Impact of Harvesting on Marine Plants, Margaree - Grandy Sound Area

Ascophyllum nodosum

Alaria esculenta

Laminaria Digitata
Impact of Harvesting on Marine Plants, Margaree - Grandy Sound Area

Prepared for:
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Prepared by:
- LGL Associates Ltd.
  environmental research associates
  St. John's

To obtain copies (and raw data)
- Dept. of Fisheries and Oceans
  Fisheries Management Sector - Program Planning & Coordination Division
  PO Box 5667
  St. John's NF A1C 5X1
  Canada

Partners/Contributors:
- Program Planning & Coordination Division
  Fisheries Management Sector
  Fisheries and Oceans Canada
  PO Box 5667
  St. John's NF A1C 5X1
- AMPI (All Material Products Inc.)
  Isle aux Morts, NF
- Dr. Robert Hooper
  Biology Dept.
  Memorial University of Newfoundland

The $10 million Fisheries Diversification Program is part of the $81.5 million Canada-Newfoundland Agreement respecting the Economic Development Component of the Canadian Fisheries Adjustment and Restructuring Initiative, announced in August, 1999. The main thrust of the Fisheries Diversification Program is industry-wide research and development initiatives that reflect the economic development priorities of the Newfoundland and Labrador fishing industry.

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1.0 Introduction

Over the past decade the Newfoundland seaweed industry has created several employment opportunities for harvesters and processors that were displaced by the 1992-93 moratorium on northwest Atlantic groundfish fisheries. As a recent ‘fishery’, the seaweed industry has the potential to produce long-term employment opportunities in rural Newfoundland, provided conservation-minded goals are identified and industry stakeholders, science, and management work together in efforts to meet these goals. Important interrelated conservation goals for the seaweed industry such as sustainable utilization, conservationist practices, and optimization of benefits will help to guide planning, and provide a means to judge success.

The harvesting strategies (gear used, methodologies, and exploitation rates) currently used in the Newfoundland seaweed industry have been adopted from marine plant harvesting regulations developed in the Maritime Provinces. These regulations were derived from large-scale, long-term monitoring programs within each region. Adequate monitoring of the influence of these harvesting strategies on seaweed regrowth and reestablishment rates and the potential effects on associated species in the Newfoundland Region will help to provide a means to judge the applicability of the Maritime harvesting plans and guide the development of Conservation Harvesting Plans (CHPs) for the seaweed industry.

With this approach in mind, LGL Limited designed (in consultation with The Department of Fisheries and Oceans, Newfoundland Region, and Dr. Robert Hooper of Memorial University of Newfoundland) and implemented a study to determine the impact of marine plant harvesting procedures upon marine plant resources in the Isle aux Morts area on the southwest coast of Newfoundland. A.M.P.I. Limited of Isle aux Morts has been conducting marine plant harvesting and processing operations for ten years in a coastal zone ranging from Port aux Basques to Grandy Sound. Although A.M.P.I. Limited has in the past harvested small amounts of the kelps (Alaria, Laminaria etc.); the majority of harvesting effort to date has concentrated upon the rockweeds (Ascophyllum, Fucus). Rockweeds (predominantly Ascophyllum with small (0-5%) amounts of associated Fucus) are harvested by hand, sun-dried and ground into powdered form for use as fertilizers and food additives. Due to past harvesting strategy in the Isle aux Morts area, the program concentrated upon investigations of the rockweed Ascophyllum.

This report details the impact of marine plant harvesting procedures upon marine plant resources in the Isle aux Morts area. This includes rockweed biomass distributions, Ascophyllum stalk length distributions, Ascophyllum cut stalk length distributions, and observations of associated fish and invertebrate species. Where possible, comparisons were made with previous seaweed work conducted in the area.
2.0 Objectives

The objectives of the Impact of Marine Plant Harvesting Procedures Upon Marine Plant Resources (Isle aux Morts, 2000) study included:

- Measuring and georeferencing (GPS) the dimensions of harvested and fallow areas, and potentially overexploited areas. (Note that due to the inconsistent/broken distribution of beds of *Ascophyllum* and the random i.e. “patchy” harvest methods employed it was not possible to perform these measurements.)

- Weighing of representative numbers of *Ascophyllum* and *Fucus* from each site to determine the average biomass (kg) per 0.25 m$^2$ quadrats.

- Measuring a representative number of *Ascophyllum* stalks from each site to determine length-class distribution.

- Measuring a representative number of cut stalks remaining at harvested sites to determine if licence conditions are being met.

- Conducting informal observations with respect to fish and invertebrate species associated with rockweed beds.

- The training of A.M.P.I. Limited personnel (time permitting) in the techniques and methodologies required to obtain consistent, scientifically defensible data with respect to harvest and plant regrowth/recovery rates.

- Setting up long-term monitoring sites (time permitting) within harvest zones to provide information with respect to regrowth/recovery rates of plants in areas of different exposure.

- Where possible, comparing results of the present (2000) study with those obtained from biomass surveys conducted in the area in 1998 (Parsons et al. 1998).
3.0 Materials and Methods

Field investigations were performed November 8-16, 2000. The study area consisted of the coastline of southwestern Newfoundland from Margaree in the west to Grandy Sound in the east (Figure 1). For the purpose of this study the coastline was divided into Zone 1-Margaree, Zone 2-Isle aux Morts, Zone 3-Coney Bay, Zone 4-Burnt Island, and Zone 5-Grandy Sound (Figure 1).

Within a zone, site selection was based on four levels of criteria: (1) first priority was given to sites harvested in 2000, (2) second priority included sites harvested prior to 2000, (3) third priority was given to sites that had been investigated in 1998, (4) lastly, if time permitted in a particular zone, an effort was made to include sites located in both sheltered and semi-exposed areas. A summary of sampling locations is presented in Table 1; maps showing the location of sampling sites are presented within the results section.

At each site, two to three transects were extended across the rockweed bed and perpendicular to the shoreline from the upper bed limit to the lower sub-tidal bed limit. On each transect, three points were sampled on foot or via snorkelling, one at the upper limit, one at mid-transect, and one at the lower limit. At each sampling point a 0.25 m² copper tubing quadrat was lowered onto the seaweed bed. Within each quadrat, the main stem of 18 randomly selected *Ascophyllum* plants were measured to the nearest centimetre from the holdfast to the upper tip. All seaweed was removed (cut with a knife) from each quadrat and placed into individual nylon mesh bags. *Ascophyllum* and *Fucus* were separated and wet weights for each species determined on site using digital scales. At the middle quadrat of each transect, six randomly selected *Ascophyllum* plants were measured (cm) from holdfast to tip and the number of branches off the main stem was determined.

At recently (2000) harvested sites, the length of cut stalks remaining was determined for all clumps that were definitively identified. At some locations it was difficult to distinguish between stalks cut during harvest and those naturally cut and torn by high seas or ice.

Additional data collected at each site included: (1) observation of fish and invertebrates associated with rockweed, (2) site positions (GPS), (3) date and time, (4) substrate, (5) bed depth (m), and (6) plant condition (good, slight damage, moderate damage, heavy damage).

Long-term monitoring sites were created by driving 1.5 m long rebar into the substrate and delineating a one meter square zone around it. Resettlement/regrowth sites had all plant material removed (including holdfasts); regrowth sites had plant material removed while leaving approximately 20 cm of stalk above the holdfast (as per the harvesting licence).
4.0 Results and Discussion

4.1 Site Results

Survey results for Margaree, Isle aux Morts, Coney Bay, Burnt Island, and Grandy Sound are presented in point format in the following sections. Biomass, stalk lengths, and comparisons with previous work are discussed after the presentation of results.

4.1.1 Margaree

One site (M-1) was investigated at Margaree (Figure 2, Table 2).

M-1
  - 47º 34.22’ latitude, 59º 03.57’ longitude
  - substrate was mainly bedrock interspersed with large boulders and coarse gravel
  - last harvested 1998
  - 3 transects and 9 quadrats completed
  - 14.24 kg/m² = mean *Ascophyllum* biomass
  - 48.8 (14-94) cm = mean (range) *Ascophyllum* stalk lengths per 0.25 m² quadrat
  - 0.4 kg/m² = mean *Fucus* biomass
  - 7 rock crab (*Cancer sp.*) observed on substrate amongst rockweed
  - numerous (20+ per plant) *Littorina* sp. attached to branches and stalks
  - numerous (100+) amphipoda observed within each quadrat

4.1.2 Isle aux Morts

Seven sites (I-1 to I-7) were investigated at Isle aux Morts (Figure 3, Table 2).

I-1
  - 47º 35.25’ latitude, 59º 00.24’ longitude
  - sheltered location in the vicinity of Isle aux Morts River
  - bed depth was 8 to 10 m
  - substrate was bedrock in the upper zone with fine gravel and mud in the sub-tidal
  - last harvested July-August 2000
  - 3 transects and 9 quadrats completed
  - 15.88 kg/m² = mean *Ascophyllum* biomass
  - 48.7 (12-89) cm = mean (range) *Ascophyllum* stalk lengths per 0.25 m² quadrat
  - 1.2 kg/m² = mean *Fucus* biomass
  - plants were in good condition
• small numbers (approx. 10 per quadrat) of juvenile blue mussel (*Mytilus edulis*) present on branches and stalks

I-2

• 47º 35.20’ latitude, 59º 00.18’ longitude
• sheltered location in the vicinity of Isle aux Morts River
• bed depth was 6 to 8 m
• substrate was bedrock in the upper zone with fine gravel and mud in the sub-tidal
• last harvested July-August 2000
• 2 transects and 6 quadrats completed
• 15.52 kg/m² = mean *Ascophyllum* biomass
• 49.5 (21-97) cm = mean (range) *Ascophyllum* stalk lengths per 0.25 m² quadrat
• 0.36 kg/m² = mean *Fucus* biomass
• plants were in good condition
• blue mussel (*Mytilus edulis*) mixture of spat and juveniles, amphipods, and *Littorina* sp. present on *Ascophyllum* branches and stems

I-3

• 47º 35.10’ latitude, 58º 59.47’ longitude
• semi-exposed location
• bed depth was 6 to 8 m
• substrate was bedrock and large boulder in the upper tidal with coarse gravel in the lower tidal
• last harvested 1999
• 3 transects and 9 quadrats completed
• 12.84 kg/m² = mean *Ascophyllum* biomass
• 52.2 (20-110) cm = mean (range) *Ascophyllum* stalk lengths per 0.25 m² quadrat
• 0.08 kg/m² = mean *Fucus* biomass
• plant damage ranged from light in the upper tidal to moderate in the lower tidal
• 2 rock crab (*Cancer* sp.) were observed on substrate
• small amounts of gastropods and blue mussel (*Mytilus edulis*) were attached to *Ascophyllum* stalks and branches
• amphipods were present within beds and upon substrate

I-4

• 47º 35.18’ latitude, 58º 59.24’ longitude
• sheltered location in northeast section of Mickle Reach
• bed depth was 5 to 8 m
• substrate is predominantly cobble and gravel interspersed with large boulders
• last harvested 1998
• 2 transects and 6 quadrats completed
• 16.48 kg/m² = mean Ascophyllum biomass
• 51.7 (20-89) cm = mean (range) Ascophyllum stalk lengths per 0.25 m² quadrat
• 0.24 kg/m² = mean Fucus biomass
• plants were lightly damaged in the sub-tidal zone
• 1 rock crab (Cancer sp.) was observed on substrate
• low numbers (10-30 per quadrat) of gastropods were attached to Ascophyllum stalks and branches

I-5

• 47º 34.39’ latitude, 58º 59.49’ longitude
• sheltered location in southern end of Squid Hole
• bed depth was 5 to 10 m
• substrate is bedrock in the upper-tidal with coarse gravel interspersed with large and small boulders in the mid and sub-tidal
• last harvested May-June 2000
• 2 transects and 6 quadrats completed
• 14.48 kg/m² = mean Ascophyllum biomass
• 48.4 (15-89) cm = mean (range) Ascophyllum stalk lengths per 0.25 m² quadrat
• 2.24 kg/m² = mean Fucus biomass
• plants were lightly damaged in the sub-tidal zone
• blue mussel spat (Mytilus edulis) and gastropods were attached to Ascophyllum stalks and branches
• mysid shrimp (Mysidae) were observed free-swimming within beds
• six winter flounder (Pseudopleuronectes americanus) were observed within beds upon substrate

I-6

• 47º 34.52’ latitude, 58º 59.46’ longitude
• sheltered location on south side of small island at the mouth of Squid Hole
• bed depth was 8 to 10 m
• substrate was bedrock and large boulder
• last harvested May-June 2000
• 2 transects and 6 quadrats completed
• 17.16 kg/m² = mean Ascophyllum biomass
• 52.0 (21-118) cm = mean (range) Ascophyllum stalk lengths per 0.25 m² quadrat
• 0.64 kg/m² = mean Fucus biomass
• plants were lightly damaged in the sub-tidal zone
• blue mussel spat (Mytilus edulis) and gastropods were attached to Ascophyllum stalks and branches
• amphipods were observed within beds
• green sea urchins (Strongylocentrotus droebachiensis) were observed feeding upon Ascophyllum at the lower edge of the sub-tidal zone
I-7

- 47º 35.25’ latitude, 58º 59.11’ longitude
- sheltered location, northeast Mickle Reach
- bed depth was 5 to 7 m
- substrate was large and small boulder interspersed with cobble and coarse gravel
- last harvested 1998
- 3 transects and 9 quadrats completed
- 15.08 kg/m² = mean Ascophyllum biomass
- 53.6 (16-92) cm = mean (range) Ascophyllum stalk lengths per 0.25 m² quadrat
- 0.72 kg/m² = mean Fucus biomass
- plants were lightly to moderately damaged in the sub-tidal zone
- 4 rock crab (Cancer sp.) were observed on the substrate within beds
- Littorina sp. were attached to Ascophyllum stalks and branches
- amphipods and isopods were observed within beds
- five winter flounder (Pseudopleuronectes americanus) were observed on the substrate within beds

4.1.3 Coney Bay

One site (C-1) was investigated at Coney Bay (Figure 4, Table 2).

C-1

- 47º 35.35’ latitude, 58º 55.09’ longitude
- semi-exposed location, small cove in northeastern section of Coney Bay
- bed depth was 2 to 7 m
- substrate was bedrock in the upper-tidal, with large and small boulders interspersed with cobble and coarse gravel in the mid and sub-tidal zones
- last harvested 1998
- 3 transects and 9 quadrats completed
- 17.96 kg = mean Ascophyllum biomass
- 52.3 (21-97) cm = mean (range) Ascophyllum stalk lengths per 0.25 m² quadrat
- 0.44 kg/m² = mean Fucus biomass
- plants were lightly to moderately damaged in the upper and mid-tidal zones, while plants in the lower sub-tidal zone exhibited heavy damage, there was also evidence (torn and ripped plants) of substantial natural loss in the sub-tidal zone
- small numbers (20-40 per quadrat) of blue mussel (Mytilus edulis) spat was attached to stalks and branches of Ascophyllum
4.1.4 Burnt Island

One site (B-1) was investigated at Burnt Island (Figure 5, Table 2).

**B-1**

- 47º 36.26’ latitude, 58º 52.42’ longitude
- sheltered location, first small island in chain situated in the northeast of God Bay
- bed depth was 2 to 7 m
- substrate was bedrock in the upper-tidal, with large and small boulders interspersed with cobble and coarse gravel in the mid and sub-tidal zones
- last harvested 1998
- 2 transects and 6 quadrats completed
- 18.96 kg/m² = mean *Ascophyllum* biomass
- 60.9 (15-116) cm = mean (range) *Ascophyllum* stalk lengths per 0.25 m² quadrat
- 0.40 kg/m² = mean *Fucus* biomass
- plants were in good condition
- juvenile blue mussels (*Mytilus edulis*) and gastropods were attached to stalks and branches of *Ascophyllum*

4.1.5 Grandy Sound

Four sites (G-1 to G-7) were investigated at Grandy Sound (Figure 6, Table 2).

**G-1**

- 47º 35.47’ latitude, 58º 51.31’ longitude
- sheltered location, small cove on island situated in the southwest section of Grandy Sound
- bed depth was 5 m
- substrate was small boulders interspersed with cobble and coarse gravel
- last harvested 1998
- 2 transects and 6 quadrats completed
- 15.28 kg/m² = mean *Ascophyllum* biomass
- 50.8 (16-90) cm = mean (range) *Ascophyllum* stalk lengths per 0.25 m² quadrat
- 0.48 kg/m² = mean *Fucus* biomass
- plants were in good condition
- large numbers (100+ per quadrat) of juvenile blue mussels (*Mytilus edulis*) and *Littorina* sp. were attached to stalks and branches of *Ascophyllum*
- amphipods were present within beds and upon substrate
- epiphytic hydroids *Sertularia* sp. were present in large numbers upon both *Ascophyllum* and *Fucus*
- *Ascophyllum* were covered with massive numbers of the polychaete *Spirorbis* sp.
G-2

- 47° 35.50’ latitude, 58° 51.52’ longitude
- semi-exposed location, island peninsula situated in the southeast section of Grandy Sound
- bed depth was 4 m
- substrate was bedrock which sloped down sharply to gravel interspersed with small boulder
- last harvested 1998
- 2 transects and 6 quadrats completed
- 13.08 kg/m² = mean Ascophyllum biomass
- 44.4 (13-85) cm = mean (range) Ascophyllum stalk lengths per 0.25 m² quadrat
- 0.04 kg/m² = mean Fucus biomass
- plants were damaged (ripped and torn)
- high numbers of Fucus were epiphytic upon Ascophyllum (these epiphytes were ubiquitous enough to give the Ascophyllum a ‘furry’ appearance)
- high numbers (100+ per quadrat) of juvenile blue mussels (Mytilus edulis) and Littorina sp. were attached to stalks and branches of Ascophyllum
- 5 rock crab (Cancer sp.) were observed within beds upon substrate
- mysid shrimp (Mysidae) were observed free-swimming within beds in schools of 20 to 50 animals at depths of 2 to 4 m
- epiphytic hydroids Dynamena pumila were present in large numbers upon both Ascophyllum and Fucus
- Ascophyllum were covered with massive numbers of the polychaete Spirorbis sp.

G-3

- 47° 36.46’ latitude, 58° 49.52’ longitude
- semi-exposed location, situated in the northeast section of Grandy Sound
- bed depth was 6 m
- substrate was bedrock which sloped gently down to fine gravel and mud
- last harvested 1998
- 2 transects and 6 quadrats completed
- 15.68 kg/m² = mean Ascophyllum biomass
- 56.5 (15-110) cm = mean (range) Ascophyllum stalk lengths per 0.25 m² quadrat
- 0.08 kg = mean Fucus biomass
- plants were moderately damaged
- high numbers (100+ per quadrat) of juvenile (and spat) blue mussel (Mytilus edulis) and gastropods were attached to stalks and branches of Ascophyllum
- amphipods were present upon plants and substrate
- 5 rock crab (Cancer sp.) were observed within beds upon substrate
- 3 juvenile winter flounder (Pseudopleuronectes americanus) were observed upon substrate within beds
- 4 juvenile cod (Gadus morhua) were observed within beds
• epiphytic hydroids *Dynamena pumila* were present in large numbers upon both *Ascophyllum* and *Fucus*

**G-4**

• 47° 35.52’ latitude, 58° 50.45’ longitude
• semi-exposed location, situated in the northeast section of Grandy Sound
• bed depth was 6 m
• substrate was bedrock
• last harvested 1998
• 2 transects and 6 quadrats completed
• 18.24 kg/m² = mean *Ascophyllum* biomass
• 56.3 (26-96) cm = mean (range) *Ascophyllum* stalk lengths per 0.25 m² quadrat
• 0.08 kg/m² = mean *Fucus* biomass
• plants were moderately damaged
• low numbers (10+ per quadrat) of juvenile blue mussel (*Mytilus edulis*) and *Littorina* sp. were attached to stalks and branches of *Ascophyllum*
• one banded rock gunnel (*Pholis fasciata*) observed within beds upon substrate
• epiphytic hydroids *Dynamena pumila* were present in large numbers upon both *Ascophyllum* and *Fucus*
• *Ascophyllum* were covered with massive numbers of the polychaete *Spirorbis* sp.

### 4.2 Biomass Distributions

Biomass (kg/m²) distributions for *Ascophyllum* were consistent for all zones examined. Mean *Ascophyllum* biomass (kg/m²) was 14.24 at Zone-1 (Margaree), 15.24 at Isle aux Morts, 17.96 at Coney Bay, 18.96 at Burnt Island, and 15.56 at Grandy Sound (Table 2, Figure 7).

Biomass (kg/m²) distributions for *Ascophyllum* were also consistent between sites within zones. Mean *Ascophyllum* biomass (kg/m²) within Zone-2 (Isle aux Morts) was 15.88 at Site I-1, 15.52 at Site I-2, 12.84 at Site I-3, 16.48 at Site I-4, 14.48 at Site I-5, 17.16 at Site I-6, and 15.08 at Site I-7 (Table 2, Figure 3). Mean *Ascophyllum* biomass (kg/m²) within Zone-5 (Grandy Sound) was 15.28 at Site G-1, 13.08 at Site G-2, 15.68 at Site G-3, and 18.24 at Site G-4 (Table 2, Figure 6).

Biomass (kg/m²) distributions for *Fucus* were consistent and statistically similar for all zones examined. Mean *Fucus* biomass (kg/m²) was 0.40 at Margaree, 0.48 at Isle aux Morts, 0.44 at Coney Bay, 0.40 at Burnt Island, and 0.2 at Grandy Sound (Table 2, Figure 7).

Biomass (kg/m²) distributions for *Fucus* were also consistent between sites within zones. Mean *Fucus* biomass (kg/m²) within Zone-2 (Isle aux Morts) was 0.12 at Site I-1, 0.36 at Site I-2, 0.08 at Site I-3, 0.24 at Site I-4, 2.24 at Site I-5, 0.64 at Site I-6, and 0.72 at Site I-7 (Table 2, Figure 3). Mean *Fucus* biomass (kg/m²) within Zone-5 (Grandy Sound) was
0.48 at Site G-1, 0.04 at Site G-2, 0.08 at Site G-3, and 0.08 at Site G-4 (Table 2, Figure 6).

### 4.3 *Ascophyllum* Stalk Lengths

#### 4.3.1 Length Distribution

Mean *Ascophyllum* stalk lengths (cm) were consistent for all zones examined. Mean *Ascophyllum* stalk length (cm) (range) was 48.8 (14-94) at Zone-1 (Margaree), 50.9 (12-118) at Zone-2 (Isle aux Morts), 52.3 (21-97) at Zone-3 (Coney Bay), 60.9 (15-116) at Zone-4 (Burnt Island), and 52.0 (13-110) at Zone-5 (Grandy Sound) (Table 2).

*Ascophyllum* stalk lengths (cm) were also consistent between sites within zones. Mean *Ascophyllum* stalk length (cm) within Zone-2 (Isle aux Morts) was 48.7 (12-89) at Site I-1, 49.5 (21-97) at Site I-2, 52.2 (20-110) at Site I-3, 51.7 (20-89) at Site I-4, 48.4 at Site I-5, 52.0 (21-118) at Site I-6, and 53.6 (16-92) at Site I-7 (Table 2). Mean *Ascophyllum* stalk length (cm) within Zone-5 (Grandy Sound) was 50.8 (16-90) at Site G-1, 44.4 (13-85) at Site G-2, 56.5 (15-110) at Site G-3, and 56.3 (26-96) at Site G-4 (Table 2).

#### 4.3.2 Length-Class Distributions

It has been established (based upon research conducted in the Maritimes) that rockweed harvesting can impact the length-class distribution of a rockweed population (Sharp 1981, 1986). Unharvested rockweed beds tend to naturally exhibit a bimodal population structure (two or more prominent length classes). Harvesting tends to shift the population towards a unimodal distribution (one dominant length class), which if left to fallow for two to three years will eventually re-exhibit bimodal characteristics (Ang et al. 1996). The distribution changes are thought to result from opening of the canopy (post harvest) that permits the settling and establishment of new plants. These small plants will (over two to three years) become established within beds and will be evidenced within the population structure as a new co-dominant modal class (Ang et al. 1991).

Length-class distributions for all sites within the study area were almost exclusively unimodal. Of the 14 sites examined, only three (Isle aux Morts, I-1; Grandy Sound, G-1; Margaree, M-1) indicate a possible second prominent length-class within their distributions (Figure 8). However, due to the proximity of the secondary length-classes to the primary (usually within 20 cm) it is uncertain if these are true length classes or sampling artefacts.

Previous investigations on the effects of harvesting on rockweed length-class distributions (Ang et al. 1996; Sharp 1981, 1986) were based upon significantly larger sample sizes and time frames than those of the present study. Ang et al. (1996) measured for five years, all the individual plants within at least 30 0.25 m² quadrats per site. Based upon a conservative estimate of 80 plants per quadrat, these length-class estimates are based upon approximately 2400 individual measurements per site. The present study measured 18 individual plants from a maximum of nine 0.25 m² quadrats per site.
Therefore, the Isle aux Morts 2000 length class estimates are based upon approximately 162 individual measurements per site. The sample sizes may not have been sufficient to account for natural variability within the populations.

Another difficulty with interpreting the 2000 data is the lack of any information with respect to length-class distributions collected prior to the onset of harvesting operations. Without information regarding either the original (i.e. natural) length-class distributions of rockweed in the area, or post-harvest data from previous years it is not possible to detect any long-term trends.

The unimodal length-class distributions identified at most sites could potentially be attributed to narrow rockweed beds, lack of shading or ice pruning, but are most likely indicative of a recently harvested rockweed population. Given the lack of previous pre-harvest or post-harvest monitoring we can only assume the unimodal distributions are related to decade-long harvesting activities in the area.

4.3.3 Cut Stalk Lengths

Only three sites within the study area were harvested in spring of 2000. These were all located in Isle aux Morts and included sites I-2, I-5, and I-6 (Figure 3). Other sites were harvested in 1999 and 1998, however no cut stalks were visible at either of these locations. Even at locations harvested in 2000, cut stalks were difficult to identify (requiring up to an hour of snorkelling time to find and measure). This is probably related to the “patchy” harvest methods employed (a plant is cut, the harvester moves a few steps and cuts another), which can result in cut stalks interspersed randomly within beds of whole plants.

Cut stalks had a mean length (cm) (range) of 27.6 (18-42) at Site I-1, 21.1 (12-36) at Site I-5, 25.9 (17-33) at Site I-6, and an overall mean of 24.9 cm (Table 3). The ‘2000 Exploratory Marine Plant Licence’ issued by DFO stipulates that rockweeds must be harvested such that a minimum of 20 cm remains above the substrate. While some of the individual cut stalks measured were below 20 cm, the mean cut stalk length per site was consistently greater than 20 cm.

At the middle quadrat of each transect, six randomly selected Ascophyllum plants were measured (cm) from holdfast to tip and the number of branches off the main stem was determined. The result of this effort was inconclusive, the number of branches could not be statistically related to either stalk length, location, or date of last harvest. Larger sample sizes in future investigations may reveal this characteristic to be a useful indicator of harvest effort and rates of recovery.

It should be noted that at all previously harvested locations (1998, 1999, and 2000) “bare” areas (completely denuded of marine plants) ranging in size from one to five square meters were frequently observed. These “bare” areas were encountered upon substrates suitable for marine plants and were commonly surrounded by healthy plants. This distribution is inconsistent with algal beds that have experienced natural (i.e. storm
or ice damage) and could be related to poor harvesting techniques. This may be indicative of “plucking” of plants and removal of holdfast cells as opposed to cutting stalks. Without pre-harvest distribution and biomass data it is not possible to definitively determine if these “bare” areas are related to improper harvesting techniques or are due to natural factors.

4.4 Comparisons With 1998 Biomass Survey

Sites included within the 2000 study that were located at or near the same location as sites investigated in 1998 (Parsons et al. 1998) include Margaree (M-1) (Figure 2), Isle aux Morts (I-5, I-7) (Figure 3), Coney Bay (C-1) (Figure 4), Burnt Island (B-1) (Figure 5), and Grandy Sound (G-1, G-2, G-4) (Figure 6).

Biomass estimates (kg/m²) of *Fucus* obtained in 2000 were consistently similar to those obtained in 1998. The overall mean *Fucus* biomass (kg/m²) for the study area was 0.52 kg in 2000 and 0.36 in 1998 (Table 4).

Biomass estimates (kg/m²) of *Ascophyllum* obtained in 2000 were consistently and significantly greater (1.5X to 3.5X) than estimates obtained in 1998 (Table 4). These differences are reflected in the overall biomass means for sites that have been repeated, 15.76 kg for 2000 and 6.44 kg for 1998 (Table 4). The lack of any pre or post-harvest monitoring in an area that has undergone various degrees of harvesting for approximately ten years makes it difficult to biologically interpret the observed biomass increase from 1998 to 2000.

Seasonal biomass fluctuations may account for some of the biomass difference. Samples collected in 1998 were taken in August (when plants are in their growth phase) while those collected in 2000 were taken in November (when the seasonal growth is complete). Bearing in mind this seasonal growth cycle we would anticipate plants sampled in November to be larger than those sampled in August. Another explanation for the increase in biomass between 1998 and 2000 is that *Ascophyllum* populations that were over-harvested in the past have undergone some recovery. Parsons et al. (1998) refers to areas of “virtual devastation” in Isle aux Morts harbour and also reports evidence of historic over-harvesting throughout the entire study area. Seaweed beds examined in 2000 appeared to be uniformly in good condition and there was no tangible evidence of devastation at any of the sites examined in 1998.

A difference in fundamental approach between the two studies may also account for some of the biomass increase. The 2000 investigation was not intended as a “biomass survey” but was structured to monitor harvest practices and ensure compliance with licence conditions. Quadrat placement within rockweed beds in 2000 was not random as it was in 1998. The goal of the 2000 study was to measure as many individual cut and uncut plants as possible, therefore quadrats were always placed upon rockweed. Some of the locations had rockweed beds with “patchy” distributions i.e. there were gaps with no plants. Random tosses within such beds would inevitably result in quadrats landing upon areas of little or no growth, resulting in lower overall biomass estimates.
The actual biomass distribution within the study area is likely to be slightly lower than the 2000 numbers would indicate. How much lower is difficult to estimate, although a reduction of 1/3 would probably bring the numbers closer to the actual. Given the “patchy” distributions of rockweed beds within the study area it is questionable if five (1998 study) or nine quadrats (2000 study) randomly tossed could adequately account for the statistical variability visually evident. In areas of such high natural variability more sampling effort is required over a longer, continuous time frame. Studies conducted seasonally for five years or more in the Maritime Provinces (Ang et al. 1996) routinely place 30 or more 0.25 m$^2$ quadrats within a sampling site. Future biomass surveys and compliance monitoring programs conducted in Newfoundland should strive to attain these standards.

4.5 Long-Term Monitoring Sites

Six long-term monitoring sites were established at Isle aux Mort, three at Site I-5 (“the bottom of Squid Hole”) and three upon the north side of a large rock in the middle of Squid Hole. Three rebar were driven into the substrate at each site and a one-meter zone was cleared around each rebar. At Site I-5 all plant material (including holdfasts) was removed, this site will be monitored for reestablishment/regrowth rates. At the rock site, *Ascophyllum* and *Fucus* were harvested as per the licence stipulations (leaving at least 20 cm of stalk above the substrate), this site will be monitored for regrowth rates. A.M.P.I. Ltd. personnel were trained in the techniques (measurement and sub-sampling methods) necessary for monitoring. It is hoped that A.M.P.I.Ltd. Personnel will, on an opportunistic basis, be able to collect seasonal data.
5.0 Summary

The Impact of Marine Plant Harvesting Procedures Upon Marine Plant Resources (Isle aux Morts, 2000) study has indicated that the rockweed resource (*Ascophyllum* and *Fucus*) within the study area has undergone some recovery from the over-harvesting and “virtual devastation” reported in the area during 1998. Biomass values (kg/m²) from all zones were comparable, ranging from 14.24 to 18.96 with a mean of 15.76. Given the lack of pre-harvest information it is not possible to compare these values with the original “natural” values.

Analysis of stalk length data indicates that most of the sites exhibited a unimodal length-class distribution. In Maritime jurisdictions a unimodal distribution is considered to be indicative of a recently (one to two years) harvested population, which, if given sufficient recovery time (three to five years), will again exhibit bimodal characteristics. Given the lack of baseline research in Newfoundland waters with respect to regrowth/reestablishment rates of harvested rockweed we can only precariously assume that the unimodal distributions in the study area indicate that the resource has not completely returned to the pre-harvest natural state. It should also be noted that given the lack of pre and post-harvest monitoring within the harvest areas it is difficult to confidently attribute any observed changes in biomass or distribution to either past harvesting or natural biological factors such as seasonal biomass fluctuations, storm damage or ice pruning.

Cut stalks were positively identified at only three sites, all of which were harvested in the spring of 2000. The mean length of cut stalks for all sites combined was 24.9 cm with a range of 12-42 cm. The ‘2000 Exploratory Marine Plant Licence’ issued by DFO stipulates that rockweeds must be harvested such that a minimum of 20 cm remains above the substrate. While some of the individual cut stalks measured were below 20 cm, the mean cut stalk length per site was consistently greater than 20 cm. The widespread presence of “bare” areas upon suitable substrate within large beds of healthy plants may indicate that some “plucking” of plants and attached holdfasts has occurred in recent harvest years. However, without pre-harvest distribution and biomass data it is not possible to definitively determine if these “bare’ areas are related to improper harvesting techniques or are due to natural factors.

Of the fish and invertebrate species directly associated with rockweed, *Littorina* sp., mussel spat and juveniles (*Mytilus*), and a polychaete (*Spirobis*) were found to be the most ubiquitous. Either of these species could be present in sufficient numbers as to completely cover the branches and stalks of *Ascophyllum* within a bed. Amphipods and isopods (both upon the substrate and free-swimming within branches) were also commonly encountered in high numbers. Rock crab (*Cancer* sp.), shore shrimp (*Palaemonetes* sp.), winter flounder (*Pleuronectes americanus*), and juvenile Atlantic cod (*Gadus morhua*) were also sporadically observed.
6.0 References


Figures

Impact of Marine Plant Harvesting Procedures
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Figure 8. continued (3)
Figure 8. continued (4)
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On Marine Plant Resources (Isle aux Morts, 2000)
Table 1. Sample locations and positions, Impact of Marine Plant Harvesting Procedures Upon Marine Plant Resources (Isle aux Morts, 2000).

<table>
<thead>
<tr>
<th>Location</th>
<th>Site #</th>
<th>Environment</th>
<th>Last Harvest</th>
<th>Sample Date</th>
<th>Time</th>
<th>Position</th>
<th># Transects</th>
<th># Quadrats</th>
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Table 2. Mean *Ascophyllum* and *Fucus* biomass (kg/m²) and *Ascophyllum* stalk lengths (cm), Impact of Marine Plant Harvesting Procedures Upon Marine Plant Resources (Isle aux Morts, 2000).

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<tr>
<th>Location</th>
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<th># Quadrats</th>
<th><em>Ascophyllum</em> Biomass (kg/m²)</th>
<th><em>Ascophyllum</em> Stalk Length (cm) Mean (Range)</th>
<th><em>Fucus</em> Biomass (kg/m²)</th>
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Table 4. Comparisons of mean *Ascophyllum* and *Fucus* biomass (kg/m²) and plant length, from both The Impact of Marine Plant Harvesting Procedures Upon Marine Plant Resources (Isle aux Morts, 2000) and The Inventory of Seaweed Resources of Southwest Newfoundland (Parsons et al. 1998).

<table>
<thead>
<tr>
<th>Location</th>
<th>Site #</th>
<th>Date</th>
<th># Quadrats</th>
<th><em>Ascophyllum</em> Biomass (kg)</th>
<th><em>Ascophyllum</em> Plant Length (cm) Mean (Range)</th>
<th><em>Fucus</em> Biomass (kg)</th>
</tr>
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<td>Margaree</td>
<td>M-1</td>
<td>Nov-00</td>
<td>9</td>
<td>14.24</td>
<td>48.8 (14 - 94)</td>
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* na = information not available