of beds per unit of shoreline (calculated from air photos) suggests that the Pennant Point to Peggy's Cove area supports the greatest biomass of Irish Moss in the study area. The biomass for this area was 237 t which is 61 % of the total biomass (Table 4, Fig. 10). It is a function of the amount of shoreline, the width of the zone and the second highest raking yield from the ground truthing results. The second largest biomass is in the Mahone Bay area at 53 t followed by La Have at 42t (Fig. 10).

Table 4. Estimates of biomass within shoreline segments with high probability of commercial quantities of Irish Moss from Pennant Point to Midway Harbour based on lineal shoreline and assumed bed width calculated from air photo analysis.

Shoreline segments	Distance m	Bed Width m	Biomass wet kg m^{-2}	Area m^2	Total kg
Pennant Pt	1910	3.1	1.64	5921	9710.44
Pennant Is W and S	1640	3.1	1.64	5084	8337.76
Islands and shoals	1320	3.1	1.64	4092	6710.88
Terrance Bay shore	4160	3.1	1.64	12896	21149.44
Shannon, Ryan, Reefs and Small Is	1810	3.1	1.64	5611	9202.04
Mosher Island (S and W)	3290	3.1	1.64	10199	16726.36
Betty Island	4870	3.1	1.64	15097	24759.08
Duck Island	540	3.1	1.64	1674	2745.36
Duck Island Ledges	600	3.1	1.64	1860	3050.4
Prospect to High Head main shore	4160	3.1	1.64	12896	21149.44
Hopson Is and Ledges	1220	3.1	1.64	3782	6202.48
Hearn Is southwest only	660	3.1	1.64	2046	3355.44
Fleming and Taylor Is exposed only	1110	3.1	1.64	3441	5643.24
Gull Is out and Inner	550	3.1	1.64	1705	2796.2
Shag End	1540	3.1	1.64	4774	7829.36
Myra Is	290	3.1	1.64	899	1474.36
Big Is	120	3.1	1.64	372	610.08
Thrum Is	260	3.1	1.64	806	1321.84
Clarke Is	810	3.1	1.64	2511	4118.04
East Dover Shore	1650	3.1	1.64	5115	8388.6
White Is	940	3.1	1.64	2914	4778.96
High Is	830	3.1	1.64	2573	4219.72
East Dover Shore South	640	3.1	1.64	1984	3253.76
Taylor Is and assoc Islands	2940	3.1	1.64	9114	14946.96
West Dover to Polly Cove Shore	2780	3.1	1.64	8618	14133.52
Polly Cove to Peggy's Shore	2620	3.1	1.64	8122	13320.08
Peggy's Cranberry	1290	3.1	1.64	3999	6558.36
Cranberry to Indian Hbr	2140	3.1	1.64	6634	10879.76
PENNANT TO PEGGY'S TOTAL	**46690**			**144739**	**237371.96**
Indian Hbr Shore and Is to Paddy head	2490	2	1.8	4980	8964

Shoreline segments	Distance m	Bed Width m	Biomass wet kg m^{-2}	Area m^2	Total kg
Shut In Is	2030	2	1.8	4060	7308
St Margaret's West Side	1270	1.6	0.93	2032	1889.76
Owls Head area	3190	1.6	0.93	5104	4746.72
Blandford Shore	3290	1.6	0.93	5264	4895.52
ST MARGARET'S TOTAL	**12270**			**21440**	**27804**
Little Tancook	1640	2.5	0.93	4100	3813
Big Tancook	5460	2.5	0.93	13650	12694.5
The Rackets	7760	2.5	0.93	19400	18042
Big Duck Is	930	2.5	0.93	2325	2162.25
Cross Is	6210	2.5	0.93	15525	14438.25
East Point Is and Miller is	4266	2.5	0.73	10665	7785.45
MAHONE BAY TOTAL	**26266**			**65655**	**58935**
Gunning Pt	1660	2	0.73	3320	2423.6
The Ovens	2550	1.4	0.73	3570	2606.1
Kings Bay to Rose Pt	4610	2.1	0.73	9681	7067.13
Hell Pt to Zink Head	3440	2.1	0.73	7224	5273.52
West Iron Bound	2790	2.3	0.73	6417	4684.41
Entrance to La Have River	5000	1.16	0.73	5800	4234
Mosher Island and Outer Island	2790	2.4	0.73	6696	4888.08
La Have Is West side	5050	1.88	0.73	9494	6930.62
La Have South end	5390	1	0.73	5390	3934.7
La Have East side	1110	1	0.73	1110	810.3
LA HAVE TOTAL	**34390**			**58702**	**42852**
Green Pt	2300	2	1.11	4600	5106
Rocky Head	680	2	1.11	1360	1509.6
The Point	1100	2	1.11	2200	2442
Front Cove	570	2	1.11	1140	1265.4
Back Cove	460	2	1.11	920	1021.2
Apple Cove	540	2	1.11	1080	1198.8
Pollack Pt.	1040	2	1.11	2080	2308.8
Great Is	2450	2	1.11	4900	5439
GREEN PT TO MEDWAY TOTAL	**9140**			**18280**	**20291**
GRAND TOTAL PENNENT TO MEDWAY				**30,826**	**387,254**

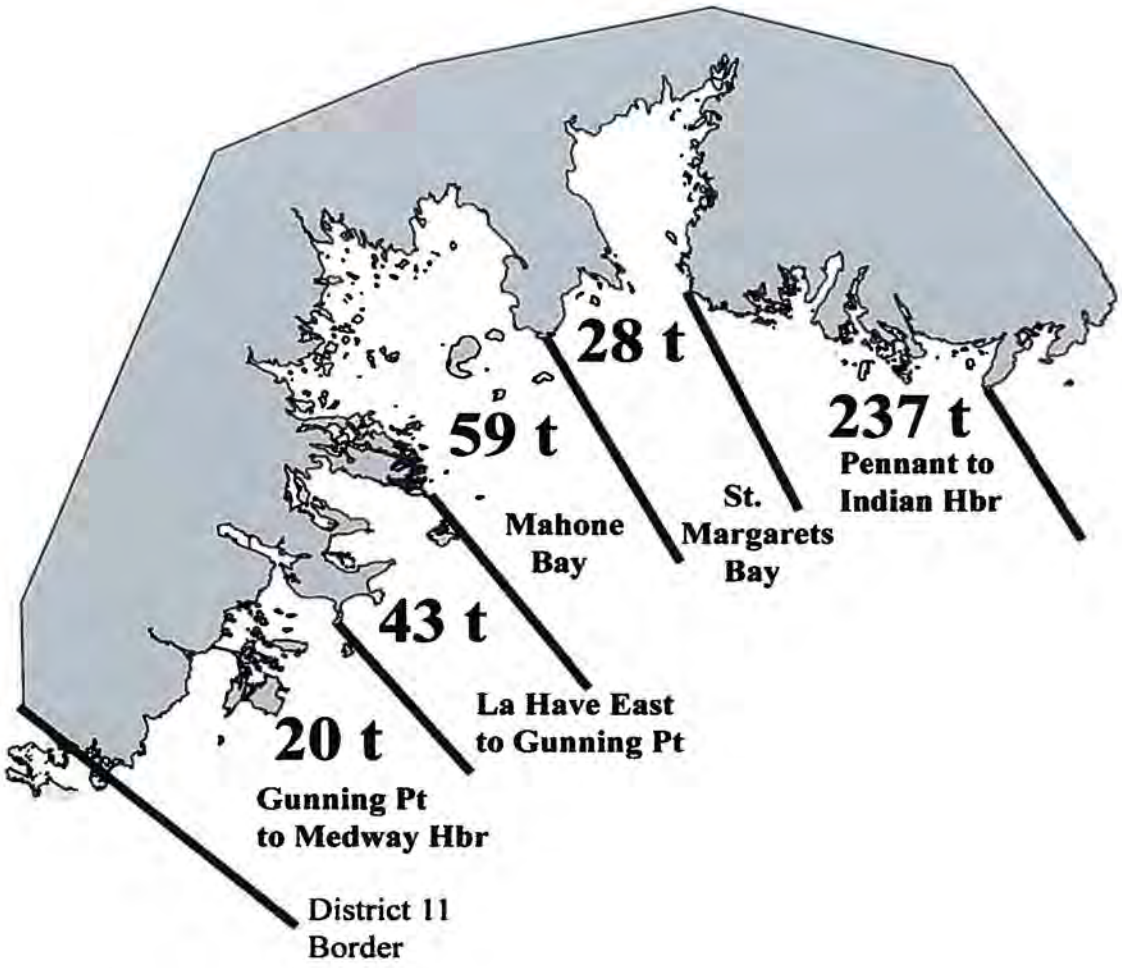


Figure 10. Combined sectors with estimates of Irish Moss rakeable biomass (wet t) from Pennant Pt to the western District 11 boundary.

4.0 DISCUSSION

The final rakeable biomass estimate of 387 t for 128 km of coastline is low when compared to the landings from south western Nova Scotia in the past decades (2000 to 10000 t per year). Our assumptions have been conservative. For example if we included all ledges distinct from islands and shoreline and traced the shoreline at the highest resolution we might increase our shoreline length by 30% and the total rakeable biomass would be approximately 500 t. While we have presented data on wave exposure, the rakeable biomass does not directly take into account accessibility. Nineteen percent of the

coastline with Irish Moss is extremely wave exposed or 100% exposed. This means it is really only accessible less than 10% of the time based on the frequency of calm days. These calm periods also need to fall on low tide periods in the day. What this region lacks with the exception of the West Dover to Pennant area is a diverse archipelago with many options for the harvests to access Irish Moss in a wide variety of weather conditions. A second factor in the accessibility of the resource is the relief and geology of the rocks. An ideal surface is one that is relatively smooth with a very low slope which creates a wide band in the tidal zone were Irish Moss is most abundant and pure. This surface is also easy to rake from a boat and the raker can access a large area without moving the boat. If the rocks have a high relief or even a very regular groove or striations, the rake may only be able to remove the Irish Moss at one angle to the rock making it difficult to fill the rake consistently and leads to poor CPUE, even if the Moss looks abundant. This was the case in the Mahone Bay area, particularly the Racketts ledges on the eastern side of the Lunenburg Peninsula. Similar geology and relief was encountered on West Ironbound and Gaff point sites. Perhaps a narrower rake may be more useful in these areas.

It is interesting to note that in the 1960's development of District 11 occurred near and east of Halifax. Why did this expansion of the harvest not occur closer to the center of infrastructure in Yarmouth to Cape Sable Area? Perhaps the early harvesters and companies found the same limitations that we outline in this report.

A single harvest of Irish Moss does not provide the total productivity for the year from the site. The concept of second and sometimes third harvests from the same piece of the bottom has been proven over the years of harvesting and has been the subject of experimentation. The Irish Moss rake is a culling instrument and removes only the largest bushiest fronds leaving behind 80 to 90 % of the fronds (Pringle and Sharp 1986). These understory fronds are then exposed to light and will have enhanced growth rates. Annual production from repeatedly raked quadrats provided 3.25 kg per m^2 (G. Sharp, unpublished data.). The initial harvest was 1.5 kg m^{-2}; which is in the range of the single harvest values from southern Nova Scotia in this survey. Production is a function of biomass per unit area, water temperature, solar radiation, and stored and ambient

nutrients. It is variable between years and between areas. Therefore it is not guaranteed that we can apply the factor of 2.2 of successively raked quadrats to our yield and apply this to the entire extent of the resource. The conservative approach is to use a factor of 1.5 resulting in an annual yield for this survey area of 580 t.

Do we have enough information to recommend how many harvesters should be licensed to harvest District 11? No, for several reasons, we have not covered the entire area of District 11 but only that area closest to District 12. How many harvesters do you need to harvest 580t? The type of harvester has a large effect on how much they can harvest in a season. During an examination of individual harvesters CPUE and frequency of landings 78 % of the landings are brought in by 35 % of the harvesters (Sharp and Roddick 1982). These "high liners", or very skilled workers, are those who are highly devoted and fish consistently within normal acceptable weather conditions. Not only is this fishery very time consuming but also very physically demanding. On the south coast, the Irish Moss resource exists in conditions that can be very difficult to harvest from a small boat. Each rake full must be pulled off the bottom and loaded onto the boat without any mechanical assists until it is unloaded at the wharf. Not only do these challenges lead to a slow learning curve for new fishers, but also create difficulties for ageing fishers. It is very common to see a decline in effort during the first 2 to 3 weeks of the season and up to 50% drop off in effort by the second month. In 1978 the average CPUE in Lobster Bay, N.S. decreased from 437 kg per delivery to 308 kg per delivery over this period.

Ideally, this survey should be extended to the full limit of District 11 including both remote sensing and ground truthing. However, for the area covered we have a reasonable estimate of the harvest that can be obtained with a fully developed infrastructure and experienced harvesting force.

5.0 REFERENCES

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APPENDIX I

LOCATIONS OF GROUND TRUTH SITES, YIELD AND PURITY OF IRISH MOSS, AND WAVE EXPOSURE

Location of the sampling sites

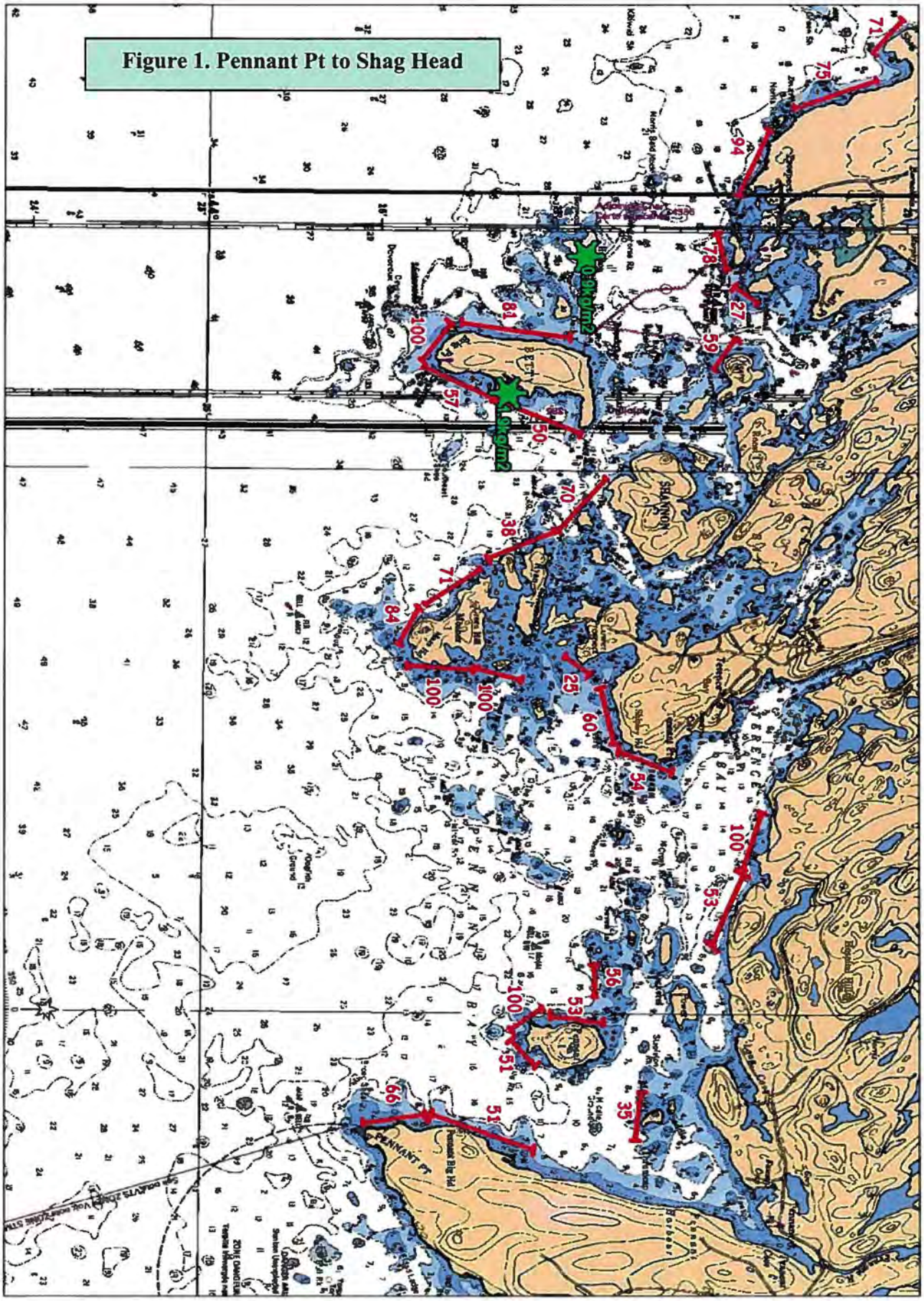
Green numbers: mean wet yield kg m-2 of Irish Moss

Purple numbers: Purity in % of Irish Moss

Red numbers: The exposure index (% Exposed to Extreme Exposed)

Red line: The portion of the coast represented by the exposure index

Figure 1. Pennant Pt to Shag Head



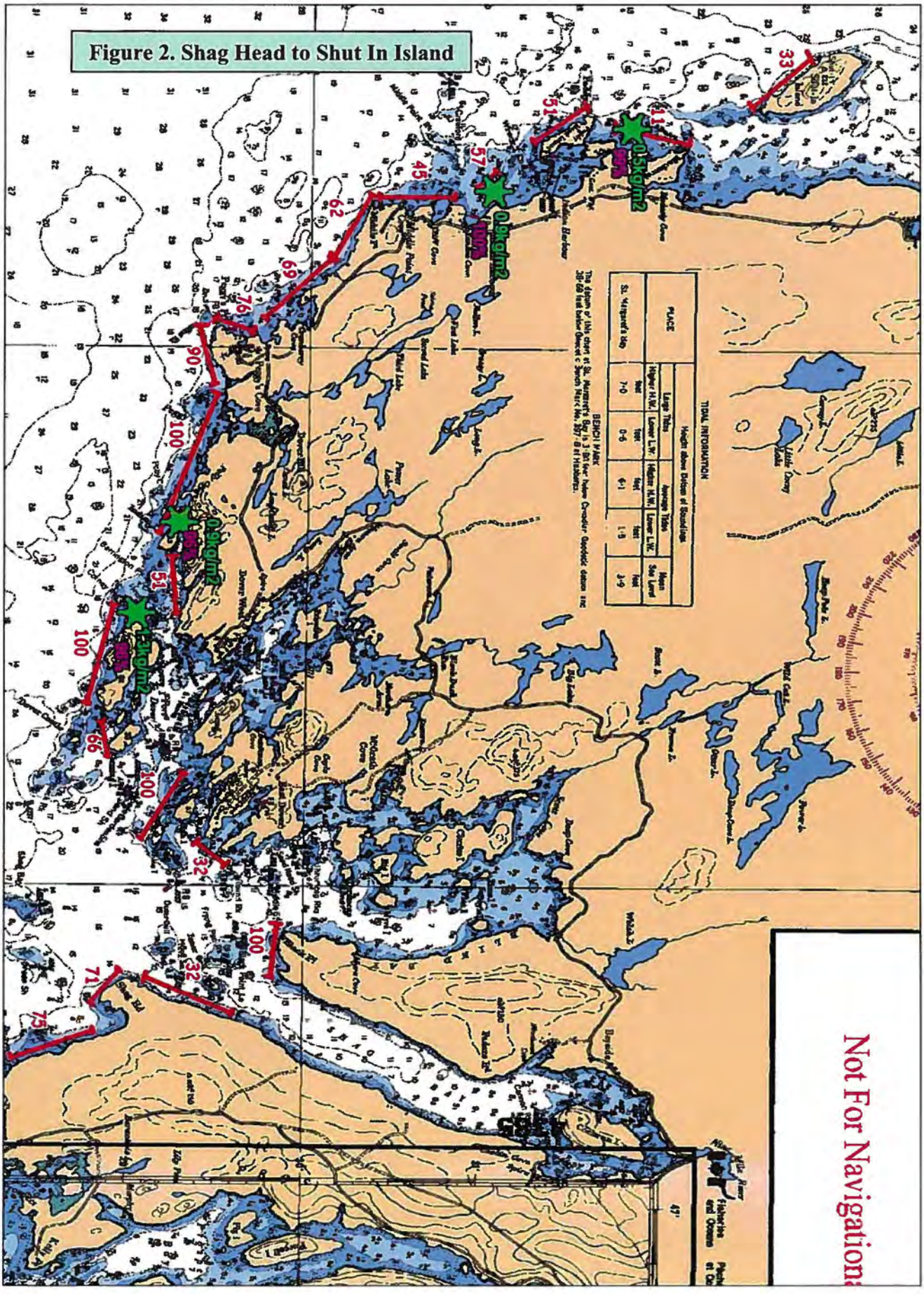


Figure 2. Shag Head to Shut In Island
0.5kg/m2
0.9kg/m2
0.9kg/m2
1.3kg/m2
33
51
11
57
45
62
69
76
90
100
51
100
66
100
32
100
32
71
75
TIDAL INFORMATION
Not For Navigation

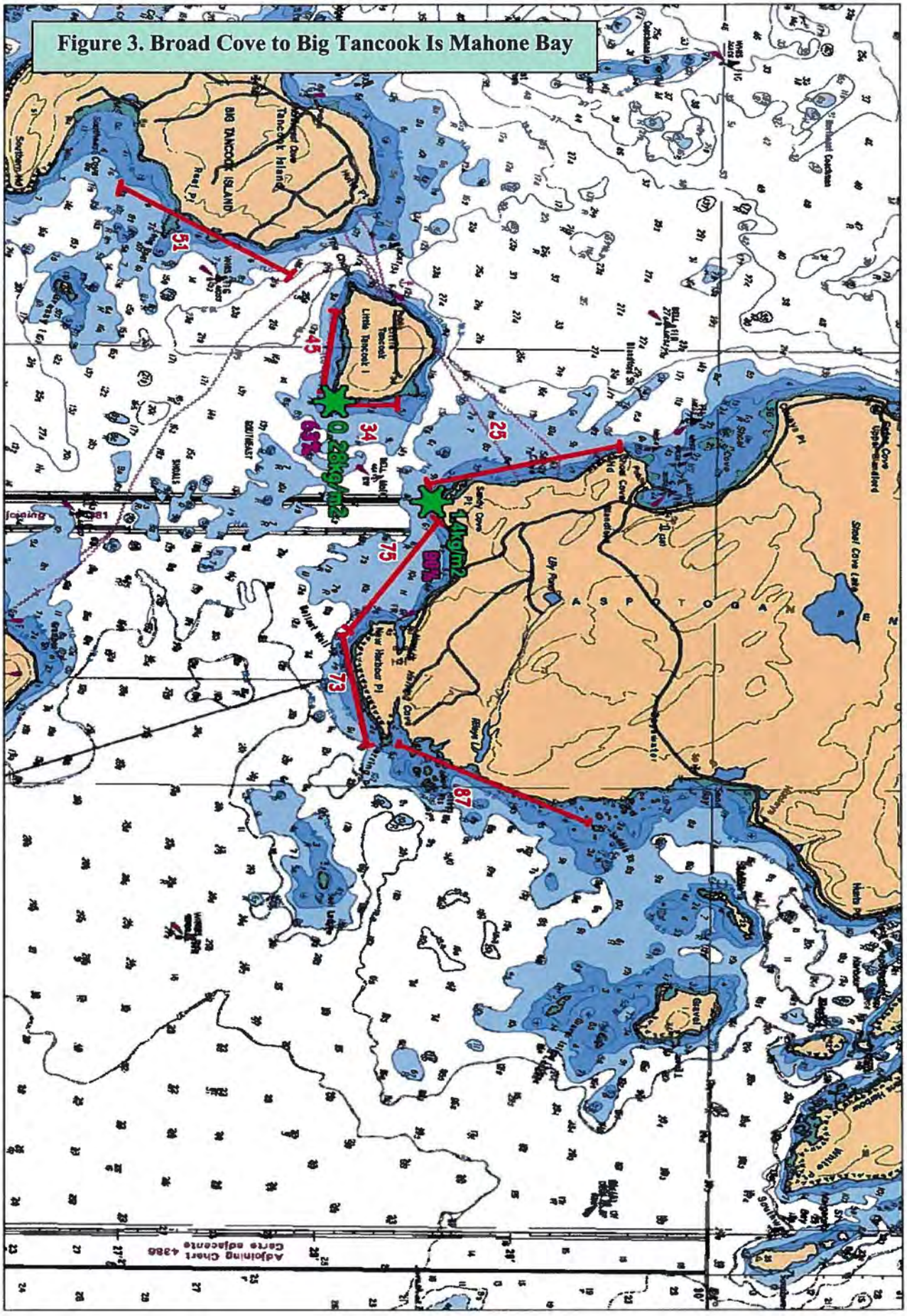


Figure 3. Broad Cove to Big Tancook Is Mahone Bay
BIG TANCOOK ISLAND
Tancook Island
Little Tancook I
51
45
0.28kg/m2
34
25
1.4kg/m2
75
73
87
Adjoining Chart 4286
Carte adjacente

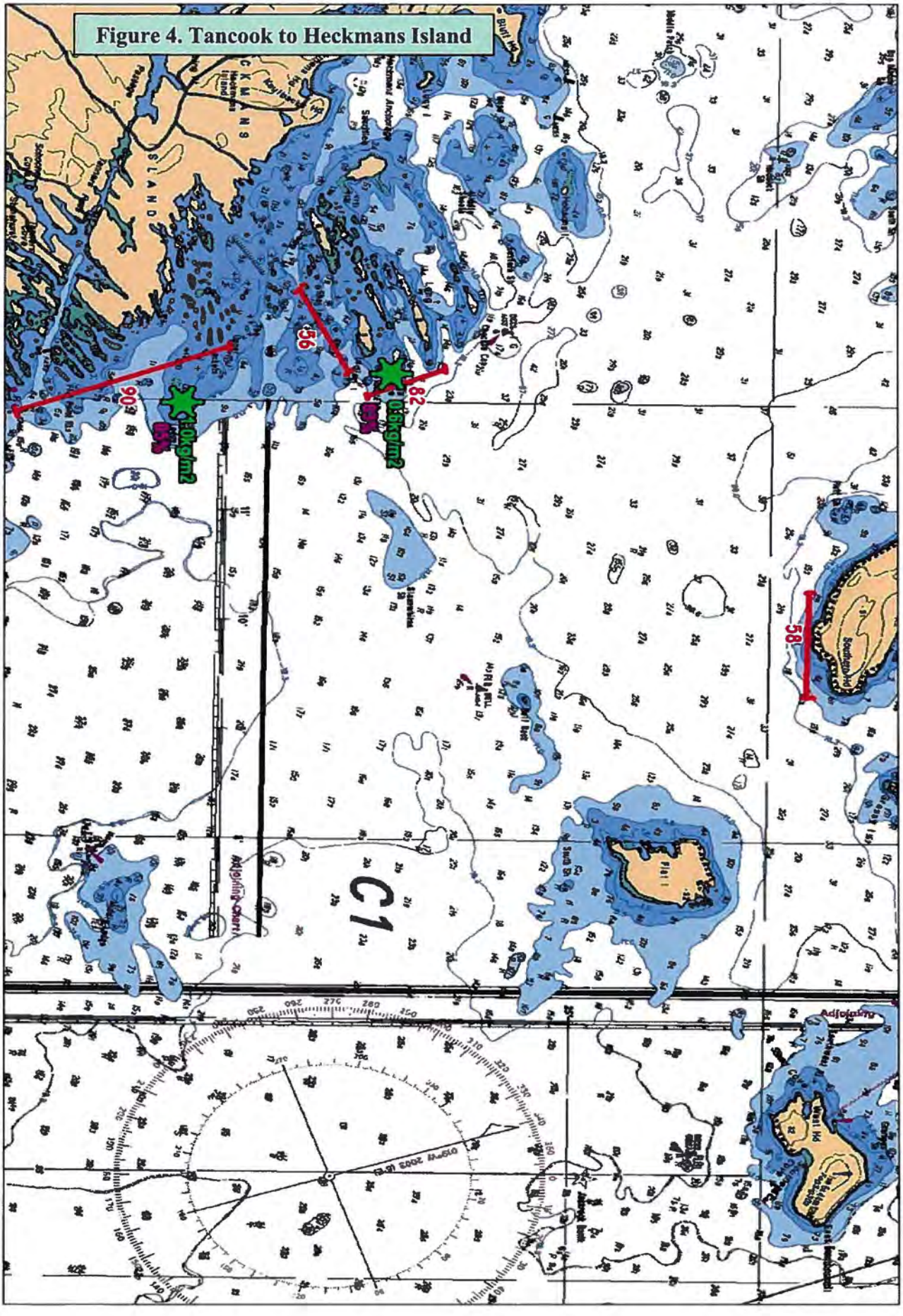


Figure 4. Tancook to Heckmans Island
56
82
90
58
1.0kg/m2
0.8kg/m2
C1

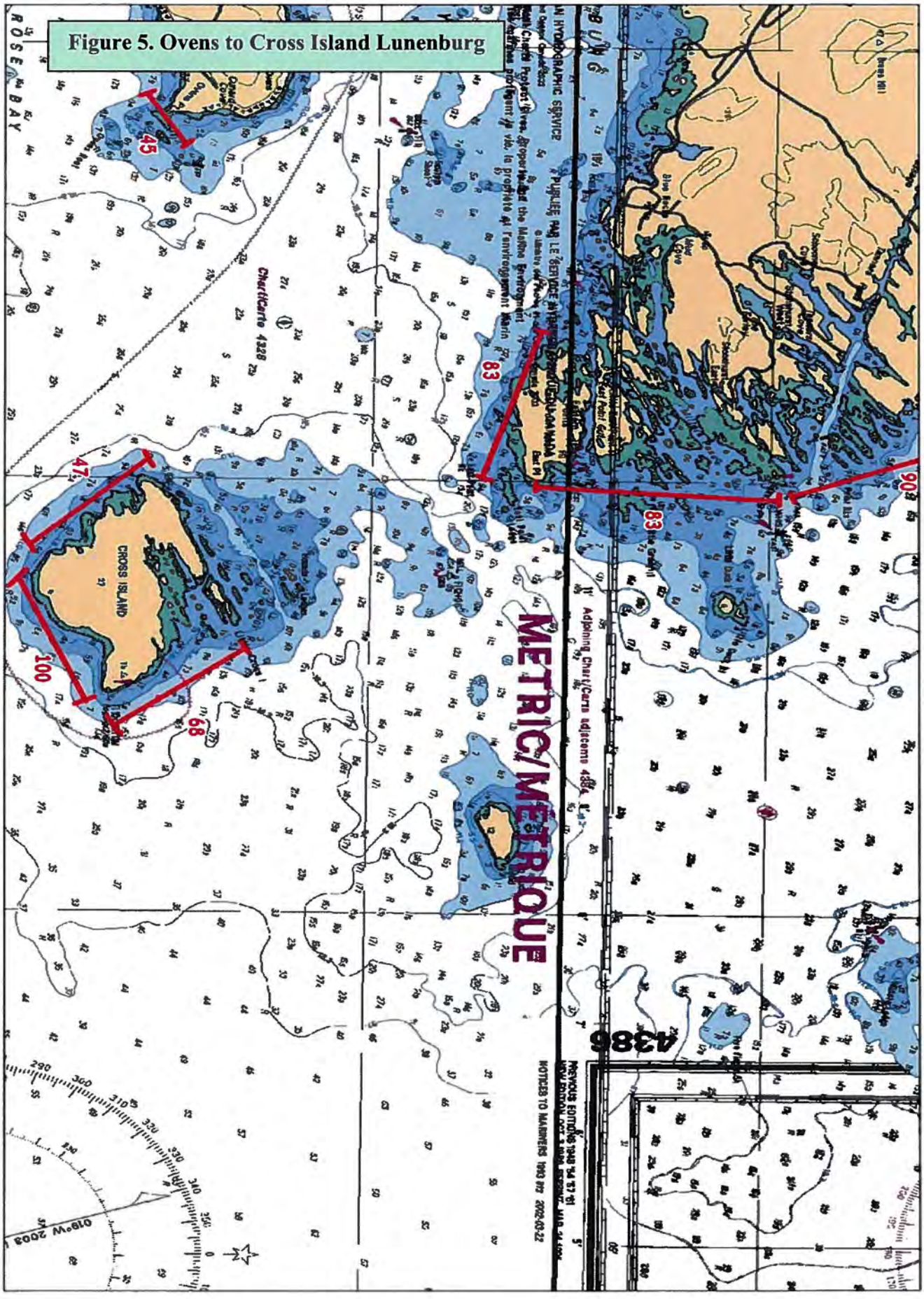


Figure 5. Ovens to Cross Island Lunenburg

Figure 6. Mosher's Island to Rose Point

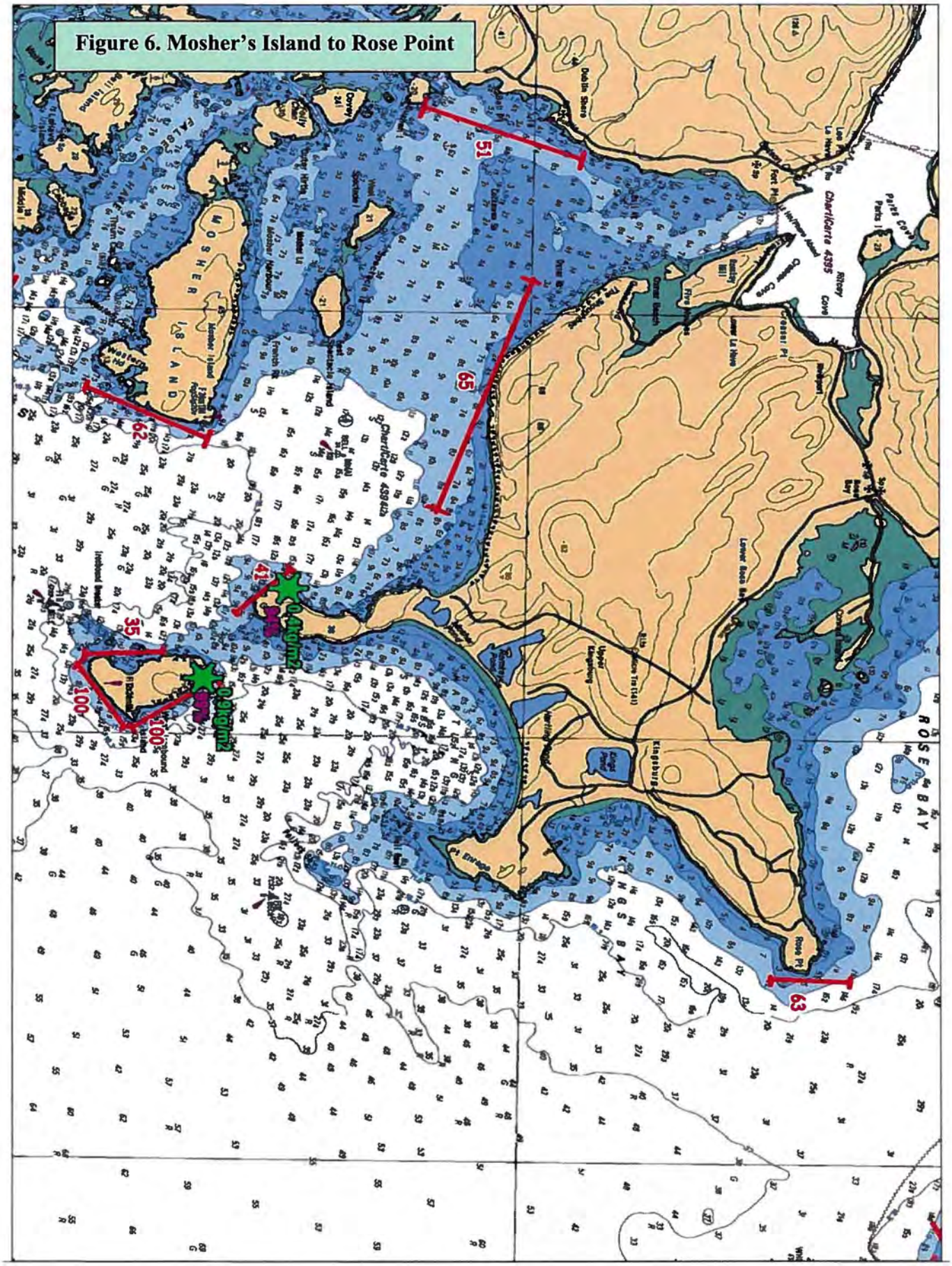


Figure 7. Broad Cove to Moshers Is

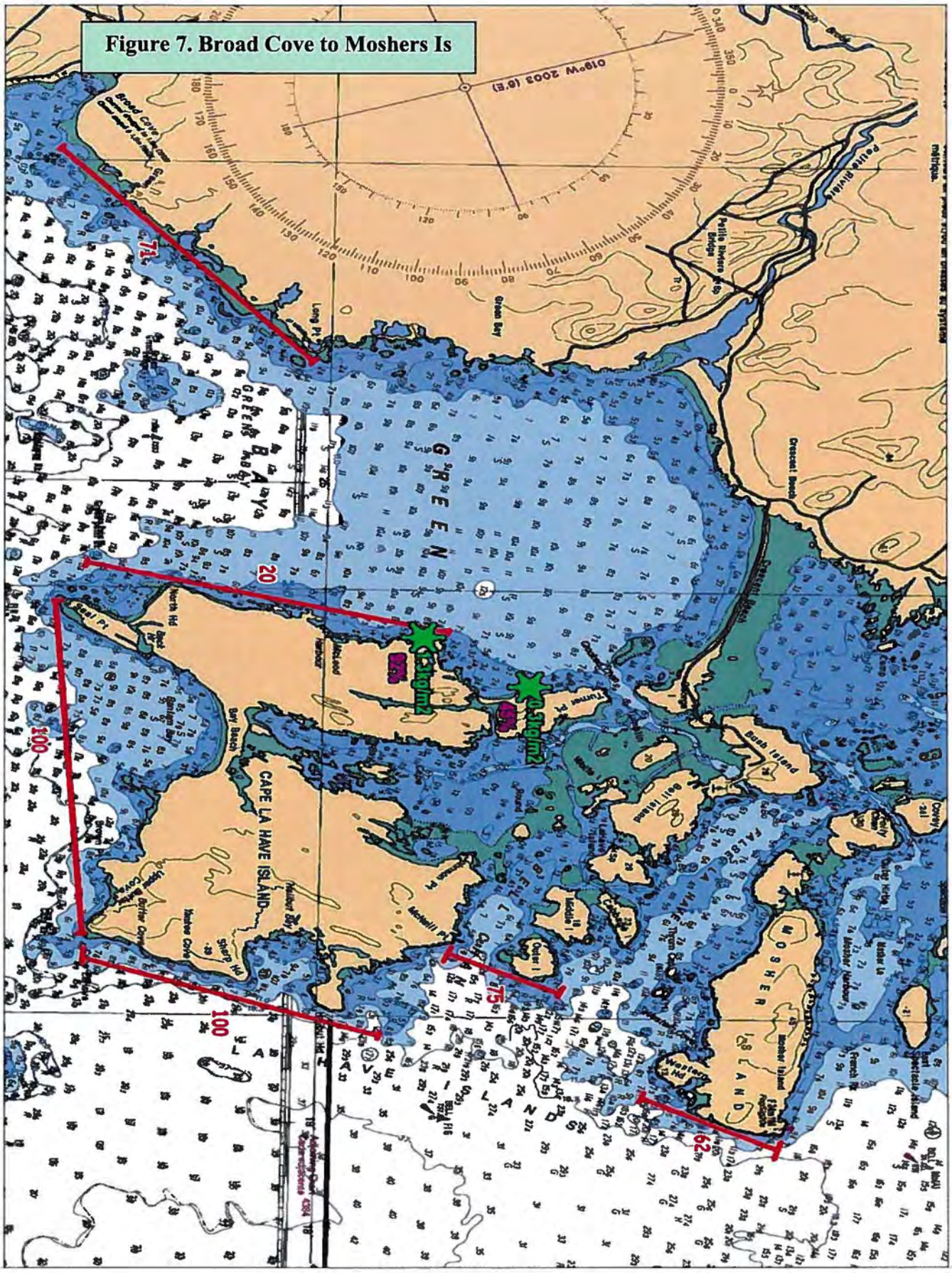


Figure 8. Medway Harbour to Little Harbour

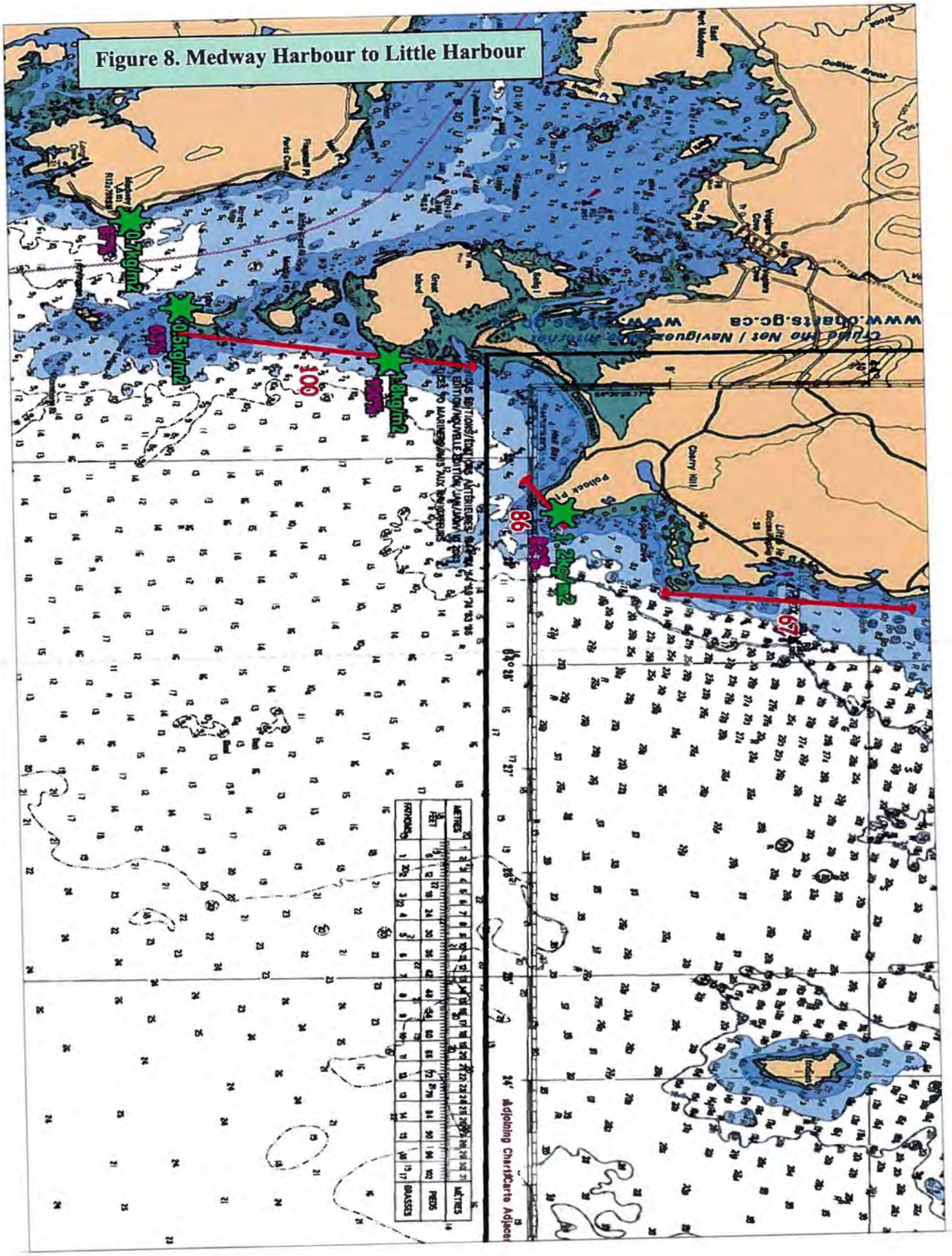


Table 1. Wave exposure index (E.I) (open to unlimited fetch/total open angle) for sectors of the Nova Scotia coastline from Port Medway to Pennant Point.

Shoreline	Sector	E.I %	Shoreline	Sector	E.I. %
Pennant Pt	SO	66	Mosher Is E	S 13	100
Duck Cove Head	S1	51	Mosher Is S	S14	84
Marin Is	S2	35	Mosher Is W	S15	71
Pennant Is E	S3	51	Ryan Is W	S16	38
Pennant Is S	S4	100	Roger Power Is	S 17	70
Pennant Is W	S5	53	Betty Is E	S 18	50
Terrance N shore	S6	56	Betty Is E2	S 19	57
Terrance N shore	S7	53	Betty Is S	S 20	100
Terrance N shore	S8	100	Betty Is W	S 21	81
Tennant Point	S9	54	Hearn Is	K 22	59
Sidney Head	S10	60	Redmond Is	K 21	27
Lower Prospect	S11	25	Saul Is	K 20	78
Ryan Islet E	S12	100	Prospect shore	K 19	94
High Head shore	K 18	75	Tancook Is SW	M 8	58
Shag Head (High H)	K 17	71	Long Is E	M 9	82
Shad Bay East shore	K 16	32	Indian Is S	M 10	56
Shag End (Black pt)	K15	100	Hell Is and Rackets	M 11	90
East Dover	K 14	32	East Point E	M 12	83
High Is & White Is	K13	100	East Point W	M 13	83
Fleming Is	K12	66	Cross Is E	M 14	68
Taylor Is S	K11	100	Cross Is S	M 15	100
Polly Cove shore	K10	51	Cross Is W	M 16	47
Peggy Soi & shore	K 9	100	The Ovens	M18	45
Peggy's Cove E	K 8	90	Rose Point	M 19	63
Peggy's Cove W	K 7	76	Moshers Bay	B 1	65
Cranberry Cove	K 6	69	Bells Point	B 2	51
Middle Pt	K 5	62	La Have East	B 3	100
Indian Harbour	K 4	45	La Have SW	B 4	100
Indian Harbour Is	K 3	57	La Have W	B 5	20
Paddy Head Is	K 2	51	Green Pt to Broad	B 6	71
Paddy Head	K 1	11	Broad C to Back C	B 7	67
Shut In Is W	K 0	33	Back C to Pollack Pt	B 8	86
Broad Cove	M 1	87	Medway Great Is	B 9	100
New Harbour E	M 2	73	Gaff Pt	H 1	41
New Harbour	M 3	75	West Iron Bound E	H 2	100
Sand Cove	M 4	25	West Iron Bound S	H 3	100
Little Tancook W	M 5	34	West Iron Bound W	H 4	35
Little Tancook S	M 6	45	Moshers Is SW	H 5	62
Tancook Is SE	M 7	51	Outer Is	H 6	75