AN ASSESSMENT OF ASCOPHYLLUM NODOSUM RESOURCES IN SCOTIA /FUNDY 1990

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ABSTRACT

Although the harvest effort for Ascophyllum has increased and spread to new areas in 1990 the total landings have declined in Scotia Fundy . Hand harvesting exploiting the resource has exceeded machine harvesting at a exploitation rate per unit of resource 30% to 95%. Hand harvest sectors surveyed in 1989 and 1990 have shown no significant signs of recovery and overharvest (>90% removal of biomass) is evident in some sectors. Harvestable standing crop for 1991 in Lobster Bay is 57,532 t based on assumed exploitation rates, calculated bed areas recovery rates and residual biomass. In 1991 landings are expected to drop below 20,000 t in Scotia Fundy unless new areas are exploited. This decline in landings will continue unless effective management strategies are implemented.

RÉSUMÉ

Quoique l'effort de récolte de l'ascophylle noueuse ait augmenté et se soit étendu à de nouveaux secteurs en 1990, les débarquement totaux ont diminué dans la région de Scotia-Fundy. La récolte à la main a surpassé la récolte mécanique. Le taux d'exploitation par unité de ressource varie de 30 % à 95 %. Dans les secteurs de récolte à la main étudiés en 1989 et 1990, on n'a décelé aucun signe évident de récupération. Il s'avère que la récolte est manifestement excessive (> 90 % de retrait de la biomasse) dans certains d'entre eux. La population sur pied récoltable dans la baie Lobster est évaluée à 57 532 t pour 1991, ce chiffre étant fondé sur des taux d'exploitation hypothétiques, sur les taux de récupération calculés pour les divers gisements et sur la biomasse résiduelle. On s'attend à ce que les débarquements de 1991 soient inférieurs à 20 000 t dans la région de Scotia-Fundy, à moins que l'on n'y exploite de nouveaux secteurs. À défaut de stratégies de gestion efficaces, cette baisse des débarquements se poursuivra.

INTRODUCTION

Ascophyllum nodosum Stackh. (Rockweed) is a brown fucoid alga dominating the rocky intertidal on the Atlantic and Fundy Coasts of Nova Scotia and New Brunswick. Traditionally, this seaweed was used as a agricultural fertilizer and soil conditioner. However, commercial exploitation began in the early 1960s in Southwestern Nova Scotia for both the production of the phycocolloid alginate and seaweed meal. Harvesting was exclusively by hand tools until mechanical harvesters were introduced in 1970. Mechanical harvesters eventually supplied 80% of the raw material (Sharp 1986). Despite mechanization landings did not exceed 8,000 t fresh weight per annum. However, after 1985 three factors lead to a dramatic increase in landings of 30 to 50% per year to 29,598 t in 1989. First, the introduction of new mechanical harvesting technology, the Norwegian suction harvester brought a 4 fold increase in CPUE. Second, alginate processing expanded from a 6-7 month operation to a year round operation. Third, increased demand for seaweed meal products brought new buyers/processors to the area stimulating hand harvesting .

Ascophyllum nodosum has continued to be in high demand through 1990. Traditional areas have been exploited at levels 3 to 5 times higher than in the era 1964 to 1985. The division of management responsibilities for this species has not been clearly defined between the Nova Scotia and Canadian governments . However management initiatives have been instituted, changing major parameters affecting distribution of effort and type of effort, as well as the status of the resource. The resource has been divided into two major areas; one that is predominantly harvested by the Norwegian suction cutter machine (Sharp 1986), and a second which is restricted to hand harvesting methods including knives and cutter rakes (Sharp 1980). Some areas have been allotted exclusively to seaweed companies while others remain open to all harvesters.

In the light of the dynamic changes in this industry, the data base on this resource was reviewed and updated to better forecast the status of the resource for 1991 and beyond.

MATERIALS & METHODS

Landings:

A geographical based reporting system for landings was introduced in 1988 to obtain a resolution of landings per 2 to 5 km of shoreline, creating a total of 231 units (Sharp & Tremblay 1989). In some areas and years this system was successful. However since the quality of this data was not consistent, it was necessary to lump landings into larger regions. In Lobster Bay, this amounted to 24 sectors with consistent reporting of data between 1988 and 1989. These sectors do not represent management areas and due to management initiatives over the past 3 years a number of these areas have had a history of both mechanical and hand harvest. A major problem area for determination of landings was the Annapolis Basin and to a lesser extent St. Mary's Bay due to strong competitive harvesting. Only one company was able to provide sectored landings for the Basin; the remainder had to be lumped into a general unit, i.e. the southern half of the basin. A further complication was the direct purchase of dried material from various hand harvesters whose area of operation was only described in general terms.

Area of Ascophyllum beds:

The total area of fucoid cover was defined by analysis of air photos for Lobster Bay (Sharp and Semple 1990, Sharp and Tremblay 1989). Additional remote sensing information was obtained for Annapolis Basin using Landsat infrared bands in a October 1987 image. Individual beds were mapped and characterized into 5 levels of colour intensity using image analysis.
The entire intertidal of the Basin was recorded on video tape in October 1990 from an altitude of 100 m. Simultaneously relative cover and evidence of harvest were noted on 1:20000 charts.

Standing Crop and Degree of Harvest Survey.

At 14 sites in the Wedgeport/Tusket area of Lobster Bay and 5 sites in the Annapolis Basin samples were taken to estimate standing crop and cover (Sharp & Semple 1990). Degree of harvest was evaluated using three variables; first, the distribution of biomass with distance from the holdfast; second, the number of quadrats with evidence of recent harvest; third, the distribution of stump (recently harvested shoots) length. To determine the vertical distribution of biomass the weight of 25 cm segments of all plant clumps within three 0.25m^2 quadrats at each site was measured to +/- 1 g. Total clump weight was divided by each segment total to determine the proportional distribution of biomass. Evidence of harvest was defined as positive if any shoot was recently truncated (unhealed wound tissue) in the quadrat. The harvest index was defined as the total number of quadrats with evidence of harvest divided by the total number of quadrats with *Ascophyllum* present. Stump lengths from a sample of 100 were placed in 20 cm length classes. Similar data was available from 27 sites in 1989 of which 14 were common between 1989 and 1990.

Harvestable Biomass

Lobster Bay
Harvestable biomass is defined herein as the area were biomass has fully recovered from harvest. This level was determined to be 12.0 kg m^{-2} or 120 t ha^{-1} wet weight in the Lobster Bay area (Sharp 1980). Recovery rate was based on a 3 year renewal of biomass or a production to biomass ratio of 0.74. (Cousens 1984). A biomass density of 12 kg m^{-2} was also assumed to be a maximum value when production losses equaled gains. The landings for each sector and year were divided by the yield per hectare set by the exploitation rate of each method to obtain the hectares harvested each year. Exploitation rate was defined as (mean yield per hectare of the harvesting method) divided by (standing crop per hectare). Yield per hectare was derived from yields per hectare in well defined areas such as islands or bays.
To calculate the harvestable biomass in 1991 from the three previous years data the following calculation was made:

1) Ayr 1 = (Ls / Yha^{-1})
2) Rb=(Rsc-Yha^{-1})
3) Gb= (Rb X 0.74) + (Rb).
4) Repeat 1 & 2 for year 2.
5) Calculate recovery of biomass for both year 1 & 2.
6) Repeat 1-5 for year 3.
7) A H = sum ha where biomass = or >120 t ha^{-1}
8)Total Harvestable biomass= AH X 120 t ha^{-1}

Where: Ayr= area of beds utilized in year 1; Ls= annual landings for the sector; Y ha^{-1} yield per hectare; Rb= residual biomass; Rsc= recovered standing crop 120 t ha^{-1} ; Gb= growth in biomass; 0.74 = growth rate; A H = area of beds unharvested or recovered.

South Shore, N.S.
For the southern shore sector air photos were unavailable to estimate bed areas by sectors. However the shoreline supporting or likely to support Fucoids was available (Sharp & Tremblay 1989). The mean yield per km from the 1990 harvest was calculated from the yields in the sector of the harvested coast line. This yield was assumed to be representative for the remaining unharvested shoreline and multiplied by this value to arrive at the biomass available in 1991.

Annapolis Basin:
Due to the lack of well resolved landing data in 1990 an assessment of plant cover was made by air survey and land observation. This technique was valid due to the very high level of biomass removal 90-98% clearly outlining the areas utilized in 1990.
These highly depleted bed areas were then subtracted from the total bed area for the Basin as determined from satellite photos. A mean biomass value (derived from sampling 5 sites) was applied to areas not totally depleted. This technique was compared to the above (Lobster Bay) method of accounting for removals and growth.

RESULTS:

Landings Scotia-Fundy

Total landings declined by 3832 t in 1990 in Scotia Fundy despite an expansion of the harvesting area (Fig.1 & Fig 2). The principal decline occurred in the traditional Lobster Bay area from 26023 to 17656 t (a 32% decline). Data quality was poor in the Annapolis Basin and St. Mary's Bay where both totals and sector definition lacked resolution.

The most striking feature of landings for 1990 was the expansion of the harvesting area beyond the traditional areas of Lobster Bay and Annapolis Basin. Mechanical harvesting obtained 37% of the total harvest by this method in the area east of Cape Sable Is. (Fig 3). Hand harvesting expanded in the Long Is. and Briar Is. area and westward in St. Mary's Bay to Sanford (Fig 4). The Wedgeport to Wilson Is. and Mikes Is. sector had a 72% drop in landings from 1989. This also reflects the removal of mechanical harvesting from this sector (Fig 5). Utilization of the Sluice Pt. to Rocco Pt. sector by hand harvesters has increased by 44% (Fig 5).

For the first time since the 1960's hand harvesting exceeded the landings of mechanical harvesting (Fig 6). This was due to two factors: the movement of mechanical harvesting effort to harvest a lower yield region for *Ascophyllum* along the south shore; and secondly, the provincial government exclusion of mechanical harvesting from 255 hectares of Ascophyllum beds in the Morris/Surettes Island region (Fig 7). Lobster Bay now has 410 ha of beds designated for hand harvest and 631ha for mechanical harvests (39% vs 61%). Hand harvesting was also permitted within some sectors of the mechanical harvesting area contributing 16% of the landings in this sector of Lobster Bay and 100% of the landings from the St. Mary's Bay/Long Is. Brier Is. exclusive license area.

Effort Scotia-Fundy

Mechanical harvesting was conducted by 1 to 2 machines operating year round. Hand harvesters were estimated between 70 and 80 individuals in Lobster Bay and 50 to 60 individuals in the Digby area. Duration of participation (principally from May to October) ranged from a few tides of harvesting to several months. (P. Gallant, Acadian Seaplants Ltd. Brownlow Ave, Dartmouth N.S. pers comm).

Regional Resource Status

1.0 Fucoid survey Wedgeport Tuskets 1990.

1.1 Harvest indices

1.11Degree of harvest

Six of fourteen sites either had no evidence of harvesting for 1990 or else had a very low harvest index (Fig 8). However landings were reported for these sectors. Four of

the fourteen sites had indices over 0.8. A site by site comparison of degree of harvest between 1989 and 1990 was made; 2 sites previously unharvested in 1989 evidence of harvest in 1990 (Table1). The mean value for all sites combined each year was not significantly different (0.44 in 1989 vs 0.40 in 1990).

1.12 Vertical distribution of biomass

In general 50% of the biomass in the canopy was within 50 cm of the substrate (Fig 9 a, b, Table 1) Notable exceptions were Chebogue (1989 and 1990) and Comeau Hill #2 (1989) both with low degree of harvest (Table 1). These sites were also areas of high water movement. Thirty-seven percent of the biomass at the 14 sites was below 25 cm in 1989 versus 34% in 1990.

1.13 Stump length.

The mean stump length at all sites ranged between 20 and 30 cm (Table 1). There was no relationship between stump length and degree of harvest or biomass.

1.14 Degree of cover.

Cover ranged from 0.52 to 1.00 and averaged 0.75 $\pm$0.13 and although highly correlated with biomass (Fig 10) it was poorly correlated with degree of harvest. Cover indices between the two years increased by 30 to 40% of the 1989 value in 5 of the 14 sites (Table 1).

1.14 Biomass of fucoids

Biomass of Ascophyllum ranged from 0.97 kg m^{-2} to 4.19 kg m^{-2} averaging 2.38 kg m^{-2}. Biomass was not highly correlated with harvest indices. Fucus biomass was less than 0.25 kg m^{-2} with the exception of Surrettes Is. and Wedgeport Point sites, where biomass was over 0.5 kg m^{-2} (Table 1).

In comparison to 1989 there was no significant change ($P<.05$) in Ascophyllum biomass 2.38 kg m^{-2} in 1989 versus 2.47 kg m^{-2} although maximum biomass at these sites declined significantly from 9.08 kg m^{-2} to 6.66 kg m^{-2}. Mean biomass did decline significantly between 1989 and 1990 at 4 sites and increased at 2 sites (Table1).

2.0 Yields Mechanical and Hand Harvests Lobster Bay

The definition of fucoid beds by analysis of aerial photography and the resolution of landings to specific islands and shoreline permitted the calculation of yields per unit area of beds. Mechanical harvesting at 23 sites in Lobster Bay averaged 76.2 t ha^{-1} (Table 2). Ten of these areas in the Tusket Islands were previously unexploited areas. Excluding these sites reduced the mean yield per hectare to 63.3 $\pm$31.0 t . Assuming recovered biomass from earlier studies (Sharp,1981) is 120 t ha^{-1} exploitation rates ranged from 63 to 53 % of the crop.
Yield per hectare data from eleven hand harvest (cutter rake) sites in the Lobster Bay ranged from 12.7 t to 64.0 t ha^{-1} (Table 2) a mean 29.2 $\pm$15.3 t ha^{-1} . At a standing crop

of 120 t ha^{-1}, this yield would equal an exploitation rate of 24%. Yield for the entire hand harvest area of Lobster Bay was 23.4 t ha^{-1}.

2.1 Harvestable Biomass 1991 Lobster Bay

In 1991, Lobster Bay will have a total of 57,532 t of fully recovered biomass. This represents 46.0% of the 125,240 total standing crop if all hectares of Ascophyllum were fully recovered. If we use an overall utilization rate of 60% (Sharp,1987) and a 2 year recycling of the recovered area (irrespective of areas to be recovered in 1992) only 17,349 t would be harvestable in 1991. The two most severely depleted sectors were Pinkney's Pt. and Woods Harbour which were hand and mechanically harvested areas respectively (Table 3, Fig 5). Some anomalies exist in these results (e.g. the landings reported for Big Tusket Is. exceed the possible yield by 8 hectares). To obtain the reported landings for this sector it was necessary to assume a reharvest of unrecovered areas (90 t ha^{-1}) and a harvest at 50% exploitation rate. Seal Island and Mud Island were excluded from this assessment due to their inaccessibility. Bon Portage was included although it has never been harvested before 1991, harvesting has begun in January 1991 (D. McKinnon,Protan Scotia Marine Ltd, Lower Woods Harbour, Shelburne co. N.S. pers comm). Due to the changing mixture of harvesting technologies most areas are in various stages of recovery from both mechanical and hand harvesting. The exception to the mixture of harvesting techniques is the southern sectors of Lobster Bay were hand harvesting has been insignificant. Residual biomass recovering in the year 1992 totaled 28,200 t, the largest concentrations being in the Shag Harbour, Comeau's Hill and the Robert's Island sectors (Table3).

3.0 Annapolis Basin

3.1 Harvest indices

3.11 Degree of harvest
The degree of harvest for all sites was 0.9 or greater. This data did not record whether stumps were cut recently or in previous years. At three of the five sites harvesting activity was noted at the time of sampling.

3.12 Degree of cover
Cover of fucoids averaged 0.58, significantly lower than in Lobster Bay. There were insufficient data from this Basin to relate cover to biomass (Table 4).

3.13 Stump length
Mean stump length ranged less than 10 cm between sites with the exception of Cornwallis (Table 4). Cornwallis and Goat Is. both had a high percentage of stumps less than 20 cm length (Table 4).

3.14 Vertical distribution of biomass
The greater portion (>75%) of the biomass at Annapolis Basin sites was less than 50 cm above the substrate (Table 4, Fig.11).

3.15 biomass

The grand mean biomass of the 5 study sites was 1.8 ±0.5 kg m^{-2} . Variability within sites was high and is typified by high maximum values up to 9.6 kg m^{-2} but low mean biomass (Table 4).

3.2 Area of Ascophyllum beds

The area of fucoid cover in the Annapolis Basin was calculated from Landsat infrared image at 109.8 ha. Analysis of color air photos by digitizer estimated 114.6 and 120.8 ha. The resolution of these methods allowed plotting of individual beds and the summation of areas for each landing sector (Fig 12). A total of 41.7 ha (38%) of the Basin fucoid cover was on the northern side of the Basin. Five levels of red were noted in the satellite image in order of increasing intensity: Class 1 (4.6 ha); Class 2 (59.8 ha); Class 3 (31.0 ha); Class 4 (2.4 ha); Class 5 (11.9 ha). These colors relate to cover and in turn the amount of biomass. However, there is insufficient ground truthing for the date of image acquisition to correlate directly with biomass.

3.31 Landings Annapolis Basin
Landings in 1990 from the Basin declined 900 t from the previous two year average. Harvesting effort was spread throughout the Basin with 50 to 60 individuals active. However, only one of the 5 crew leaders in this basin kept accurate records of sector landings. As a result we were only able to accurately attribute landings to northern sectors. Landings for the southern area were combined (Fig 4).

3.32 Yields from hand harvesting in Annapolis Basin
The landings from sectors were divided by the area of each sector to obtain yield per hectare. Values obtained from reliable 1988 data from 9 sectors range from 23.9 to 85.6 t ha^{-1} averaging 48.2 ±25 t ha^{-1} .
Calculating from total landings for the Basin and total area yields were 49.9, 51.6 and 37.3 t ha^{-1} for 1988, 89 and 90 respectively.

3.33 Harvestable biomass in Annapolis Basin
Assuming the 5 sites sampled represent biomass density in the Basin (72 t ha^{-1}), the total biomass would be 7905 t. Fully recovered biomass at 120 t ha^{-1} would provide a standing crop of 13,176 t. However direct observation of beds in the basin to estimate cover eliminated many beds on the north shore of the Basin plus the Digby shore and portions of the north and south shore due to 90 to 95% biomass removal (Fig 12). This left 26 hectares in various degrees of harvest totaling 1,872 t. At a .67 exploitation rate 1,264 tons could be harvested or approximately 400 t per year spread over 3 years.

The least optimistic approach is to assume the mean yield of 48.2 t ha^{-1} is 80% of the standing biomass 60 t ha^{-1}. Utilization of the area over the past 3 years was 49.9 ha in 1988, 51.6 ha in 1989. Since this leaves only 8 hectares unharvested in 1990, it would be necessary to reutilize the 1988 and part of the 1989 area prior to full recovery. Thus, in 1991 no area of the Basin would be fully recovered.

4.0 St Mary's Bay, Brier and Long Island
Harvesting effort has spread in this area to Brier Island from Long Island and southward on St. Mary's Bay to the Sandford area from the Metegan-Saulnierville area (Fig 4). Stands in these areas can be considered as previously unexploited stocks. We do not

have measurements of bed areas or estimates of shoreline utilized for this region and therefore cannot estimate residual or recovered biomass.The landings for all of St Mary's Bay increased in 1990 by 905 t to 2495 t.

5.0 Southern Nova Scotia.

5.1 Harvestable biomass 1991

Harvesting (primarily by machines) of this previously unexploited stock was extensive in the winter of 1991 . A harvest of 3160 t was removed from sheltered waters from Baccaro Pt. to Sandy Pt. (Fig 3). Hand harvesting accounted for only 61.5 t of the landings Since the area of beds was unknown from this region, yields were based on km of shoreline with a potential to support Ascophyllum. A maximum yield of 87.7 t km^{-1} was obtained at John's Is. and the minimum 16.8 t km^{-1} at Mc Nutts Is., for an overall average of 48.8 t km^{-1}. Biomass density derived from a 1989 survey of 7 sites was 86.8 t ha^{-1} (Table 5). Assuming a bed width of 10 m then the standing crop of Ascophyllum is 87.7 t km^{-1}. Exploitation rates based on the above assumptions are 56%.
The length of shore line unharvested in 1990 from Cape Sable to the Shelburne County line was 39.8 km including all bays and headlands. The 1991 standing stock would be 3490 t and 1956 t would be harvestable. However this area would have to sustain the landings for the next 2 years minimum, therefore 800-1000 t would be the recommended level of removals.

DISCUSSION

The forecast for the 1990 landings (Sharp and Semple 1989) in Lobster Bay was 15,000 t . Although this was 2,656 t lower than actual landings, there were several signs in 1990 pointing to the validity of a downward forecast in landings. First, the diversification of raw material sources despite higher unit costs is a natural response to a dwindling traditional resource base. A second sign was the overharvesting of traditional areas such as Annapolis Basin in an attempt to maintain the yields from this area. Third, the abandonment of systematic harvesting plans (e.g. harvesting of areas not fully recovered to optimal biomass) is an attempt to meet raw material demand. Fourth, survey data from the Wedgeport-Tusket area did not detect any significant increase in standing crop between 1989 and 1990 suggesting reharvests of unrecovered biomass.

A number of assumptions used in the calculation of residual or recovered biomass must be placed in the perspective of harvesting history. For example the survey data from the Annapolis Basin and in Lobster Bay described the situation in mid to late summer of 1990. Harvesting in both areas continued for at least two more months. Estimates based on the residual biomass derived from these surveys therefore should be considered a maximum.

The assumption of a 3 year recovery period (recovery rate of 0.74 annually) is generous under strong harvesting pressure. In particular the Annapolis Basin hand cutting techniques allowed 90-95% removal of biomass in 1990. These areas will require 4 years to recover at a .74 growth rate from the initial biomass of less than 0.2 kg m^{-2}. In areas of heavy overharvest in Europe recovery has required 8 to 12 years (Baardseth, 1970). This degree of biomass removal was not used in our calculations of exploitation for 1988, 89 since it was not observed until 1990. However this level of exploitation was accounted for by the elimination of depleted beds from any calculation of residual biomass and must be considered out of production for 3 to 4 years.

It is not usually possible using the cutter rake to remove over 80% of the biomass since the rake cannot be consistently manipulated to reach the base of the plant (Sharp, 1981). However, within the hand cutter rake areas Lobster Bay it appears exploitation rates are exceeding the maximum 40% exploitation level permitting annual cropping of the beds.(Fig 13). In most of our calculations 30% was used to determine yield. However, it was not possible to reach the landings from certain sectors without increasing the assumed exploitation rate. At an exploitation rate of 30% it would require the whole of the hand harvest area (410 ha) to be covered each year to obtain the annual landings of 10,000 t. The normal harvesting behavior of the crews is to focus on areas nearest to their home wharf and to work in an unsystematic fashion.

Survey data for the Tusket-Wedgeport area supports this conclusion as the sites for both years showed little evidence of harvest . Successive annual harvests of *Ascophyllum nodosum*, even at 25 cm leads to either declining yields or a very low sustained yield of 20 - 30% of initial harvest (Keser et al; 1981). A continuing concern with the cutter rake technique is its tendency to remove entire plants, 15% of harvest weight (Sharp 1981). This damage is low but cumulative and amounts to scraping the plant from the substrate. Recruitment of Ascophyllum germlings is very episodic and survival very low (Vadas 1989)

The assumption of an initial biomass of 120 t ha^{-1} for the Lobster Bay Ascophyllum beds in 1988 was derived from sampling in two studies of 16 unharvested or recovered sites in Southwest and Southern Nova Scotia (Sharp 1980, Cousens 1984). However a harvest of 20,000 t was taken from Lobster in 1987 at a 60% exploitation rate therefore 278 hectares of beds would have been only one year into the recovery period. We made a further assumption that the beds would be fully recovered by 1990 and were not prematurely harvested in 1989. Utilization of beds would have amounted to 309 ha in 1988 and 356 ha in 1989 at a exploitation rate of 60% leaving the 1987 harvest area intact.

CONCLUSIONS

1) Although there has been an institution of management measures (issuance of exclusive harvesting , purchasing licenses and general harvesting guidelines) the *Ascophyllum* resource continues to decline in overall abundance in some parts of traditional harvest areas.
2) Although purchasing companies have developed harvesting plans and strategies these have been ineffective due the lack of control of the hand harvesters operational areas.
3) Short falls in raw material have been made up for by exploiting new areas, harvesting biomass prior to full recovery or overharvesting (>80% exploitation rate) of recovered areas. A quota in one hand harvest sector did not prevent over exploitation.
4) Landings in 1991 are unlikely to exceed 20,000 t unless previously unexploited areas are utilized.

RECOMMENDATIONS

1) Lobster Bay
a) Effort should be directed away from over-harvested areas.
b) Harvesting techniques should conform with existing regulations regarding the cutting action of tools and the retention of holdfast material.

2) Annapolis Basin
a) There is insufficient biomass left in Annapolis Basin to risk further over-harvesting. A fallow period of 2 years is recommended with a full evaluation of recovery prior to renewed harvesting.
b) Exploitation rates should be controlled in this area in the long-term either by cutting height or effort limitation.

3) Southern Nova Scotia
a)Areas harvested in 1990 should be allowed a minimum fallow period of 2 years.
b) The harvesting area should be expanded east the Queens county line if 1990 landings are to be sustained from this shoreline.

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Table 1. Comparsion of Fucoid Biomass and Harvest Indices for the Tusket/Wedgeport Area for 1989-90.

No.	Site	Year	*Ascophyllum* Kg.25m^{-2} Mean	*Ascophyllum* Kg.25m^{-2} Max	*Fucus* Kg.25m^{-2} Mean	*Fucus* Kg.25m^{-2} Max	Cover Index	Harvest Index
1.	Tucker's Island	89	2.40±1.3	5.9	0.45±0.8	2.2	0.93	0.73
		90	2.79±1.8	7.0	0.27±0.6	2.0	1.00	0.00
3.	Wedgeport Point	89	2.06±2.7	8.5	1.06±1.6	5.8	0.66	0.94
		90	2.04±1.9	5.6	0.54±0.9	3.4	0.91	0.81
4.	East Wedgeport Wharf	89	1.70±1.8	5.1	0.06±0.3	1.9	0.80	0.96
		90	2.12±2.0	7.6	0.18±0.5	1.8	0.91	0.97
5.	Wedgeport Tuna Wharf	89	3.15±2.2	10.0	0.21±0.6	1.8	0.89	0.95
		90	2.85±2.0	6.7	0.06±0.3	1.8	0.81	0.77
7.	Mike's Island	89	1.80±2.5	8.6	0.37±0.8	2.6	0.67	0.42
		90	1.93±2.1	6.3	0.06±0.3	1.7	0.75	0.31
9.	Surrette's Island	89	1.33±1.8	5.3	0.12±0.4	1.8	0.54	0.95
		90	0.99±1.2	4.1	0.60±0.7	2.3	0.52	0.08
10.	Comeau's Hill #1	89	3.70±3.2	15.1	0.30±0.8	3.6	0.90	0.01
		90	2.36±1.8	5.4	0.17±0.5	1.8	0.91	0.04
14.	Comeau's Hill #2	89	2.96±4.1	21.3	0.07±0.4	2.1	0.68	0.29
		90	3.07±2.0	7.7	0.00±0.0	0.0	0.90	0.88
17.	Sluice Point	89	2.24±2.2	7.5	0.12±0.4	1.5	0.77	0.00
		90	4.19±2.3	8.5	0.00±0.0	0.0	0.66	0.00
19.	Squire's Island	89	2.37±1.9	6.4	0.10±0.4	2.1	0.76	0.04
		90	2.66±2.6	8.0	0.02±0.1	0.7	0.79	0.64
20.	Bourgues Cove	89	1.97±2.3	7.0	0.44±1.0	4.2	0.72	0.00
		90	0.97±1.2	3.0	0.00±0.0	0.0	0.62	0.00
21.	Goose Point	89	1.86±2.4	7.7	0.05±0.3	1.6	0.68	0.10
		90	2.83±3.0	10.5	0.20±0.7	3.0	0.68	0.00
24.	Chebogue Point	89	2.38±2.7	10.2	0.43±1.0	4.6	0.65	0.00
		90	2.65±2.0	7.9	0.04±0.2	1.2	0.92	0.08
27.	Wilson Island	89	3.38±2.5	8.6	0.00±0.0	0.0	0.89	0.78
		90	3.12±0.9	5.0	0.04±0.2	1.3	0.97	0.98

Table 2. Yields per hectare for mechanical and hand-harvested areas.

Location	Area ha	Harvest wet t	Yield ha^{-1} wet t	
Mechanical Harvest				
Thrum & Gooseberry Is.	4.3	361	76.3	
Etoile Is.	3.2	334	104.4	
Jones, Rum & Goose Is.	13.3	1156	87.0	
Ram Is.	2.5	145	58.0	
Board Is.*	2.6	206	79.2	
Holmes Is.*	1.1	144	130.9	
Ellenwood Is.*	2.2	343	156.9	
Turpentine Is.*	2.8	371	132.5	
Candlebox Is.*	0.8	66	82.5	
Murder Is.*	6.2	393	63.3	
Peases Is.*	2.6	160	61.5	
Owls Head Is.	2.9	240	82.7	
Deep Cove Is.	2.6	159	61.3	
Channel Is.	1.8	96	53.1	
Lears Is.	2.2	191	87.0	
Rankin Is.	2.4	90	37.3	
Birch Is.	1.4	97	69.0	
Bond Is.	2.8	71	25.1	
Vigneau Is.	8.7	575	66.0	
Soloman's Is./Godwins Is.	24.7	1174	47.5	
Stoddards Is.	8.4	432	51.4	
		Yield ha^{-1}	mean= 76.8 ± 32.4	n=21
Excluding unexploited areas*		Yield ha^{-1}	mean= 64.7 ± 21.5	n=14
Hand-Harvest				
Wilson Is.	14.1	349	24.7	
Cook's Is.	7.2	235	32.6	
Wedge Point to Tuna Wharf	5.3	339	64.0	
Goose Bay Ledges	3.0	121	40.3	
Chebogue, Fox Is., etc.	12.7	329	25.9	
Morris Is.	21.3	571	26.8	
Pubnico Harbour (1989)	47.8	1560	32.6	
" "	(1990)	47.8	808	16.9
Chebogue (1989)	7.8	172	22.2	
" " (1990)	7.8	108	12.8	
Big Tusket Is.	25.0	1125	45.0	
		Yield ha^{-1}	mean= 29.2 ± 15.3	n=12

Table 3. Recovered Ascophyllum Biomass for Sectors in Lobster Bay.

Area (in order of biomass)	1991 Biomass Exploitation Rates (80% Mechanical 30% Hand Harvested)	Exploitation Rates (60% Mechanical 30% Hand Harvested)	Biomass Recovering in 1992 (80% Mechanical 30% Hand Harvested)
Big Tusket	0	0	396
Pinkeys Pt*	0	0	744
Comeaus Hill (both sides)	0	0	2856
St John Is	240	936	708
Argyle	552	1152	1344
Woods Harbour/Charlesville	851	0	6504
Tusket River	1200	1200	0
The Tuskets	1524	2172	5088
Bon Portage	1428	1428	0
Wedgeport	1656	2196	4068
Sluice-Rocco Pt.*	1752	2196	480
Argyle Sound	2364	1644	1200
Chebogue/Yarmouth	2496	2496	0
Cape Sable Is	2532	2304	0
Glenwood/McKinnon	3612	3528	324
Pubnico West/Abbots Har.	4448	4444	408
Pubnico Harbour	4218	4218	1608
Surrettes/Morris	7248	6660	1752
Roberts/Morris	9627	10656	2112
Shag Harbour	11784	12288	5040
Totals	**57532**	**59518**	**34632**

* Hand harvest exploitation rate 50%

Table 4. Annapolis Basin biomass and harvest indices from selected sites in 1990.

Site	n=	Biomass 0.25 m^2	Cover	% Biomass in Classes <25cm	% Biomass in Classes <50cm	Stump Height	Mean Stump Length
Oak Point	15	2.41 ± 2.33 Max. 6.5	.64	.82	.97	30% < 20 cm	35.7
Cornwallis	30	1.25 ± 2.53 Max. 8.2	.57	.25	.57	40% < 20 cm	24.0
Goat Island	29	1.31 ± 2.01 Max. 7.5	.60	.46	.85	15% < 20 cm	40.4
Bear Island	29	2.21 ± 3.04 Max. 9.6	.70	.41	.75	43% < 20 cm	32.2
Smith Cove	26	1.94 ± 2.24 Max. 8.2	.87	.46	.80	10% < 20 cm	40.9

Overall mean= 1.8 ± 0.5

Table 5. Biomass of Fucoids on Southern Nova Scotia Survey Sites in 1989.

Site	Biomass (Kg 0.25m^{-2}) of *Ascophyllum*	sd	Biomass (Kg 0.25m^{-2}) of *Fucus*	sd
John's Island	2.010	2.30	0.680	0.91
Baccaro	0.996	1.70	1.050	1.13
N.E. Cove	1.300	1.97	0.213	0.43
Blanche	3.500	3.30	0.018	0.31
Shelburne	2.010	2.27	0.240	0.46
Jordan Bay	3.280	2.98	0.344	0.61
Enslow (Jordan Bay)	4.386	2.67	0.086	0.26

Overall mean= 2.17

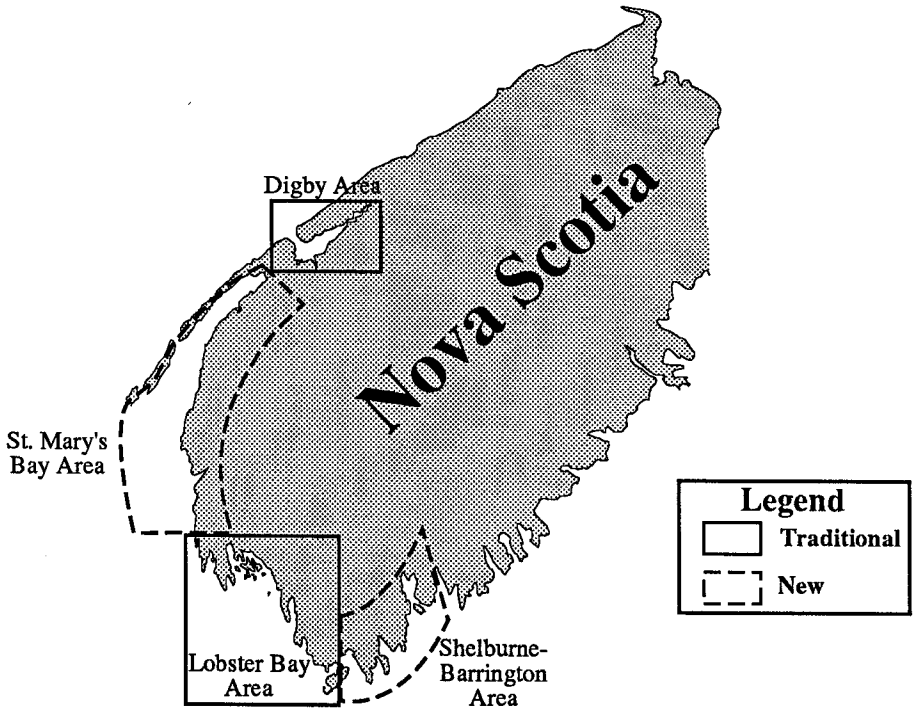

Figure 1. Southwestern and Southern Nova Scotia indicating "traditional" and "new" Ascophyllum harvesting areas.

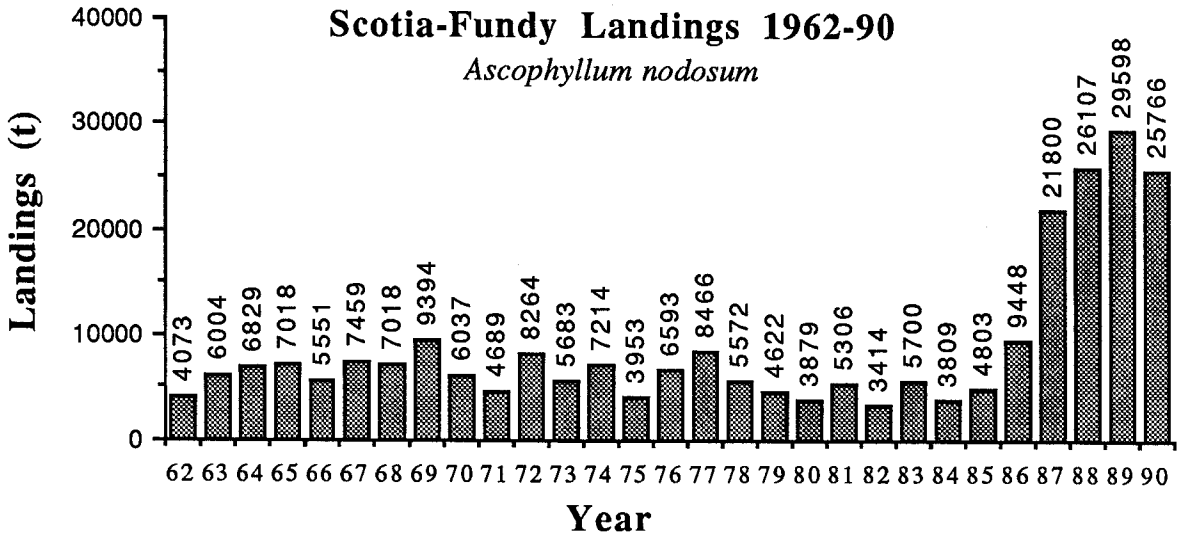

Figure 2. Landings wet weight of Ascophyllum nodosum 1962-1990 Scotia Fundy Region.

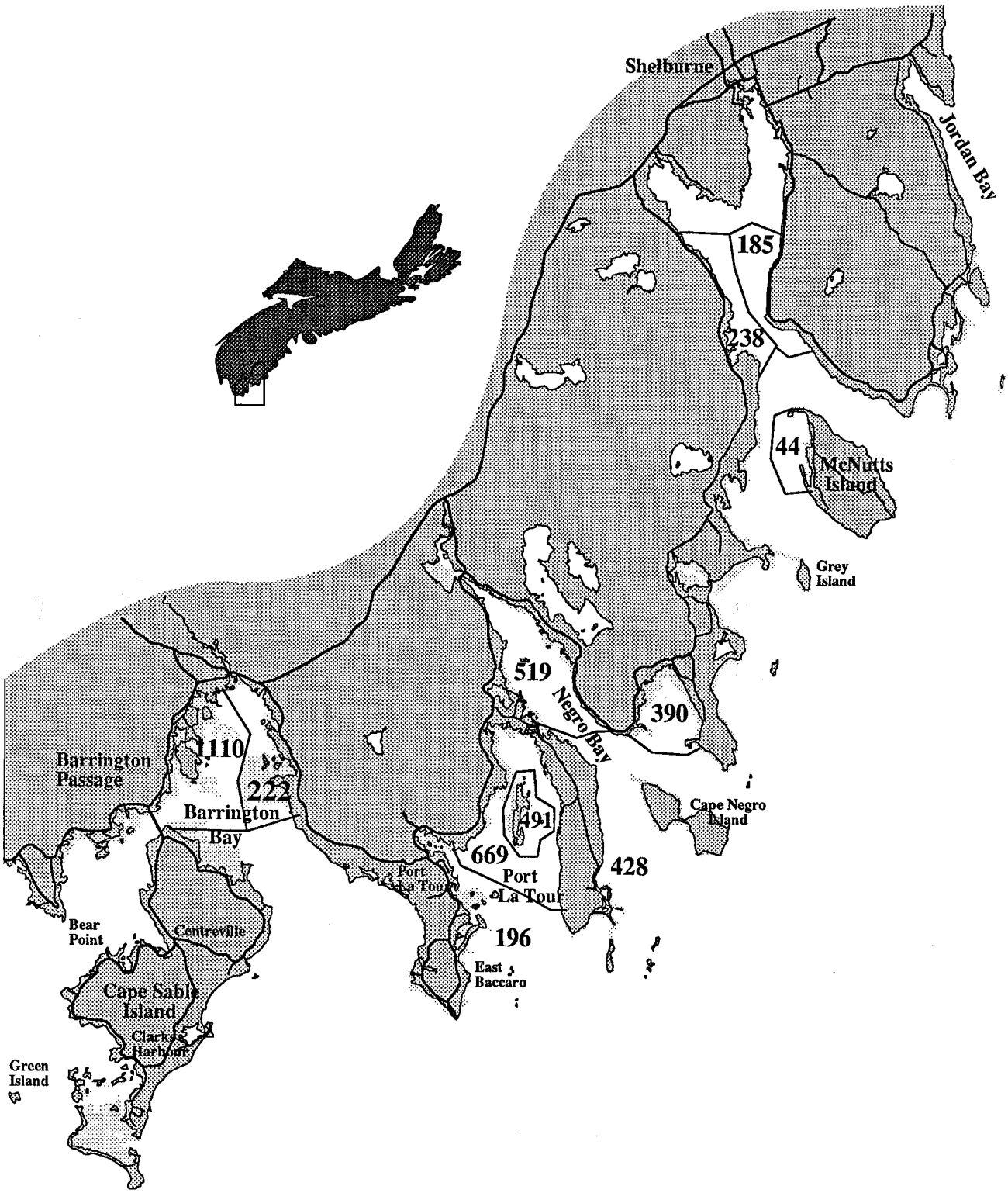

Figure 3. Distribution of *Ascophyllum nodosum* landings from Southern Nova Scotia (t. fresh weight), 1990

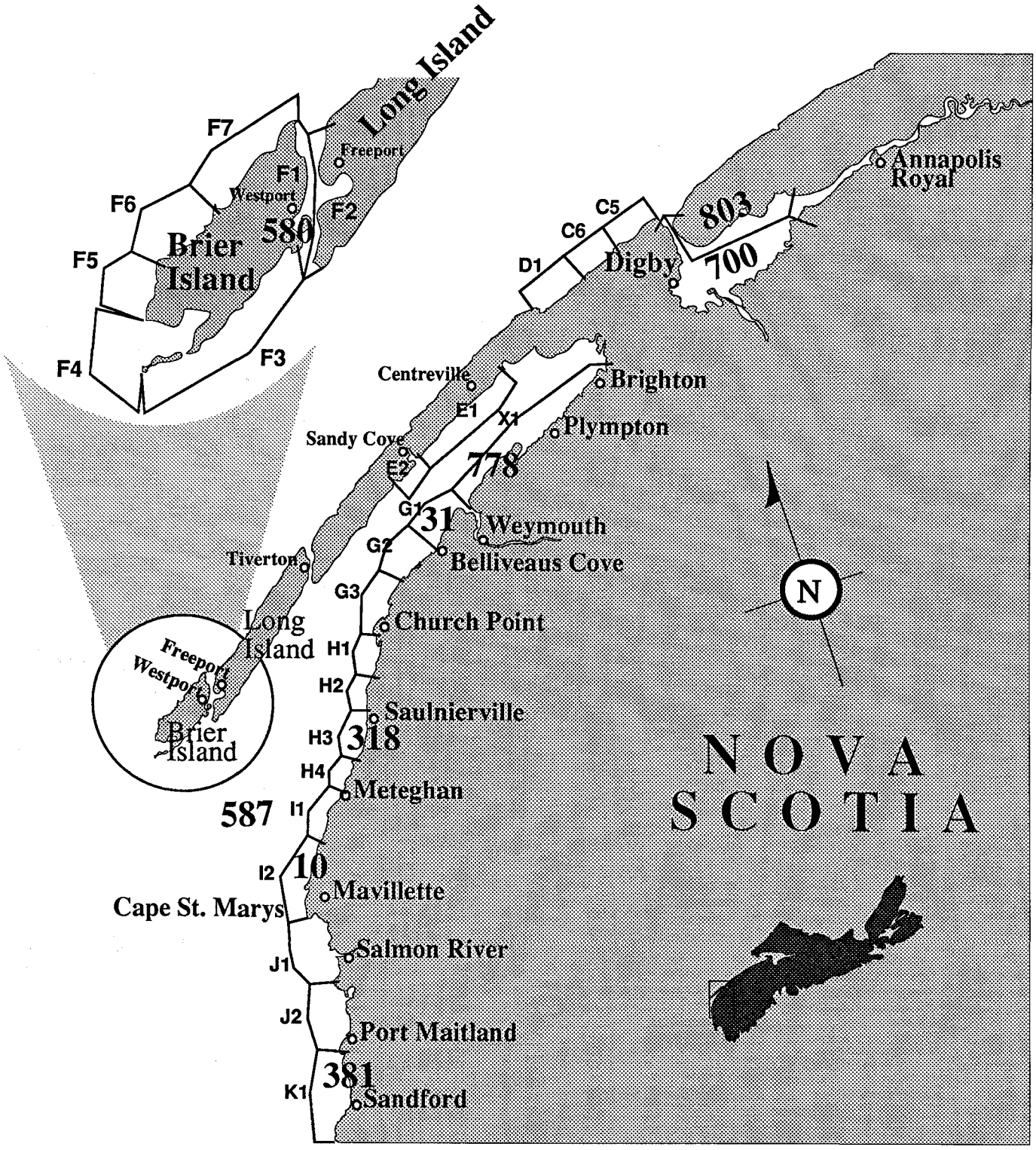

Figure 4. Distribution of *Ascophyllum nodosum* landings in St. Mary's Bay and Annapolis Basin (t. fresh weight), 1990.

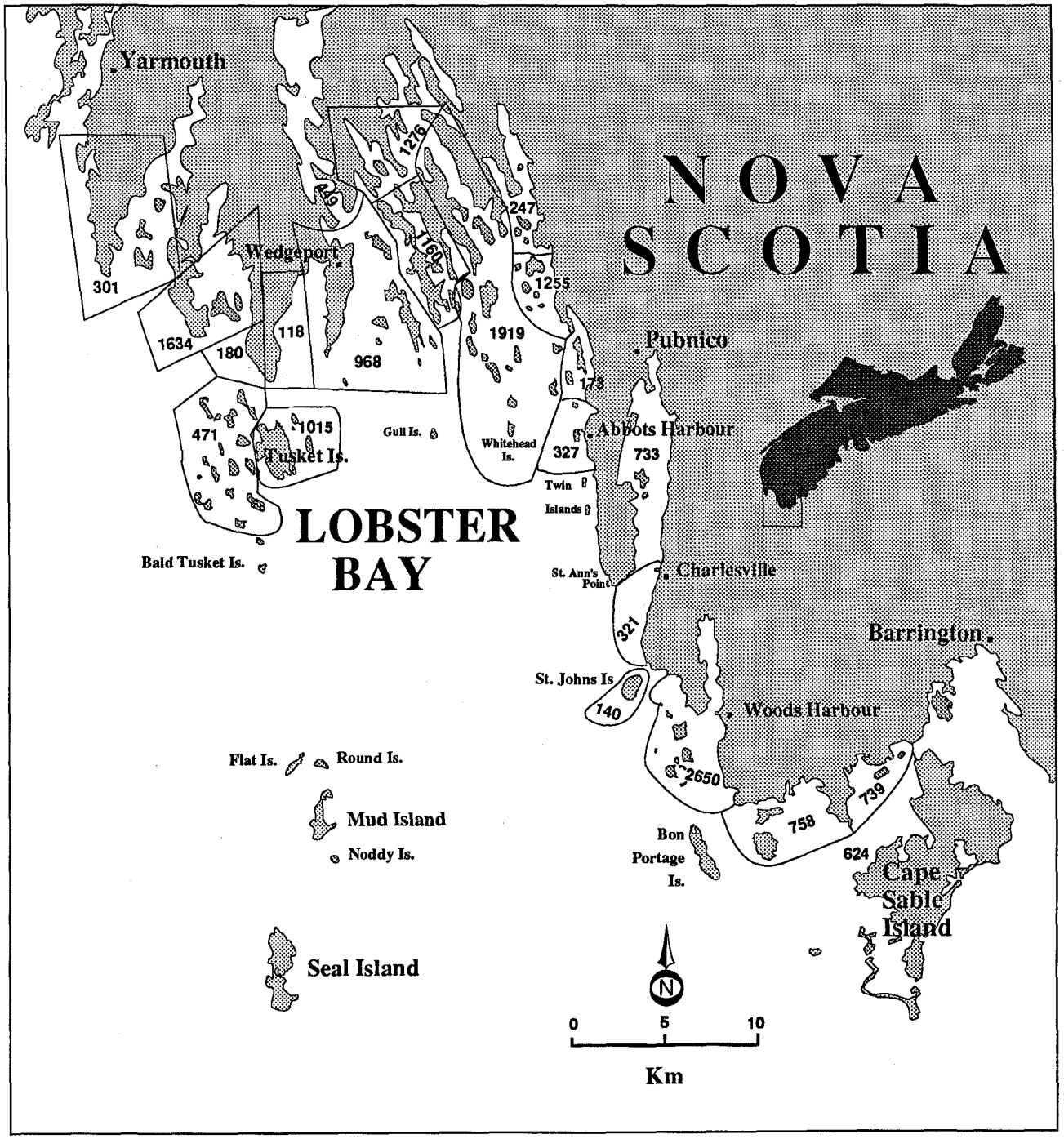

Figure 5. Distribution of *Ascophyllum nodosum* landings in Lobster Bay (t. wet weight), 1990.

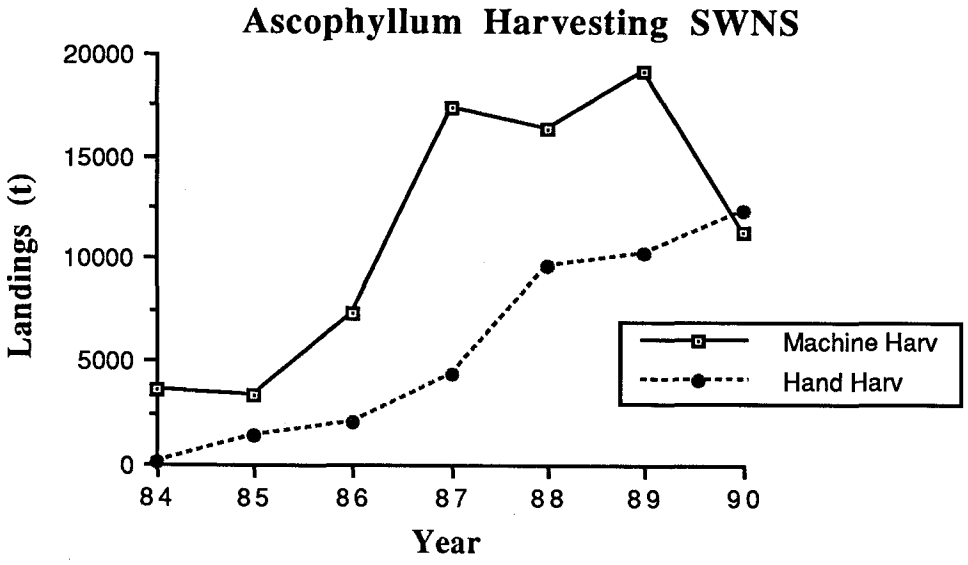

Figure 6a. Comparsion of mechanical to hand harvested landings in southwestern Nova Scotia from 1984 to 1990

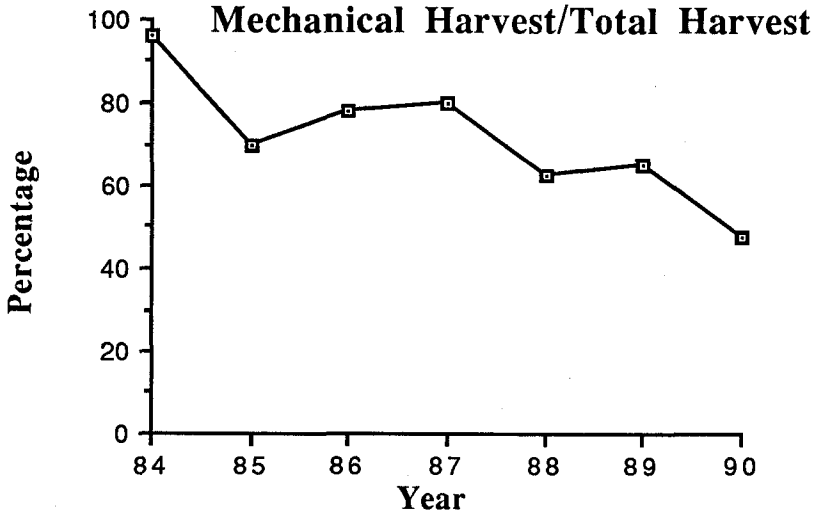

Figure 6b. The percentage of mechanical harvesting to total harvest from 1984 to 1990.

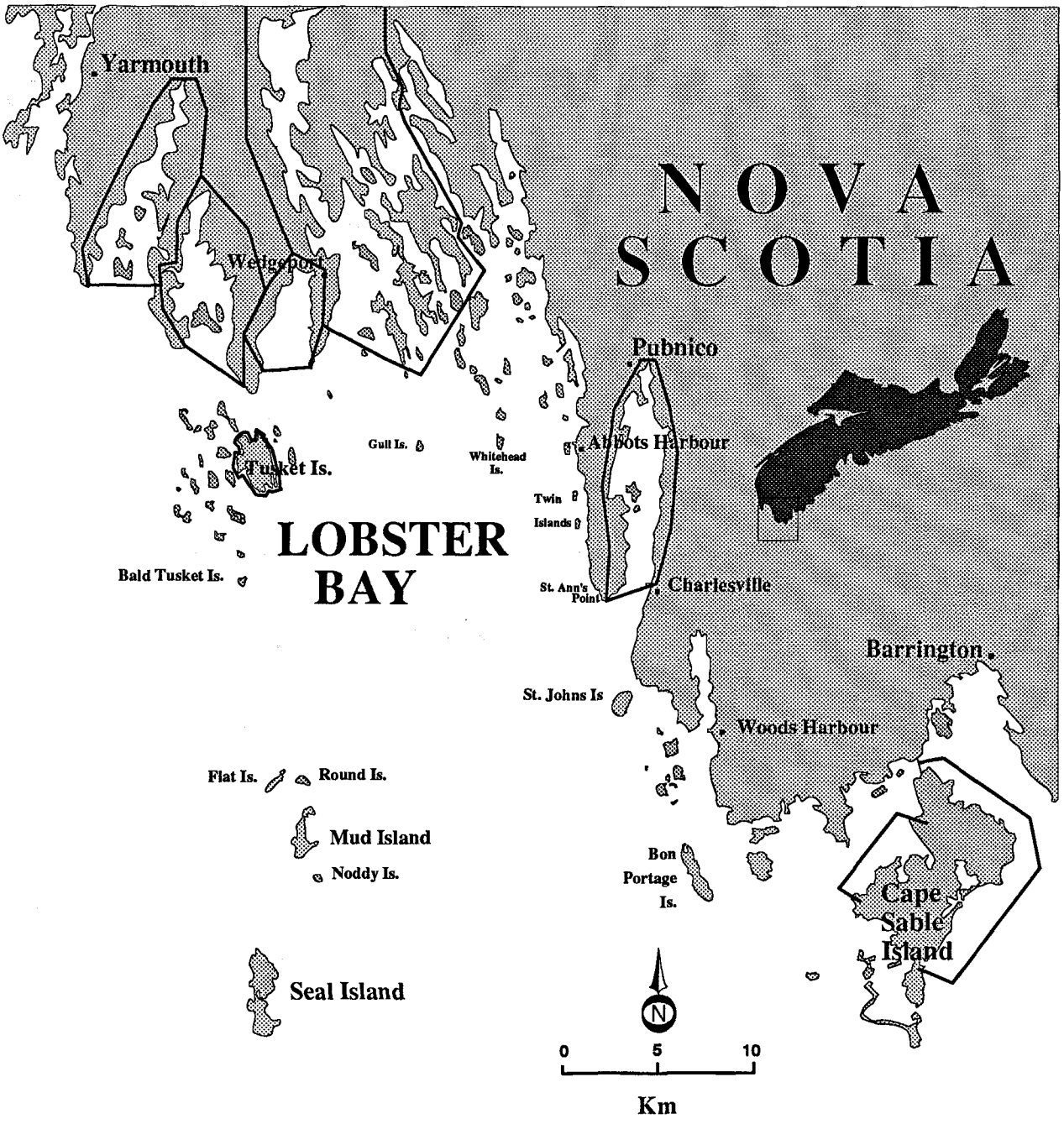

Figure 7. Location of *Ascophyllum nodosum* hand-harvesting areas in southwestern Nova Scotia

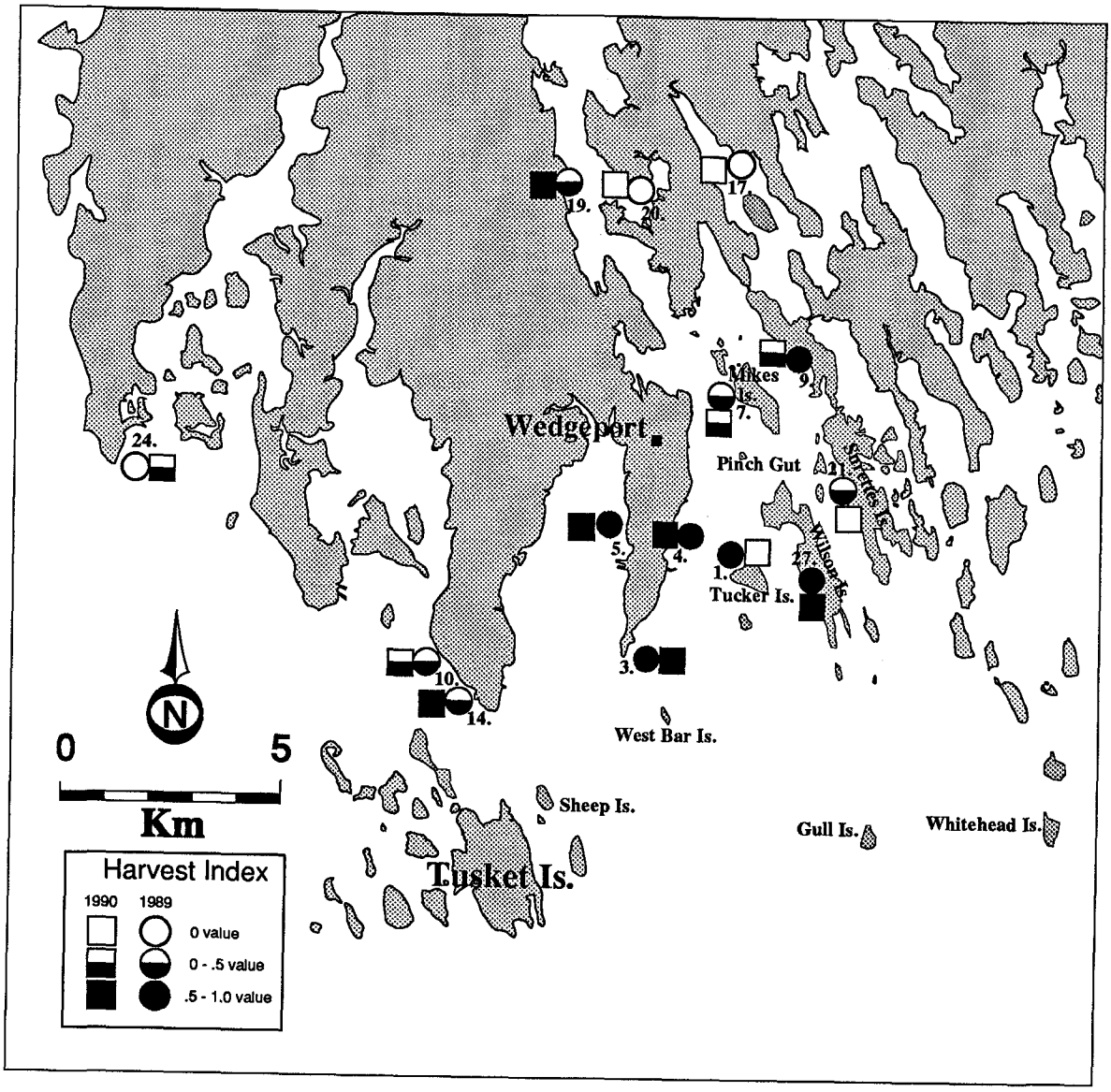

Figure 8. Harvest indices for Tusket/Wedgeport 1989-1990 sites

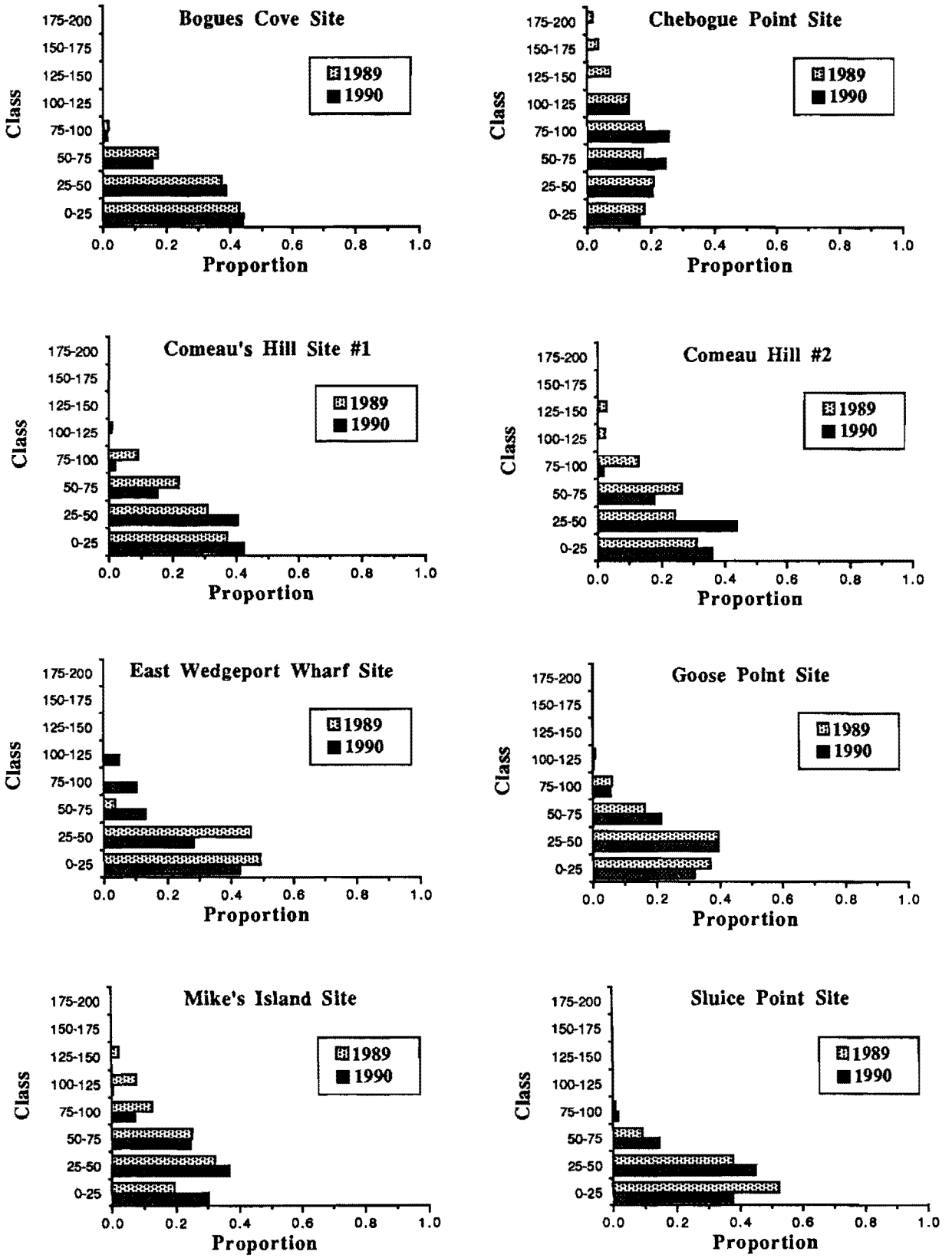

Figure 9a. Vertical Distribution of Biomass for the 1990 Wedgeport Sites.

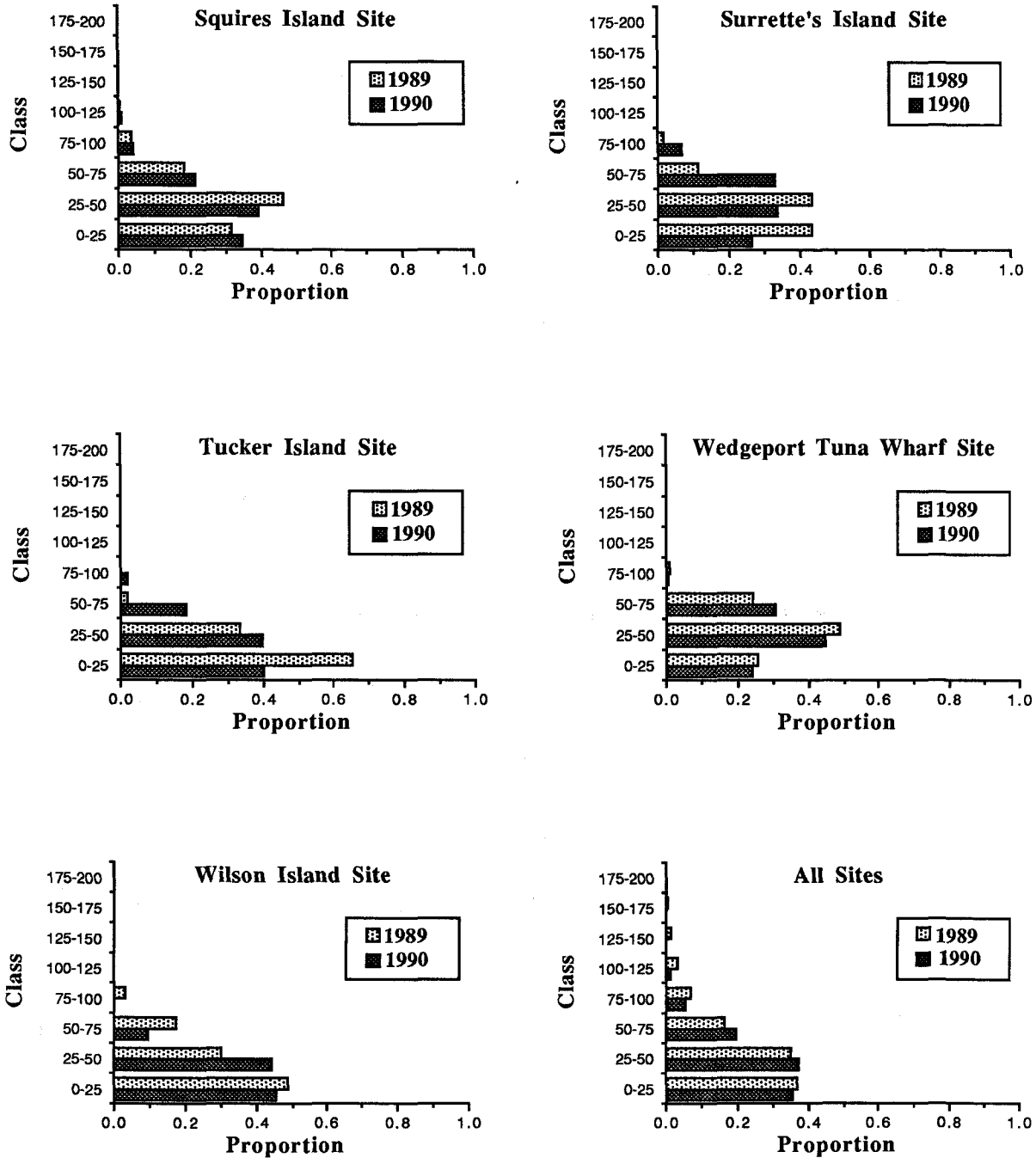

Figure 9b. Vertical Distribution of Biomass for the 1990 Wedgeport Sites.

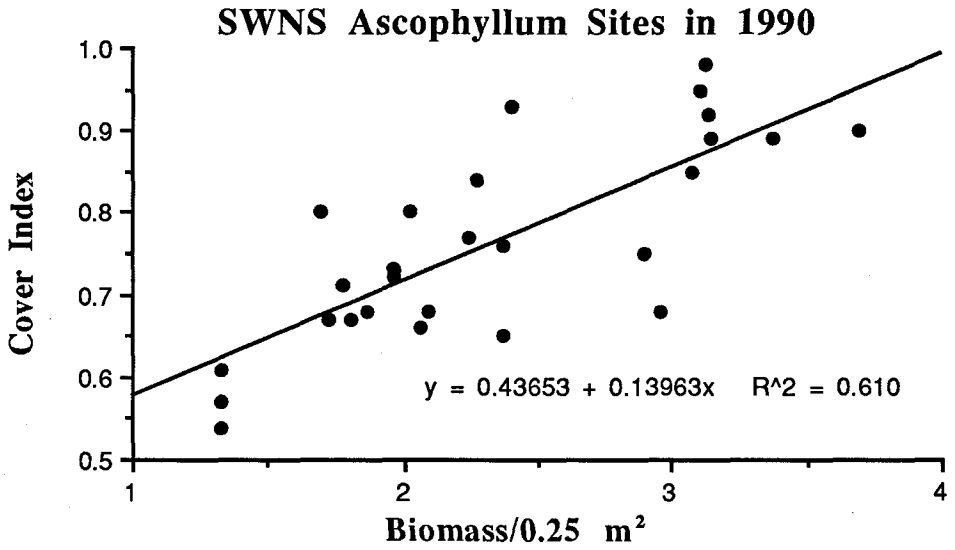

Figure 10. The correlation with the cover index and the mean biomass of Ascophyllum per square metre from the southwest Nova Scotia 1990 sites.

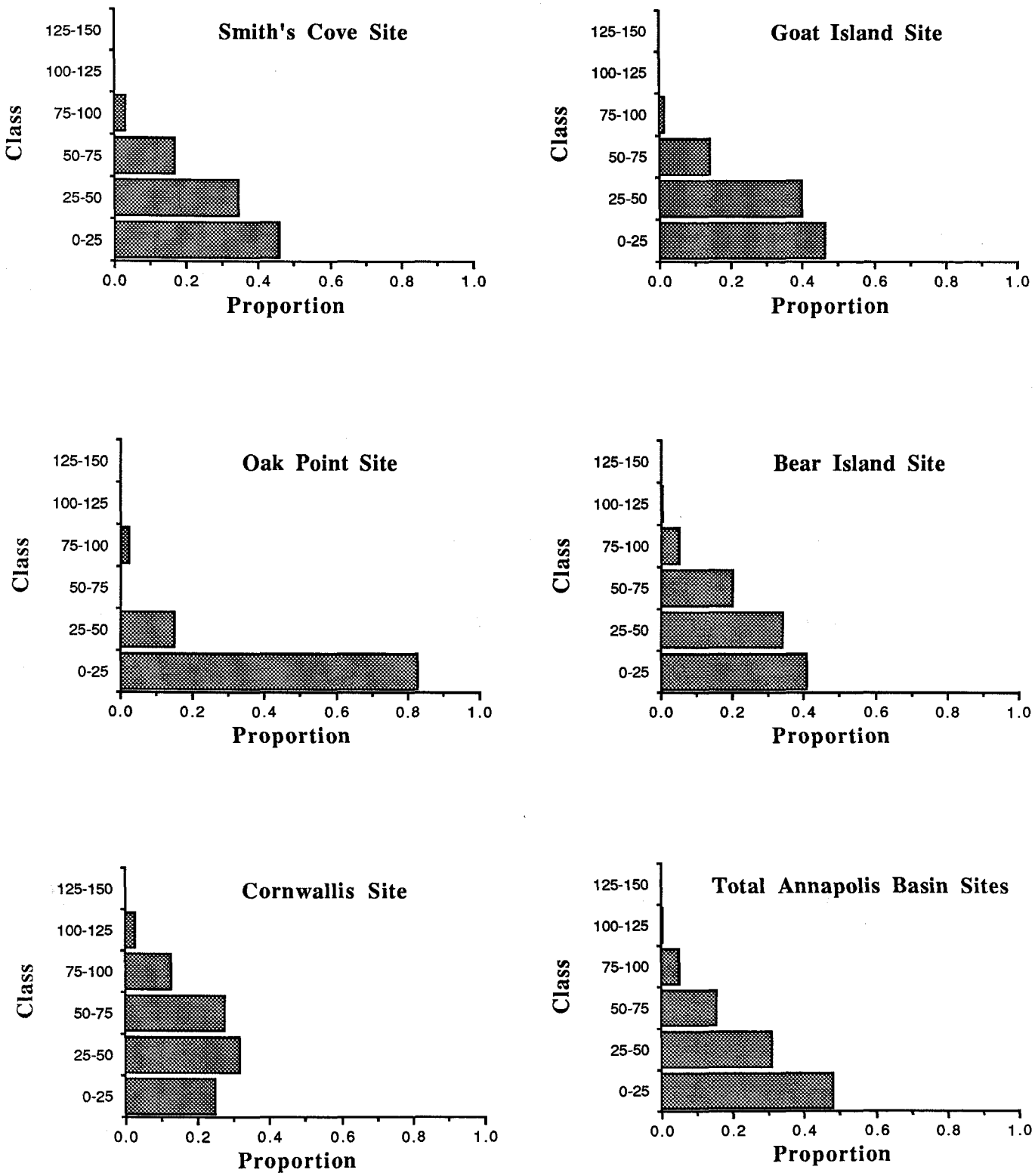

Figure 11. Vertical Distribution of Biomass for the 1990 Annapolis Sites

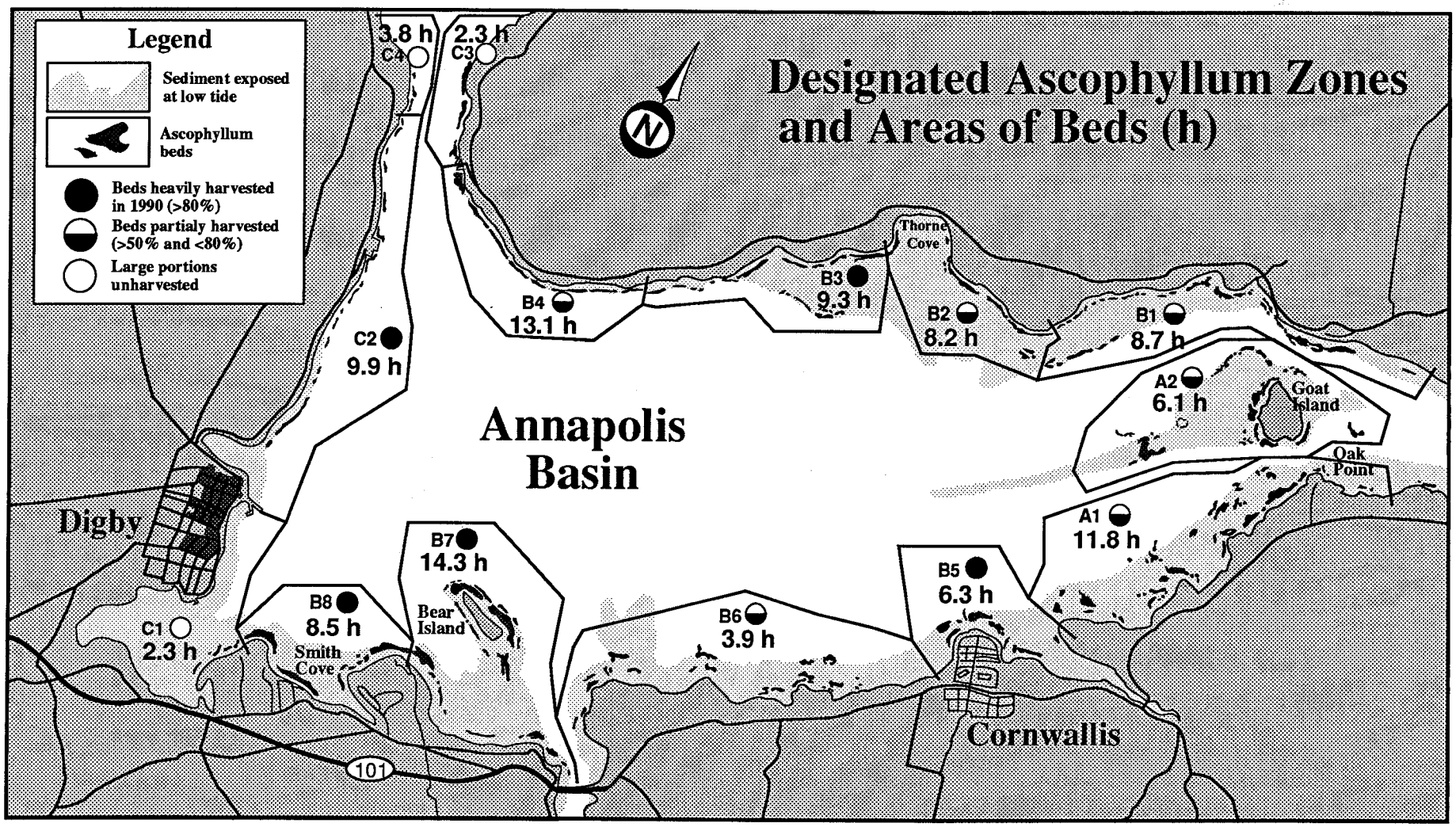

Figure 12. Distribution, area (h), and harvesting pressure on the Ascophyllum beds in the designated zones of the Annapolis Basin.

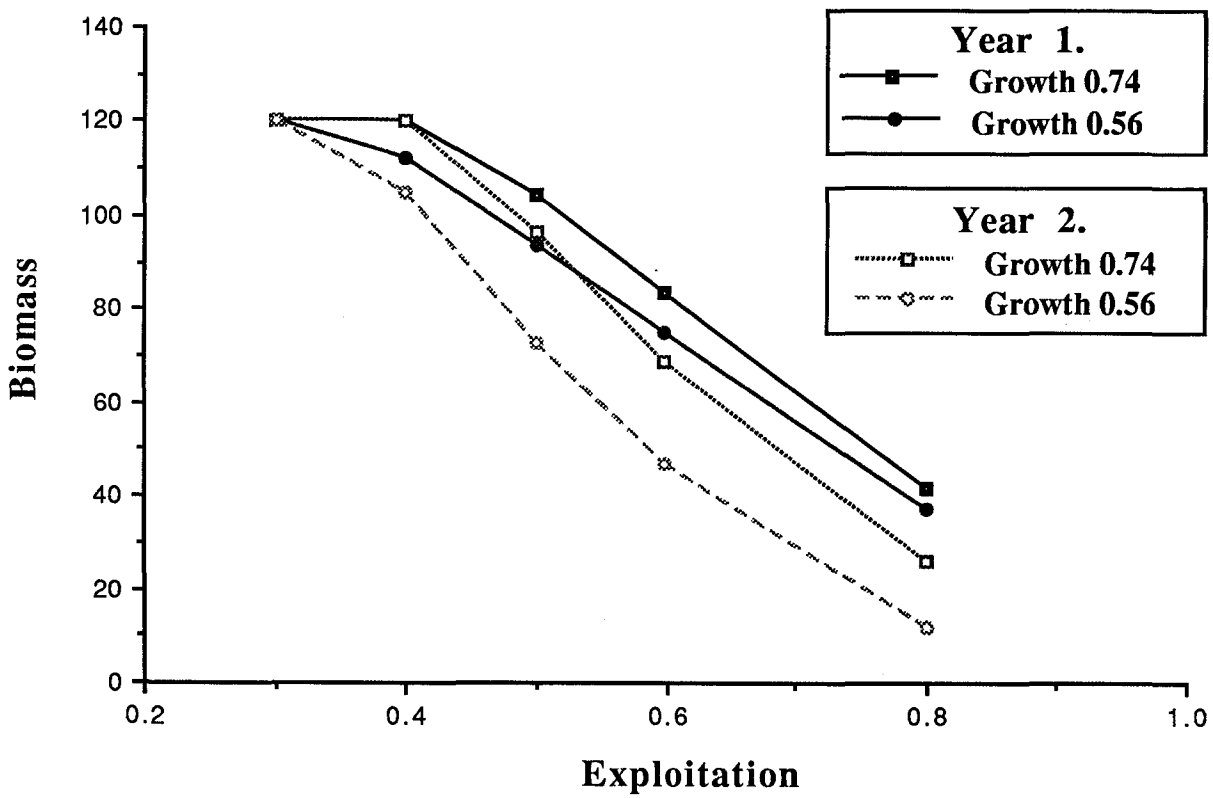

Figure 13. The relationship between biomass and exploitation in two successive years of harvest and two rates of recovery