Cah. Biol. Mar. (2001) 42 : 63-70

A new approach to seaweed management in Eastern Canada: the case of *Ascophyllum nodosum*

Raúl A. UGARTE[1] and Glyn SHARP[2]
[1] Acadian Seaplants Limited, 30 Brown Avenue, Dartmouth, N.S., Canada, B3B 1X8.
[2] Invertebrate Fisheries Division, Department of Fisheries & Oceans,
Bedford Institute of Oceanography, Dartmouth, N.S., Canada.

Abstract: Recent collapses of some important fisheries in Atlantic Canada have created a strong public concern regarding management policies for marine resources. Consequently, a precautionary approach has been urged for these resources. Previously marine plant management was either "laissez faire" or based only on single species resource sustainability. A new approach was applied to the management of the fucoid *A. nodosum* (Rockweed) as this resource plays a role as a habitat for invertebrates and vertebrates. In 1995, under a four-year pilot plan, the *A. nodosum* harvest expanded from Nova Scotia to the unexploited area of southern New Brunswick. A new joint federal/provincial management strategy for Rockweed was implemented after reviewing existing biological information and 30 years of harvesting history and experience in Nova Scotia. Maximum exploitation rate, cutting height, gear restrictions, and protected areas were management measures within a precautionary pilot harvest plan. A research and monitoring program involving the industry, universities and the provincial and federal government was simultaneously initiated to evaluate the effect of the harvest on the resource and associated species and to provide information to improve the management of Rockweed. A scientific peer committee carried out a review of this information in April 1998 and 1999. The consensus was that the harvest impact on the habitat architecture was minimal and of short duration, therefore, it was advised to continue the harvest but to maintain the precautionary approach to management.

Résumé : Les déclins récents de quelques pêcheries importantes au Canada Atlantique ont suscité un fort intérêt citoyen pour les politiques de gestion des ressources marines. En conséquence, une approche préventive a été recommandée pour ces ressources. Auparavant, la gestion des plantes marines était soit le « laissez-faire » ou était basée sur la disponibilité de la seule espèce exploitée. Une nouvelle approche a été appliquée à la gestion des populations de l'algue brune ficoïde *Ascophyllum nodosum* car cette algue représente un habitat d'importance pour des invertébrés et des vertébrés. En 1995, un plan de gestion de quatre ans a envisagé l'expansion de la récolte d'*A. nodosum* de la Nouvelle-Écosse vers des zones inexploitées au Nouveau Brunswick. Une nouvelle stratégie conjointe entre le niveau fédéral et provincial a été adoptée après examen des donnés biologiques existantes et l'expérience des trente dernières années de récolte d'*A. nodosum* en Nouvelle-Écosse. Les mesures de gestion de ce plan pilote de récolte consistaient à définir des taux d'exploitation maximum, la hauteur de coupe, les restrictions sur l'équipement de coupe et des aires de réserves. Un programme de recherche et de surveillance impliquant les industriels, les universités et les gouvernement fédéral a débuté pour simultanément évaluer les effets de la récolte sur la ressource et les espèces associées et fournir des données affines d'améliorer la gestion d'*A. nodosum*. Un comité scientifique a réalisé une évaluation de ces données en avril 1998 et 1999. Un consensus a été atteint pour constater un impact très faible et de courte durée sur l'architecture de l'habitat, mais cependant le principe de précaution s'impose pour la poursuite de la gestion.

Keywords : seaweeds, fisheries, harvesting, management, *Ascophyllum nodosum,* rockweed.

Introduction

Ascophyllum nodosum (rockweed) extends from the Arctic Circle to New Jersey in North America and in a wide range of wave exposures on stable substrate (Baarsdeth 1970). Rockweed is replaced or mixed with other related species (Fucus spp.) in the most exposed or ice scoured areas (Sharp 1986). Rockweed has become the most important commercial seaweed in Canada and it is the dominant perennial brown seaweed in the intertidal zone along the Atlantic coastline of the Maritimes where it forms extensive beds.

Shoots of this seaweed arise from a holdfast and develop a complex structure of dichotomous and lateral branching (Fig. 1). The plant is dioecious, producing gametes from specialized structures called receptacles. As the tide rises, the plant is buoyed up by means of gas bladders (vesicles) on the shoots creating a floating canopy. The majority of new shoots arise vegetatively from existing basal holdfast tissues. As the plant grows, its holdfast begins to coaless with holdfasts of adjacent plants forming clumps. The high density of branching shoots in a clump and the distribution of clumps in a bed create a complex habitat for invertebrates and fishes during the tide cycle. This is a productive habitat; annual production of vegetative biomass varies between 20% to 45% depending on wave exposure (Causens 1984).

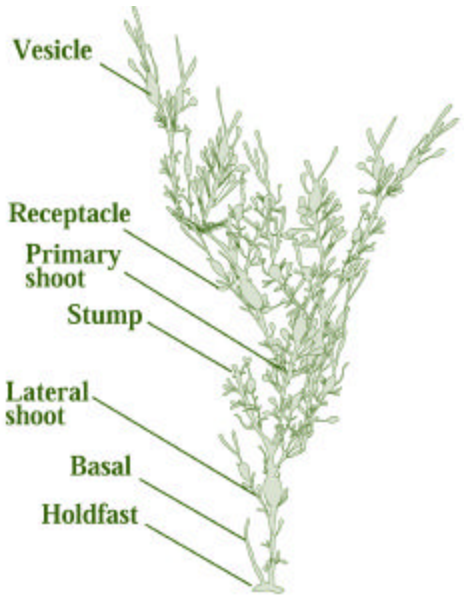

Figure 1. *Ascophyllum nodosum*. Nonmenclature of morphological features.
Figure 1. *Ascophyllum nodosum.* Nomenclature des caractéristiques morphologiques.

Despite episodic recruitment from sexual reproduction, rockweed forms a very stable cover in the intertidal zone. Storms, ice action and pollution can reduce abundance or restrict its distribution (Sharp 1986).

Commercial exploitation of Rockweed along the coastal areas of Nova Scotia began in the late 1950's when it was used as raw material for sodium alginate and "kelp" meal. Today this seaweed is used as a fertilizer and as animal feed supplement. Traditionally the harvest of rockweed in the Maritime Provinces of Canada was an open fishery with no limit on the number of harvesters, their area of operation or levels of exploitation. After 1959, the provincial government issued a few exclusive-purchasing licenses in Southwestern Nova Scotia. The company's sole responsibility was to provide a purchasing infrastructure to obtain wet or dried seaweeds and pay a royalty on landed tonnage. The majority of the resource was totally open to harvest and the level of exploitation was generally low, with a few areas of concentrated harvest in Southwestern Nova Scotia (Fig. 2) (Sharp 1986).

Over the past 30 years both manual and mechanical harvesting techniques were used concurrently. An American company, Scotia Marine Products Limited, developed mechanization techniques for the rockweed harvest in the early 1970's. The first mechanical harvesters consisted of a reciprocating cutter mounted on a paddle wheel driven barge (Fig. 3a). These machines were replaced in 1985 by a Norwegian harvester propelled by water jets. This machine cut and pumped the rockweed into a net bag in a single operation (Fig. 3b) (Sharp and Semple 1997). Early in the development of the harvest, hand harvesters working from vessels and on the shore used a range of cutting and gathering tools. By the 1980's a rake with a cutter blade was the preferred manual harvesting gear used to provide 20-30% of the landings (Fig. 3c). In the last ten years there was a transition from machine to manual methods of harvest (Fig. 4). Today there are no mechanical harvesters active in the Maritimes (Sharp and Semple 1997).

Area based management was introduced in the late 1970's. This management strategy placed harvesting controls on small geographic units or sub-sectors. Initially this management was ad-hoc. Overall landings for the licensed area were reported on a sub-sector basis but no biomass targets were set for areas. The exceptions were mechanically harvested areas where exploitation rates were 40% to 60% of the harvestable biomass, requiring a two to three year fallow period for recovery of biomass (Sharp et al. 1995).

After 1985, as the demand for rockweed increased with additional processors/buyers and more of the coastline was placed under exclusive license, effective area based management became imperative. Assessments of the resource were produced by government research groups and

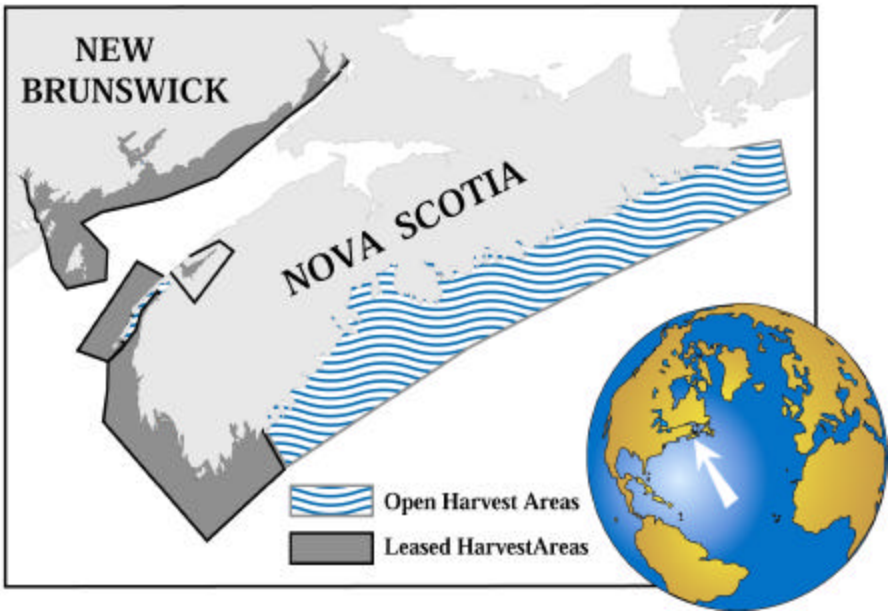

Figure 2. *Ascophyllum nodosum* harvesting areas in Nova Scotia and New Brunswick.
Figure 2. Secteurs de récolte *d'Ascophyllum nodosum* en Nouvelle-Écosse et au Nouveau-Brunswick.

by informal "non-scientific" company surveys. Quotas were based on an annual sustainable harvest (exploitation rates below 25% of harvestable standing stocks) were assigned to sub-sectors. However, control of exploitation levels by artisan harvesters posed a challenge due to the large number of independent harvesters spread over a large area (Sharp and Semple 1997).

Government agencies (provincial and federal) promoted the use of pre-season management plans consisting of exploitation targets by sub-sectors, but they were not obligatory. The result was a very uneven management system for the Nova Scotia resource as a whole. There was a mix of open areas with no limitations; exclusive licensed areas with true area based management and other areas with an un-monitored ad hoc management plan.

New approach to seaweed management

Before the province of New Brunswick opened the harvest of *Ascophyllum* for the first time in 1995, there was no legislative structure for marine plants management in that province. Following discussions on areas of responsibilities, a Memorandum of Understanding (MOU) was signed between the Federal Department of Fisheries and Oceans (DFO) and the Provincial department of Fisheries and Aquaculture (DFA). This agreement set terms for shared management of the Rockweed resource (Annon. 1994). There were five goals in this memorandum:

1) To maximize the number of continuing full-time employment opportunities for New Brunswick residents.
2) To ensure a sustainable harvest.
3) To promote the development of a commercial viable industry founded on sound business principles.
4) To integrate the rockweed industry with other users of marine resources.
5) To ensure rockweed harvesting and processing are undertaken in an environmentally acceptable manner.

Despite the economic benefits associated with the Rockweed harvest, the opening of the fishery was delayed in New Brunswick. Although seaweed harvesting was a traditional fisheries activity in Prince Edward Island and Nova Scotia, this activity was new to southern New Brunswick. As well, the credibility of the Department of Fisheries and Oceans was under strong criticism due to the collapse of the groundfish fisheries in Atlantic Canada. The collapse caused one of the worst social and economical disasters in Canadian history, threatening coastal communities throughout Atlantic Canada and Québec (FRCC 97). Therefore, conservation groups highlighted stakeholder concerns regarding a rockweed harvest in New Brunswick. These concerns included the long and short-term sustainability of harvesting, as well as, the cumulative impact of harvesting on the larger Bay of Fundy ecosystem particularly on existing fisheries. *Ascophyllum* has an important role in the Fundy ecosystem as it provides habitat for the prey of some waterfowl (Hamilton 1997). Also, at least 22 species of fish (7 of commercial importance) are known to be associated with Ascophyllum in parts of their life cycle (Rangeley 1994, Rangeley and Kramer 1995). Managers, cognisant of the need to have a precautionary approach designed a five year management strategy to develop the fishery in a sustainable way while protecting the ecosystem. In order to achieve these goals, four phases were established in this management strategy (Fig. 5).

Phase I.

A Rockweed Management Committee was formed to review management plans, monitoring, assessment, and environmental data and develop a guideline for licence

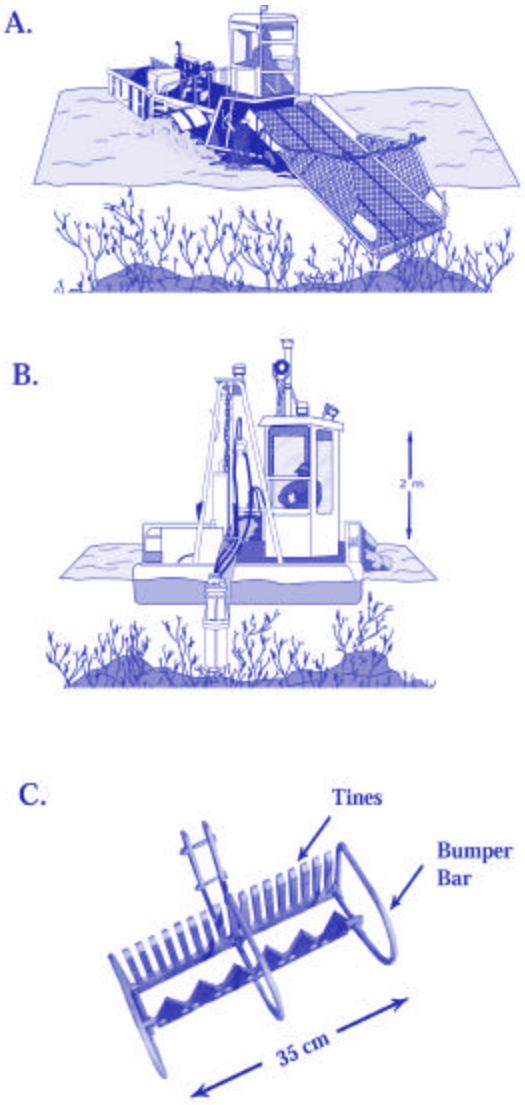

Figure 3. Gear used in Atlantic Canada for the harvesting of *Ascophyllum nodosum.*

A. The paddle wheel propelled Aquamarine *A. nodosum* harvester used in Nova Scotia from 1972 to 1985.

B. The Norwegian suction cutter jet powered *A. nodosum* harvester used in Nova Scotia (1985-1994), Norway and Iceland.

C. The manual cutter rake used for harvesting A. nodosum today. This rake is attached to a six-feet pole (not shown).

Figure 3. Equipements utilisés au Canada Atlantique pour la récolte d'*Ascophyllum nodosum*.

A. La moissonneuse d'Aquamarine à propulsion à roues, utilisée pour la récolte d'*A. nodosum* en Nouvelle-Écosse de 1972 à 1985.

B. Le coupeur à succion norvégien utilisé pour la récolte d'*A. nodosum* en Nouvelle-Écosse (1985-1994), Norvège et Islande.

C. Le râteau-coupeur manuel utilisé aujourd'hui pour la récolte d'*A. nodosum*. Ce râteau est attaché à un manche de six pieds (non illustré).

applicants (Fig. 5). It consisted of a core of DFA and DFO managers and scientists. This core advised a second level committee of two, the Deputy Minister of Fisheries and the Regional Director General of DFO.

During this phase European (Baardseth 1970) and regional (Thomas et al. 1983, Johnson and Schiebling 1987, Rangeley 1994) studies provided the biological information to establish a scientific baseline for this plan. Standing crop estimates and productivity measures were utilized to establish annual quotas (Cousens 1984, Prouse et al. 1984, Sharp 1986, Bradford 1989). The resource was divided in three major harvesting areas (Fig. 6). Each one of these areas was subdivided into sectors, the smallest management units of the system (Fig. 6). Total standing stock of *A. nodosum* in Southern New Brunswick was estimated at 153,053 tonnes (CAFSAC 1992).

Following a formal DFO peer review of these databases, a pilot harvest was recommended (CAFSAC 1992). Significant knowledge gaps, however, were identified, especially in relation with the impact of the harvest on the habitat and associated species. Thus, a monitoring and research program was recommended with the pilot harvest. Study sites were set aside to provide undisturbed areas for research. Also closed areas were established to protect wildfowl and prevent gear conflict. Stakeholder input was solicited at public meetings. These meetings provided information on the decision to harvest and addressed questions about the development of the resource.

Phase II.

In the In the second phase (Fig. 5) managers set a pilot harvest quota of 10,000 t (7% of the estimated standing crop) as a precautionary approach to management. Companies, individuals, or associations who were interested in harvesting Rockweed were asked to submit a proposal. These proposals were to address how the stated development objectives (maximize employment, sustainable harvest, sound business principles and environmental acceptability) would be achieved. Proponents were required to include: a harvest management plan outlining a three year schedule of annual raw material requirements, a map showing which sectors would be harvested, a plan detailing the projected levels of exploitation by sector, the frequency of re-harvest, mechanisms to assess the impact of harvesting on the resource and a description of the type of controls to ensure effective management. After reviewing the proposals, the Rockweed Management Committee recommended one company (Acadian Seaplants Limited) be awarded an exclusive license to all three rockweed harvesting areas. This decision was based on the conclusion that this company was the only proponent that successfully met the proposal criteria.

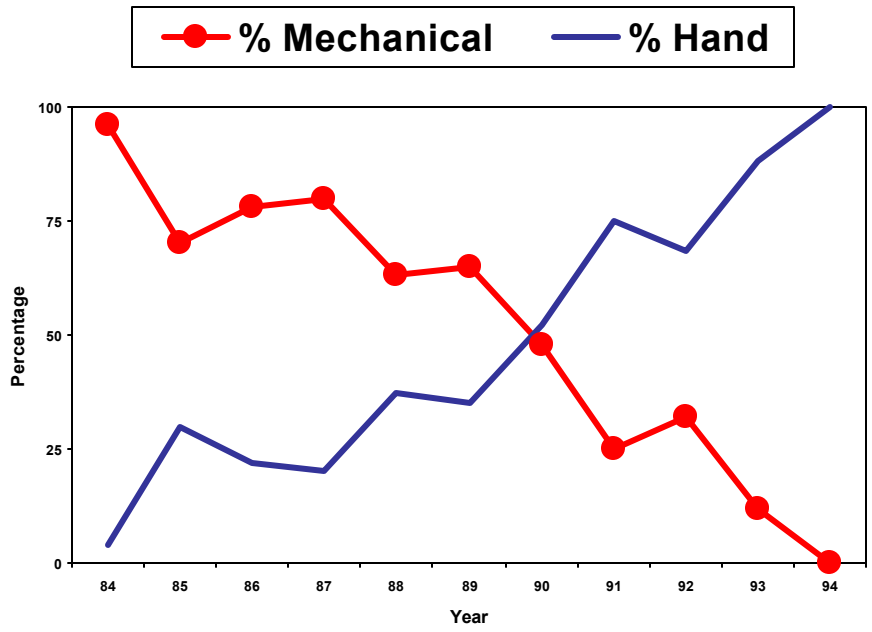

Figure 4. Evolution of the harvesting methods used in the *Ascophyllum nodosum* in Atlantic Canada.

Figure 4. Evolution des méthodes de récolte utilisées dans la pêcherie *d'Ascophyllum nodosum* en Nouvelle-Écosse et au Nouveau-Brunswick.au Canada Atlantique.

Phase III.

The third phase of the management process began in 1995 with the commencement of the pilot scale harvest (Fig. 5). In this phase the company was required to submit a new management plan for the harvest of rockweed at the beginning of each year. This management plan was to include the projected annual harvest by sector. At the end of each year the company was to provide the government vital statistics on the resource including records of monthly purchases from harvesters, price paid, location, and harvest dates. The Rockweed Management Committee conducted three reviews of the company's performance at pre-season, mid-season and post-season meetings. These reviews were designed to investigate problems with harvesting strategies and ensure the company was fulfilling its obligations. Finally, an independent third party was to be hired by the company to audit the recorded landings of rockweed. This review process was designed to ensure that the company complied with the yearly management strategy and the overall strategy of harvesting the resource.

During this phase a multifaceted approach was taken to carry out the monitoring and research program. This program focused on the effect of the harvest on three major components; rockweed biology, the habitat, and associated fauna. The degree of shoot removal and effect of the harvest on population structure, growth and mortality were addressed by the licensee. DFO habitat studies focused on the invertebrate fauna of the canopy and primary space. University research workers examined food linkages to wildfowl and fish use of intertidal zones, as well as nutrient variation on harvested and non-harvested plants. DFA personnel monitored invertebrate by-catch and clump mortality associated with rockweed landings for sector and seasonal variability.

Although there was an extensive detailed management plan for the pilot harvest, the provisions of this plan were not immutable. New information was anticipated annually and changes in aspects of exploitation levels, seasonal effort, distribution of the effort, and harvest technology could be integrated into the plan each year (Fig. 5). Data inputs were derived from all sources harvesters, researchers, stakeholders and the licensed company. For example, resource allocation between harvesting areas was modified in 1999 based on a re-assessment of the resource base from the perspective of accessibility and economics provided by the licensed company in 1998 (Ugarte 1998).

Phase IV.

This phase marked the end of the pilot harvest and the final review of the information gathered during the research and monitoring plan as well as the general performance of the company (Fig. 5). The pilot harvest finished in October 1998 and Phase IV is in place. In April 1999 a formal peer review committee, Regional Assessment Process (RAP), analysed the information gathered during the three-year pilot harvest. Although it was agreed that the harvest impact on the habitat architecture minimal and of short duration, it was advised to continue the harvest maintaining a precautionary approach in light of other knowledge gaps.

Discussion

Although the concept of ecosystem management in fisheries has been widely recognized very few attempts have been made to achieve it (FAO 1996). The ecosystem aspect is critical for marine plants, especially large fucoids

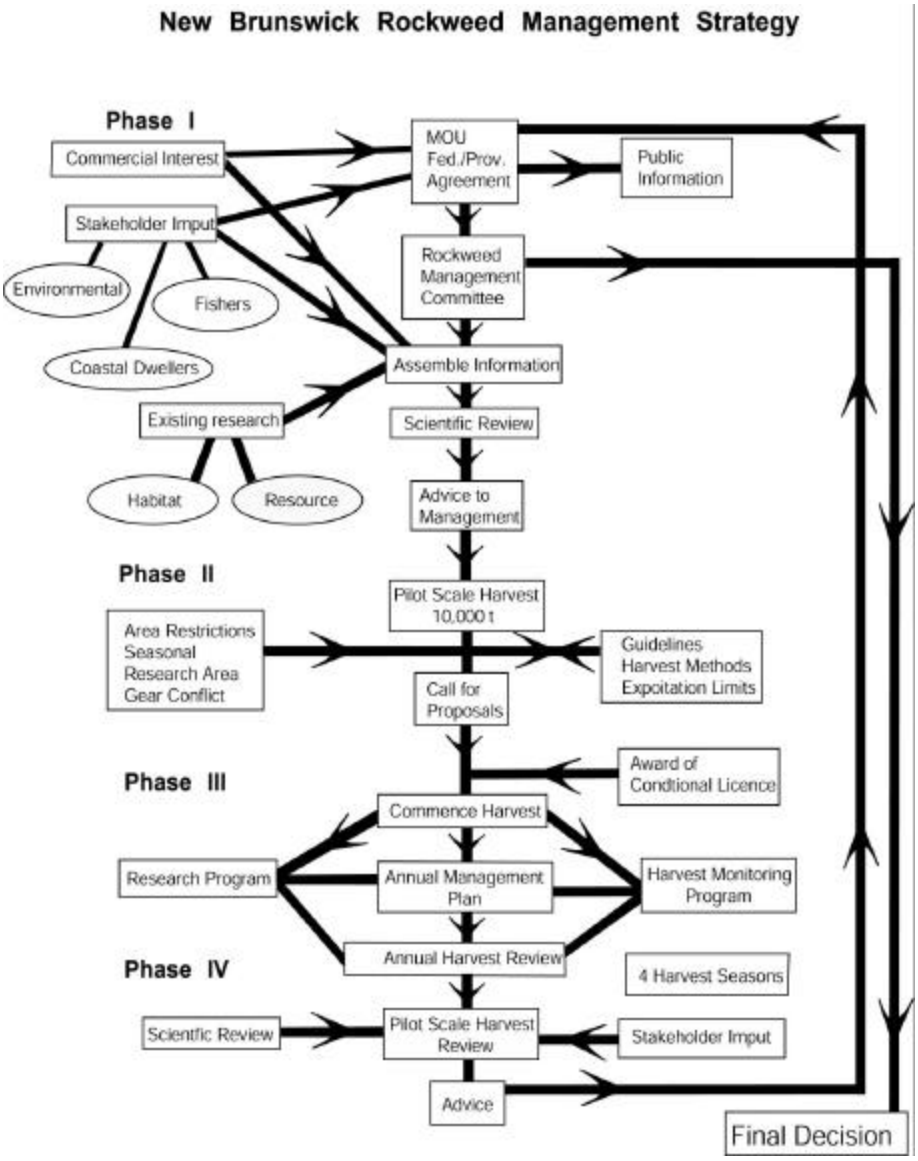

Figure 5. Phases in the development of the management plan for *Ascophyllum nodosum* in southern New Brunswick.

Figure 5. Etapes dans le développement du plan de gestion *d'Ascophyllum nodosum dans le sud du* Nouveau-Brunswick.

and kelps, which have been recognized as both a resource and a habitat (Foster and Barilotti, 1990; Santelices and Ojeda, 1984; Santelices, 1996; Vásquez, 1989), consequently, these seaweeds cannot be exploited under the concept of single species resource sustainability. Since there is no fishery where all the necessary biological information is available to develop a zero risk management plan, the recommendation is to apply a precautionary approach. In this sense, the development of the rockweed harvest in New Brunswick has resulted in new approaches to coastal resource management by integrating habitat, stakeholder and social-economic issues.

The low exploitation rate, pilot harvest, study areas and special rockweed management areas, were components of the precautionary approach and general conservation principles. The goal of this harvesting plan was to either make no significant changes in habitat structure or to keep impacts short term and within limits that could be mitigated. To reach this goal the management plan controlled cutting height, incidence of cut shoots, holdfast removal, number of clumps cut in a stand and the patchiness of the harvest. Controls allowed the development of a spatial model of structural change in the habitat beginning with the shoot and ending with the rockweed beds in a sector (Sharp et al, 1999). Rarely in a fishery provisions are made to protect the surrounding habitat and to control ecological impact of the gear. Under this new harvesting strategy in New Brunswick, the degree, extent, and duration of change in the habitat structure is being controlled using area based management at a high level of resolution.

Area based management can be used to customize harvest plans to respond to small-scale ecological concerns relevant to the resource or the habitat; for example, protection of waterfowl breeding areas. It also allows optimization of yield when there are changes in productivity or geographical differences in productivity within harvest areas over time. Other advantages of area based management are economic. The assignment of an exclusive license gives the company the security of raw material supply. This, in turn, has permitted investment of both human and monetary resources in research and development to reach the goals of the harvest plan and make a viable industry.

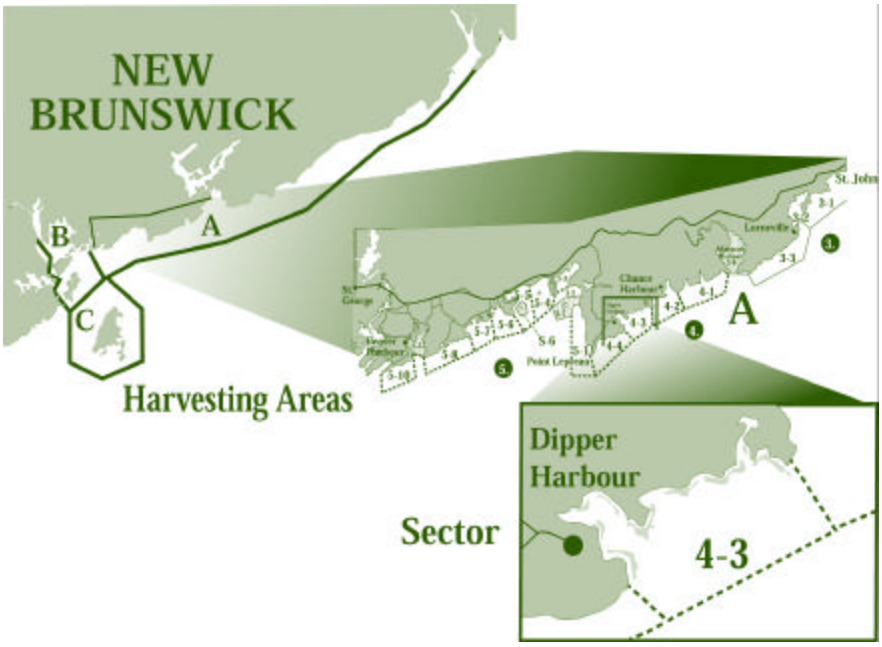

Figure 6. *Ascophyllum nodosum* harvesting areas (A, B and C) and an example of a harvesting sector in Southern New Brunswick.

Figure 6. Secteurs de récolte d'*Ascophyllum nodosum (A, B and C) et un exemple d'un secteur de* récolte dans le sud du Nouveau-Brunswick.

Alternatives to exclusive area based management include complete government control of day-to-day harvesting. This approach would include the assignment and monitoring of quota by sub sector and allocation of effort. Assigning sectors or groups of sectors to harvesters with the obligation to report landings via logs also requires a large monitoring effort at public cost. Recent DFO policy has been moving away from this approach with more responsibility and costs being given to the resource users. Pulse harvesting based on quota allocation by area, as an alternative, abandons any attempt of habitat protection. The resource itself could recover in the closed fallow periods but the habitat would be significantly altered between harvests (Ang et al. 1995).

New fisheries development, like the rockweed in New Brunswick, can be a highly controversial issue today in Canada. Established fishermen feel overwhelmed by increasingly restrictive license conditions and do not want any new activities in their area. Most arguments against the opening of a fishery point to the lack of knowledge of the resource, the risk to other commercial species and the potential impact of the gear on the surrounding habitat. In the case of rockweed, there was extensive information on the biology of this species and associated fauna gathered during the last 50 years. Also, there was a history of more than 30 years of harvest in the neighboring province of Nova Scotia and 200 years in Europe that showed the sustainability of the resource. However, conservation groups considered these facts inadequate. Some local scientists argued that the uniqueness of Southern New Brunswick reduced the relevancy of this data (Rangeley 1991). The uncertainty of the long-term impact of the harvest on the ecosystem as expressed in the CAFSAC (1992) document increased these concerns. This anticipation of negative impacts from the rockweed harvest resulted in an initial reluctance of local people to accept or to participate in this new fishery (Marshall 1999). However, the negative perception dissipated after the second year of the pilot harvest as stakeholders had the chance to verify directly in the field the healthy condition of the resource at the end of the harvest season. During the spring of 1999, more than 80 local fishermen showed interest to harvest rockweed in New Brunswick, 50 of them were selected, trained on harvesting procedures by the company and harvested more than 7,000 tonnes of rockweed during that season.

The research and monitoring program provided a considerable amount of information related to the impact of the harvest on the rockweed structure, degree, extent and duration of change in the complexity of the habitat (Sharp et al. 1999). However, this information was felt by some to be insufficient to open a full-scale harvest, as some issues related to the long-term impact on the ecosystem were still unresolved. The possibility of gathering all the ecological information suggested as knowledge gaps in the CAFSAC document is very unrealistic for any marine resource in the world. In the case of rockweed, risks were minimized since structural changes in the habitat are short lived as the reduction in standing crop is compensated by the overall production during the summer months, the time of active harvest (Sharp et al, 1999). Consequently, the probability of habitat loses is minimal. Uncertainty is low for several major issues in this harvest, estimates of abundance, fishermen's responses to regulations, and manager's objectives (Hilbourn and Peterman 1995). We are less certain about future environmental conditions and the future economic and political situation. Most of the uncertainty in this fishery is with the interrelationships and degree of dependence between rockweed and its associated species. At this time, we cannot build a

model of these interrelationships or place values of parameters in a conceptual model. The safety margin for the ecosystem lies in the degree and control of habitat change.

References

Ang P.O., Sharp G.J. & Semple R.E. 1993. Changes in the population structure of *Ascophyllum nodosum* (L.) Le Jolis due to mechanical harvesting. *Hidrobiologia,* **260-261**: 321-326.

Annon. 1994. Memorandum of understanding between the New Brunswick Department of Fisheries and Aquaculture and the Department of Fisheries and Oceans, Canada. 3pp.

Baardseth E. 1970. Synopsis of biological data on knobbed wrack *Ascophyllum nodosum*. *Fao Fisheries Synopsis*, **38**, Rev. 1: 41 pp.

Black R. & Miller R.J. 1991. The use of the intertidal zone by fish in Nova Scotia. *Environmental Biology of Fishes*, **31**: 109-121.

Bradford B. 1989. Standing crop estimate of marine algal macrophytes of the intertidal zone in the Passamaquoddy Bay to St. Croix River Region. Msc. Thesis, Acadia University, Nova Scotia. 123 pp.

CAFSAC 1992. Rockweed in southern New Brunswick, *CAFSAC Advisory Document* **92**/13.

Cousens R. 1984. Estimation of annual production by the intertidal brown *alga Ascophyllum nodosum* (L.) Le jolis. *Botanica Marina*, **27**: 217-227.

FAO 1996. Precautionary approach to fisheries. Part 2. Scientific papers. *FAO Fisheries Technical Papers* No **350**, Part 2. Rome FAO. 210 pp.

Foster M.S. & Barilotti D.C. 1990. An approach to determining the ecological effects of seaweed harvesting: a summary. *Proccedings of the International Seaweed Symposium*, **13**: 15-16

FRCC. 1997. A groundfish conservation framework for Atlantic Canada. *Fisheries Resource Conservation Council*, **97**.R3. July 1997. 58 pp.

Hilborn R. & Peterman R.M. 1995. The development of scientific advice with incomplete information in the context of the precautionary approach. *FAO Fisheries Technical Paper* **350/2**:77-101.

Hamilton D.J. 1997. Community consequences of habitat use and predation by common eiders in the intertidal zone of Passamaquoddy Bay. Ph. D., University of Guelph. 211 pp.

Johnson S.C. & Schiebling R.E. 1987. Structure and dynamics of epifaunal assemblages on intertidal macroalgae *Ascophyllum nodosum* and *Fucus vesiculosus* in Nova Scotia, Canada. *Marine Ecology Progress Series*, **37**: 209-227.

Marshall J. 1999. Bitter Harvest. *Alternatives Journal*, **25/4**:10-15.

Pringle J.D. & Sharp G.J. 1986. Rationale for the path chosen in bringing assessment science to the eastern Canadian Irish moss (Chondrus crispus). In: *Actas Segundo Congreso Nacional Sobre Algas Marinas Chilenas* (R Westermeier ed), pp. 75-90.

Rangeley R.W. 1991. A critique of the proposed rockweed management and development for the Bay of Fundy. MS Report to N.B. Minister of Fisheries and Aquaculture. 5 pp.

Rangeley R.W. 1994. Habitat selection in juvenille Pollock, Pollachious virens: Behavioural Responses to Changing Habitat availability. Ph.D., McGill University (Montreal). 179 pp.

Rangeley R.W. & Kramer D.L. 1998. Density-dependent antipredator tactics and habitat selection in juvenile pollock. *Ecology* **79(3)**: 943-952.

Santelices B. 1996. Seaweed research and utilization in Chile: moving into a new phase. *Hydrobiologia*, **326/327**: 1-14.

Santelices B. & Ojeda F.P. 1984. Effects of canopy removal on the understory algal community structure of coastal forest of *Macrocystis pyrifera* from Southern South America. *Marine Ecology Progress Series*, **14**: 165-173.

Sharp G.J. 1986. *Ascophyllum nodosum* and its harvesting in Eastern Canada. In: Case studies of seven commercial seaweed resources. *FAO Technical Report*, **281**:3-46.

Sharp G.J., Ang P.O. & McKinnon D. 1995. Rockweed harvesting in Nova Scotia, Canada: its socio-economic and biological implications for coastal zone management. In: *Proceedings of the Coastal Zone Conference* (P.G. Wells & P. Ricketts eds), pp. 1632-1644.

Sharp G.J. & Semple R.E. 1990. An assessment of *Ascophyllum nodosum* resources in southwestern Nova Scotia. *CAFSAC Research Document*, **91**/1.

Sharp G.J. & Semple R.E. 1997. Rockweed (*Ascophyllum nodosum*). *CAFSAC Research Document*, **97**/31, 10 pp.

Sharp G.J., Ugarte R., MacEacheron T., Semple R.E & Black G. 1999. Structure of *Ascophyllum nodosum* (rockweed) habitat and the effects of harvesting perturbation in southern New Brunswick. *Fisheries and Oceans Canada, Regional Assessment Process, Working Paper,* **99/29**. 18 pp.

Thomas M.L., Arnold D.C. & Taylor A.R.A. 1983. Rocky intertidal communities. In*: Marine and Coastal System of the Quoddy Region, New Brunswick* (M.L.H. Thomas ed*). Canadian Special Publications of Fisheries and Aquatic Sciences*, **64**: 35-73.

Ugarte R. 1998. An assessment of *Ascophyllum nodosum* resources in southern New Brunswick. 1995-8. *Fisheries and Oceans Canada, Regional Assessment Process, Working Paper*, **98**/143

Vásquez, J.A. 1989. Estructura y organización de huirales de *Lessonia trabeculata*. Ph. D. Thesis. Facultad de Ciencias, Universidad de Chile: 261 pp.