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Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 89/1

CSCPCA Document de recherche 89/1

AN ASSESSMENT OF *ASCOPHYLLUM NODOSUM* RESOURCES IN SCOTIA FUNDY

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ABSTRACT

From current and historical data bases the Ascophyllum nodosum (Rockweed) resources of Scotia Fundy were estimated to be 290,000 t standing crop. The annually harvestable biomass ,47,000 t , is a function of harvesting technique, harvesting strategy, and resource productivity. The majority of the harvestable biomass occurs in Southwestern Nova Scotia and Southern New Brunswick. The dramatic increase in landings from Southwestern Nova Scotia, 5000 t in 1985 to 27,000 t in 1988, has resulted in a wide mix of residual biomass in a variety of recovering stages in Lobster Bay, Yarmouth county,N.S. Ascophyllum requires 2 to 5 years to recover from harvesting depending on the degree of harvest and local productivity. Haphazard open harvesting of the resource will lead to a steady decline in landings beginning in 1989.

RÉSUMÉ

En utilisant des banques de données historiques et courantes, la biomasse d'Ascophyllum nodosum a été estimée à 290,000 t. La biomasse récoltable de 47,000 t par année est une fonction de la technique et de la stratégie de récolte et de la productivité de la ressource.La majorité de la biomasse récoltable se trouve au sud-ouest de la Nouvelle-Écosse et au sud du Nouveau-Brunswick.L'augmentation dramatique des débarquements du sud-ouest de la Nouvelle-Écosse, de 5,000 t en 1985 à 27,000 t en 1988,a résulté en une diversité de biomasse résiduelle à différents stages de récupération dans Lobster Bay, comté Yarmouth, N.É. Ascophyllum nécessite de 2 à 5 ans pour se rétablir dépendant de l'intensité de la récolte et de la productivité locale.Une récolte ouverte, faite au hasard,résultera en un déclin continu des débarquements à partir de 1989.

INTRODUCTION

Ascophyllum nodosum Stackh. (Rockweed) is a brown fucoid algae dominating the intertidal on the Atlantic and Fundy Coasts of Nova Scotia and New Brunswick (Fig 1). Traditionally this seaweed was used as an agricultural fertilizer and soil conditioner. Commercial exploitation began in the early 1960s in Southwestern Nova Scotia (SWNS) for both the production of the phycocolloid alginate, and seaweed meal. Hand tools were used for the harvest exclusively until 1970 when mechanical harvesters were introduced and they eventually supplied 80% of the raw material (Sharp,unpublished data). Despite mechanization, landings did not exceed 8,000 t fresh weight per annum. After 1985 three factors lead to a dramatic increase in landings of 30 to 50% per year to 27,000 t in 1988 (Fig 2). First, the introduction of new mechanical harvesting technology the Norwegian suction harvester increased catch per unit effort (CPUE) four fold. Second, alginate processing became a 12 month operation from a 6 to 7 month one. Third, increased demand for seaweed meal products brought new buyers/processors to the area stimulating hand harvesting (Fig 3).All of this increased activity has been focused on the traditional harvesting areas of Southwestern Nova Scotia.

As a result of these rapid changes in the industry there have been reports of local conficts for access to the resource, local problems with "overharvesting" and a general breakdown in normal harvesting strategies. There is a need to reassess the resource base and our management strategies in the light of these changes.

This paper provides estimates of sustainable yield for Scotia Fundy Ascophyllum resources and evaluates the quality of data bases for these estimates. Projections for 1989-90 landings are provided based on several scenarios of harvesting strategies.

METHODS

a) Standing Crop (survey methods):

There is no comprehensive survey of Ascophyllum resources for the Scotia Fundy coastline. However , a number of local surveys were completed between 1945 and 1988 (Table 1). These surveys ranged from extensive studies of commercial biomass (MacFarlane, 1952 ; Neish,1971) to intensive examinations of single sites to correlate stand structure and biomass with environmental factors (Cousens ,1981). The following is a description of the studies relevant to each coastline area of Scotia Fundy.

i) Southwestern Nova Scotia:

The earliest survey of this area was conducted between 1948 and 1950 on unexploited resources (MacFarlane, 1952) . Although the sampling was extensive it was selective and limited for the large area (520 km) of shoreline (Table 1). No statistical treatment of the data was done nor are the raw data available for comparison or analysis (MacFarlane, 1952). The coverage area was calculated as a function of shoreline length and the mean fucoid zone width.

Recent surveys were a part of harvesting studies conducted between 1978 and 1988 in SWNS. A minimum of 3 strip transects perpendicular to the shoreline and 25 m apart were divided into 1m by 0.25m segments from the top of the fucoid zone to the lower limit of distribution. Fucus spp. and A. nodosum were separated and weighed on autopsy scales accurate to 50 g. Additional sites were sampled at preset intervals (0.25m-10 m) along transects, providing a minimum of 30, 0.25m^2 samples per site.This data was combined with the analysis of air photos from existing overflights targeted on land masses (Sharp et al, 1981; Sharp,unpublished data). The fucoid zone was traced from color positive air photos at 1:10,000 scale and area calculated on an image analyzer. Photos varied in quality due to tide height and water clarity in the series available. Air photo coverage was inadequate for 8 km of shoreline therefore a mean shoreline width of 30 m was used to calculate area.

The value for standing crop from Digby and St Mary's Bay was based on the yield of sustained hand harvests from this area over 20 years (1,000 to 2,500 t) and a 3 year reharvest interval.

ii) Southern and Eastern Nova Scotia:

Seven sites on the South coast of Nova Scotia from Baccaro Pt to Jordan River were ground surveyed in 1987-88 (Fig 4). Study sites were selected on the basis of a subtidal survey which identified areas with foreshores of stable substrate and algal populations (Moore and Miller,1983; Moore et al, 1986). Sites were systematically placed at each 16 km of stable substrate foreshore. Each site was sampled by the methods described above for SWNS (Table 1). Analysis of air photos was not complete for this area due to the lack of low tide scenes in some areas. In these cases the procedure used to calculate area is described below.

The data base available for the remainder of the southern shore and all of the eastern shore of Atlantic Nova Scotia was limited to sites chosen for population or ecological studies. Estimates of standing crop for this area were based upon a combination of analysis of existing color air photos or identification of foreshore capable of sustaining algal populations (Moore and Miller ,1983; Moore et al, 1986). Shoreline with a shallow subtidal of stable substrate was assumed to have intertidal of the same material. The coastline was measured on hydrographic charts (1:60,000 - 1:40,000), and a mean width of 5 m for the fucoid zone was multiplied by shoreline length to obtain area. Values of mean biomass were derived from random samples from the mid-point of the fucoid zone (Cousens, 1981). Sampling was non destructive, correlating plant biomass with volume as a function of length and circumference (Pielou,1981).

iii) Southern New Brunswick:

Charlotte Co. , N.B. was surveyed in 1970 using the selection criterion of "significant quantities" for establishing transects (Neish, 1971). One transect was placed perpendicular to the shoreline at each site or bed, the frequency of transects ranged from one per 35 km to one per 2 km of coastline. On each transect , bed width was measured and visual estimates of biomass were checked by unspecified numbers of random weighed samples (Table 1). Infrared aerial photography was available for this area but the photos were not found to be interpretable, therefore field charts and direct measurements were used for area estimates. A subjective cover estimate was incorporated into the calculation of biomass for a given bed as a discount multiplied by area and biomass values. A portion of Charlotte Co., Passamaquoddy Bay was resurveyed in 1981 and 1985 by aerial photography and ground surveys (B.Bradford, pers comm.).[1] Analysis of false infrared (1:10,000) photos was used to establish a 4 part classification of color density. Ground surveys of transects divided the intertidal into 4 to 12 equal zones. Within each zone 3, 0.25m^2 samples were removed for measurement. A mean value for biomass was obtained for each color density and multiplied by the area measurement for each color class in the survey area. Two sites in Grand Manan ,N.B. were surveyed in 1988 by the authors with methods described for 1988 surveys of SWNS.

The total standing crop calculation for Scotia Fundy was based on a selection of the most current and comprehensive surveys for a shoreline (Table 1). The minimum mean biomass values or standing crop estimates were used from the available range. However the wide variation in standing crop due to harvesting in Lobster Bay forced the use of a less conservative value, the recovered biomass density for the entire area.

b) Harvestable Standing Crop:

The definition of harvestable standing crop has two dimensions; one, the biomass density required to provide a minimum economic CPUE, and two, biomass which is accessible to the harvesting technique. The Neish (1971) survey of Charlotte Co. ,N.B. biomass set a minimum harvestable biomass density of 6.8 kg m^{-2} based upon a hand tool harvesting trial correlating CPUE with biomass density.

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[1] B. Bradford Msc. Student Acadia U. 1987

Accessibility for hand harvesting relates to the means of transport of the harvest, that is either sufficient water depth for boat access or vehicular access to the shoreline. Mechanical harvesters are limited by their sea keeping capabilities which make very wave exposed shores unharvestable or infrequently harvestable. Water depth and currents can limit access to large estuarine areas depending on the draft and power of the vessel. None of these factors were used in the assessment of harvestable biomass since the area of operations has not been defined for a given harvesting technique. However it would be necessary to consider these factors when designating or sectoring the area for management purposes.

c) Annual Harvestable Biomass:

Annual harvestable biomass is a function of the resource productivity and the minimum economical CPUE. In general a minimum of 2 years (usually in cases of low harvest intensity, <50%) and a maximum of 5 years (areas of slow growth or of severe harvest intensity, 80-90%) is required for biomass recovery (Siep,1980; Keser et al, 1981; Sharp,1981) . Mechanical harvesting removes 40 -60% of the standing crop and 50% was used to discount standing crop estimates. A 3 year recycling period was determined from an experiment which monitored the recovery of an area following normal harvesting (Sharp,unpublished data). This recovery period was supported by productivity studies. Annual production as measured by successive biomass increments for a range of 8 sites in Atlantic Nova Scotia peaked in SWNS at Cape Sable Island at 2.25 to 2.85 kg dry weight per year m^{-2} from a biomass density of 3.81 kg dry weight m^{-2}(Cousens, 1981a).

d) Distribution of Landings 1988:

In 1988 a new method of recording Ascophyllum landing statistics was introduced; rather than reporting the landing point, the origin of the material was attributed to sections of shoreline from where it was removed. The Southwestern Nova Scotia coastline was divided into a series of 231 sectors (5- 30 km) delimited by identifiable headlands,wharves, bays and islands. Maps of these sectors and data sheets were provided to all major buyers/processors to record weekly landings.

RESULTS

a) Standing Crop:

Values of mean biomass density recorded by MacFarlane (1952) are the highest for the Scotia Fundy region (Table 1). The mean Ascophyllum biomass density in the 1948 survey is only reached by single maximum values in all other studies. All other studies have ranges of means overlapping significantly. Southwestern Nova Scotia has a wide mixture of biomass densities relating to degrees of harvesting intensities and the time since last harvest (Table 1). A recovered biomass (12 kg m^{-2}) was used to calculate standing crops for this area.

The intertidal zone of Southern and Eastern N.S. has a narrower width than SWNS and the Bay of Fundy due to shore slopes and lower tidal amplitude (1.5-2.0m versus 4.5-10.0m) . Standing crop per km was 40 to 50% less for the 7 stations completed than in SWNS (Fig 5). Fucus spp. were a larger proportion of the rockweed biomass on the Southern N.S. shore (10% - 50%). Standing crops from N.B. have an extreme range (58-2000 t km^{-1}), due to the selective sampling method and the variety of foreshore. The total standing crop in Scotia Fundy based on existing data sets is 290,000 t. Passamaquoddy Bay, Grand Manan and Lobster Bay have the greatest concentration of biomass for the shoreline length. In Southern N.B. and in Lobster Bay, N.S. tidal range, low shore slopes, the large number of shoals and islands with high biomass densities are the major factors contributing to high standing crops.

b) Annual Harvestable Standing crop:

The annually harvestable standing crop was derived as a direct function of standing crop as described in methods but this data has been subdivided into statistical districts for higher geographical resolution (Fig 6).

c) Distribution of Landings 1988:

Seventy-five percent of buyers/processors responded to the request for landing information and special inquiries brought in missing data. All Ascophyllum landings occured in Southwestern Nova Scotia and of the 27,000 t total, 22,300 t were landed in the environs of Lobster Bay. Landing reports showed some anomalies such as excessive (greater than standing crop) landings for a sector and clumping of sectors in an area as a routine reporting procedure. However the pattern of landings and the active harvesting sectors were obtained for 1988 in Lobster Bay (Fig 7) and in St Mary's Bay/Annapolis Basin (Fig 8). Landings were widely distributed in Lobster Bay. The greatest concentration of harvesting occurred in the Wedgeport area where both mechanical and hand harvest methods were used in a competitive manner. Similarly hand and mechanical methods were competitive in the Shag Harbour area (Fig 7). Landings were more widely distributed in the St Mary's Bay and Digby area and overlap of harvesting effort only occured in one sector.

Reporting landings for a sector does not imply it is completely harvested. For example the Argyle area has islands and foreshore unharvested in 1988 (Fig 9). The degree of harvest within any sector will be a function of harvesting efficiency, the tidal range during the harvest, incentives to do a systematic harvest and the prevailing weather, particularly wind speed and direction. The probability that an underutilized area will be harvested in the near future is dependent on the harvest strategy of the buyer/processor and the degree of documentation for the harvest.

d) Projections for landings 1989/1990:

Projections for landings 1989-90 are based on residual biomass, growth, and areas remaining fallow. These projections exclude the potenial expansion of the harvest into areas beyond Southwestern Nova Scotia which have in excess of 20,000 t annually available crop. Excluding the inaccessible Mud and Seal Islands our survey projected an annual harvestable crop of 20,600 t for Lobster Bay (Fig 6). In 1988, 22,300 t were landed 1700 t above the estimated sustainable yield. Adjustments could be made in subsequent years if detailed weekly records were kept of location and yield . However, with the exception of one company's records and our reporting scheme no exact record of fully harvested versus partially harvested or unharvested areas exists. The entire bay and particularly hand harvested areas near Wedgeport and secondarily the Shag Harbour area are a myriad of harvesting intensities and residual biomass densities. The Wedgeport area has been overharvested by 4000 t based upon a 3 year reharvest interval (Fig 7). The harvesting regimes for companies which plan at least 3 years in advance have been greatly disrupted by competitive harvesting. Areas scheduled for harvest in 1989 were utilized in 1988. The residual biomass after the 1988 harvest is 40,600 based on the assumption that all remaining areas are fully recovered in biomass. However the assumption residual biomass is fully recovered is not valid. In 1987,21,800 t of Ascophyllum was harvested in Lobster Bay (Fig 9). Therefore large portions of the residual biomass will be in the second year of recovery in 1989. This further adds to the patchy distribution of biomass on a large geographical scale in Lobster Bay. Residual biomass is concentrated in the Argyle/Pubnico area which is not a traditional hand harvest area (Fig 10) . Assuming recovery of 1988 harvest areas by 1991 the 1989 and 1990 harvest could be 20,300 t. If the general haphazard overharvest of 1988 continues in 1989 the residual biomass in Lobster Bay will only support landings of less than 18,000 t in 1989 and less than 15,000 t in 1990.

The data from St Mary's Bay and Annapolis Basin are insufficient to calculate residual biomass therefore no projections are made for this area. However landings from this area were among the highest in the history of exploitation, approximately 4000 t and most of the sectors have been at least partially utilized.

DISCUSSION

There are a number of factors which can lead to large errors in the estimation of standing crop in seaweeds.The large variation in biomass density is indicative of patchiness in this environment. Substrate type is an important factor determining the presence or absence of Ascophyllum (Topinka, 1981). The degree of substrate relief adds or reduces surface area of the shore and the amount of suitable habitat for Ascophyllum. Wave exposure influences biomass density on a micro-geographical scale, and peak biomass is reached in areas of moderate wave exposure (Cousens, 1984). The biomass of A. nodosum peaks in late spring due to the development of reproductive structures (receptacles) which are rapidly lost in early summer. Surveys during this period of biomass change must use correction factors. However, the timing and degree of reproductive production varies between sites.

The degree of variation (95% confidence intervals) in biomass sample suites for sites in the St Lawrence river estuary range from 10% to 40% (Breton-Provencher,1976). Two standard errors of the mean had a range of 30% to 80% of the mean for sample suites in Southern and Southwestern Nova Scotia (Cousens,1981; Sharp ,1981).

Remote sensing methods used in Scotia Fundy to date do not have sufficient resolution to distinguish between Fucoid species and areas calculated must be considered an overestimation of Ascophyllum coverage by an average of 5%. Interpretation is also limited by water depth particularly with infrared film which cannot penetrate water below 25cm. Unless overflights are carefully timed for the best low tide period, the interpretation of photography is a minimum area coverage. In Lobster Bay flightlines were oriented for land coverage and thus frequently provided a minimum estimate for Ascophyllum cover. Air photos were rejected if they were taken later than one half high tide and underestimation was limited to a range of 0 to 30% for an individual photo. Determining the lower limit of Ascophyllum is a function of the substrate or vegetative type at this boundary. Sand or gravel bottom is highly reflective allowing clear definition of lower zone limits (Sharp et al,1981).

The application of biomass density to areas can be based upon a characteristic value for each site; a global value from a wide range of sites within a bay or estuary and/or values correlated to color densities.The degree of error increases with the lower level of specificity in values and the increasing degree of physical heterogeneity. In areas where harvesting has occurred in a patchwork fashion designation of a characteristic biomass value is impossible without an intensive and extensive sampling program. Lobster Bay estimates of total biomass must be considered for 1988 an overestimate however these values were discounted by the 1988 harvest for 1989-1990 projections.

A comparison of a 1988 survey of Hog Island in Lobster Bay was made with a 1948 survey of the same shoreline. A 900 m section of the southern end of Hog Is was surveyed by 10 perpendicular transects from which 75 samples were removed for biomass density. The area of the bed was derived from color air photo analysis and computer aided planimetry. The values for total tonnage were similar, 720 t in 1948 and 773 t in 1988. However, the area of coverage was 12.0ha in 1948 and 6.0ha in 1988. The use of aerial photographs eliminated the error related to interpolation from several zone width measurements.The lower biomass value for 1948 was not typical for the larger survey and may relate to the low number of samples typically taken per site.

Similarly the area of Passamaquoddy Bay surveyed in 1970 and 1981/85 was compared. The 1970 survey (Neish,1971) of this area did not include the U.S.A. shores of the Bay therefore a correction factor of 100 t per km shoreline (24 km) was added to the 1971 estimate of 7900 t for a corrected total of 10300 t. The two estimates of 1981 and 1985 for this shoreline were 30,000 and 50,000 t respectively (B. Bradford, pers.comm.)[1] . The sampling methods for biomass density were selective in 1971 and would have overestimated biomass. Area coverage was based on direct measurements at 28 stations and may have underestimated area greatly in comparison to the image analysis by Bradford (pers.comm.)[1].However the 24% change in standing crop between 1981 and 1985 was attributed to

[1] B. Bradford Msc. Student Acadia U. 1987

biomass density increase rather than area which had decreased due the low tide timing of the two overflights.

CONCLUSIONS & RECOMMENDATIONS

Although we do not have an accurate map of biomass distribution in SWNS on a micro-geographical scale, we do have a good concept of the proportional distribution of recovered biomass within large sectors of Lobster Bay (>100 hectares). This data plus our knowledge of the production characteristics of the resource permit consideration of management options. A pulse harvest strategy is optimal for a widely distributed sessile resource which can be fully exploited and has a renewal period of over one year. Once an area is fully cropped it is closed to reharvest for a minimum of 2 and a maximum of 5 years. The optimal reharvest interval must be determined on site by assessment of biomass recovery. The degree of harvest or harvest intensity will directly affect the recovery period.The degree of harvest in marine plant resources is related to the harvesting gear, the skill of the harvester/machine operator and the minimum economic CPUE. A mixture of harvesting methods or strategies in a sector will prevent accurate assessment of crop maturity. The management area must be of sufficient size to allow for variation in accessibility with weather and season.

Marine plants offer an excellent opportunity to allow a significant degree of self-management if the harvester/buyer can be assured control over a sector of the resource.To allow management strategies to be applied to the resource it must be sectored and harvesting privileges and responsibilities allotted to groups or individuals. Existing regulations need monitoring and enforcement but the limited harvest area requires the individuals involved manage their harvest.

The amount of yield with a given harvesting strategy can be predicted and the effects of mistakes in management strategy are limited to the sector. A review of management performance can be made on an annual basis assessing yield, intensity of harvest, distribution of harvest and residual biomass. The alternative is a very interventionist central agency management including control measures such as area quotas, limits on residual biomass, and reharvest interval limits. .

Ideal management of a sector begins with the removal of 50 to 60% of biomass. The mean cutting height is 20 cm or above to harvest the majority of a plants biomass without affecting the recruitment of new shoots either basal or laterally (Baarsdeth, 1970).The area is documented by yield and location and left fallow for 2 or more years then the degree of biomass recovery is evaluated prior to reharvest. This scenario is not possible in an open fishery. Opportunistic utilization of the resource on a first come first serve basis results in 1) patch work harvesting 2) no overall knowledge of the state of the resource 3) overharvesting of some areas to prevent incursion by competitors 4) premature harvesting of areas in fallow.

Areas beyond SWNS with significant Ascophyllum standing crops provide an option to transfer some harvesting pressure. These areas contain virgin standing crops and therefore cannot be expected to sustain the first harvest, however our estimates for these areas were conservative. Sustainable annual harvests should not be used as quotas for an area as the figure is only a guide to show the distribution of resource and provide a concept of possible management sectors.

Recommendations:

1) The annual sustainable harvestable crop of A. nodosum in Scotia Fundy is 47,000 t

2) Lobster Bay, St Mary's Bay and Annapolis Basin have reached or exceeded the annual sustainable yield of A. nodosum

3) A new management strategy is required to prevent a decline in the resource over the next 2 years.

Baardseth, E., Synopsis of biological data on knobbed wrack, *Ascophyllum nodosum* (Linnaeus)
1970 Le Jolis. FAO Fish. Synop.,(38) Rev.1:41p

Breton-Provencher, M., Aspects écologiques de la production des algues benthiques
1976 médiolittorales de la région de bic , estuaire Maritime du Saint-Laurent. MSc Thesis Université de Laval, Québec ,P.Q.

Cousens,R., The population biology of *Ascophyllum nodosum*. Ph.D. Thesis. Dalhousie
1981 University,Halifax,Nova Scotia.

Cousens,R., Variation in annual production by *Ascophyllum nodosum* with degree of exposure
1981a to wave action. Proc.Int.Seaweed Symp.,10:253-258

Cousens,R., Estimation of annual production by the intertidal brown algae *Ascophyllum nodosum*
1984 (L.) Le Jolis. Bot. Mar.,27:217-227

Keser,M.,R.L.Vadas and B.R.Larson, Regrowth of *Ascophyllum nodosum* and *Fucus vesiculosus*
1981 under various harvesting regimes in Maine U.S.A. Bot Mar.,24: 29-38

MacFarlane,C., A survey of certain seaweeds of commercial importance in southwest Nova Scotia.
1952 Can.J.Bot., 30:78-97

Moore,D.S. and R.J.Miller, Recovery of macroalgae following widespread sea urchin mortality with
1983 a description of the nearshore hard bottom habitat on the Atlantic coast of Nova Scotia. Can.Tech. Rep.Fish.Aquat.Sci. 1230:94 p.

Moore,D.S., R.J. Miller and L.D. Meade, Survey of shallow benthic habitat: Eastern shore and
1986 Cape Breton,Nova Scotia. Can.Tech.Rep. Fish.Aquat.Sci. 1546:49 p.

Neish,I.,The distribution and abundance of rockweed on the Bay of Fundy shore of New
1971 Brunswick. Report to the New Brunswick Department of Fisheries and Environment Atlantic Mariculture Ltd.: 40 p.

Pielou,E.C.,Rapid estimation of the standing crop of intertidal fucoids on an exposed shore.
1981 J.Environ.Manage.,13:85-98

Sharp,G.J.,An assessement of *Ascophyllum nodosum* harversting methods in southwestern
1981 Nova Scotia .Can.Tech.Rep.Fish.Aquat.Sci., 1012:28 p.

Sharp,G.J., J.Carter ,D.L.Roddick and G.Carmichael,The utilization of color aerial photography
1981 and ground truthing to assess subtidal kelp (*Laminaria*) resources in Nova Scotia , Canada.<u>In</u>:Technical papers of the American society of photogrammetry p.56-67

Seip, K.L., A computational model for growth and harvesting of the marine alga *Ascophyllym*
1980 *nodosum*. Helgol.Meeresunters., 24:446-54

Topinka,J.,L.Tucker and W.Korjeff, The distribution of fucoid macroalgal biomass along central
1981 coastal Maine. Bot.Mar.,24:311-319

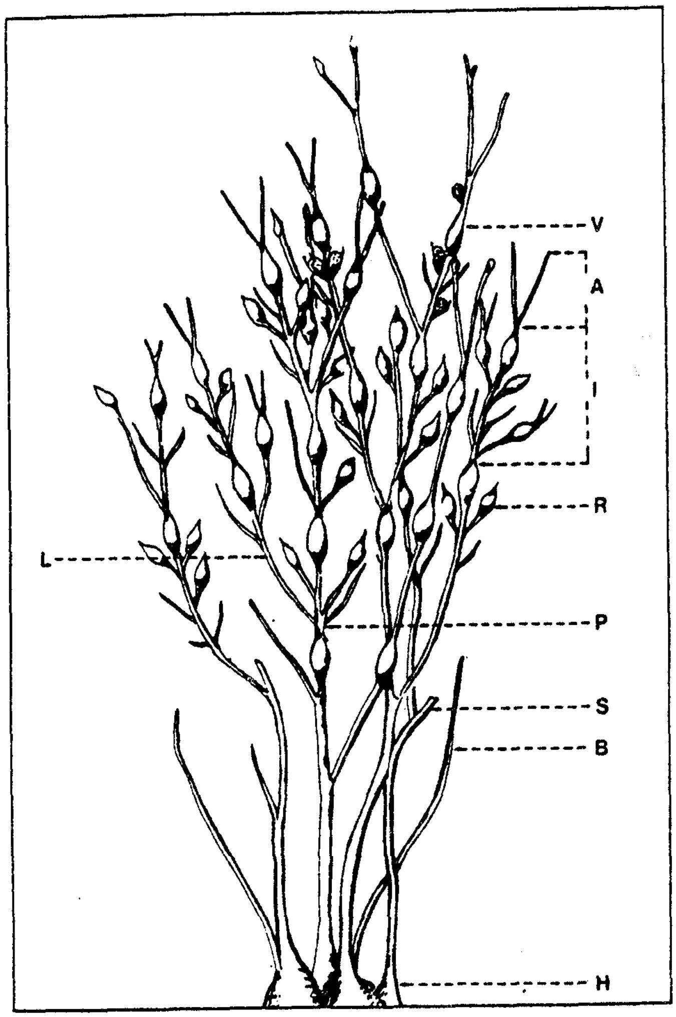

Figure1. *Ascophyllum nodosum* fronds and associated terminology : A, apical tip ;B, basal shoot ; H, holdfast ; I, internode ; L, lateral shoot ; P, primary shoot ; R, receptacle ; S, stump ; V, vesicle.

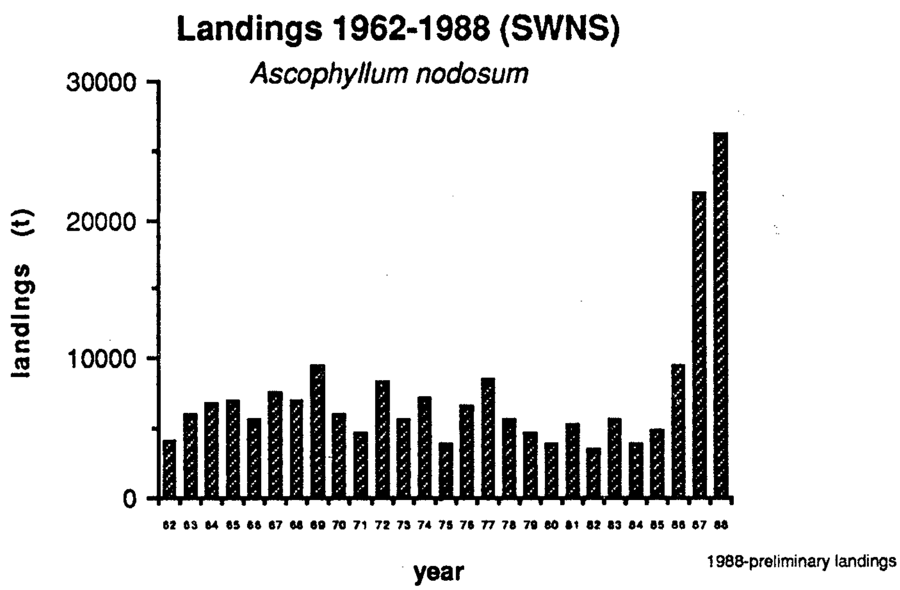

Figure 2.*Ascophyllum nodosum* landings (t. fresh weight) 1960-1988,Southwestern Nova Scotia.

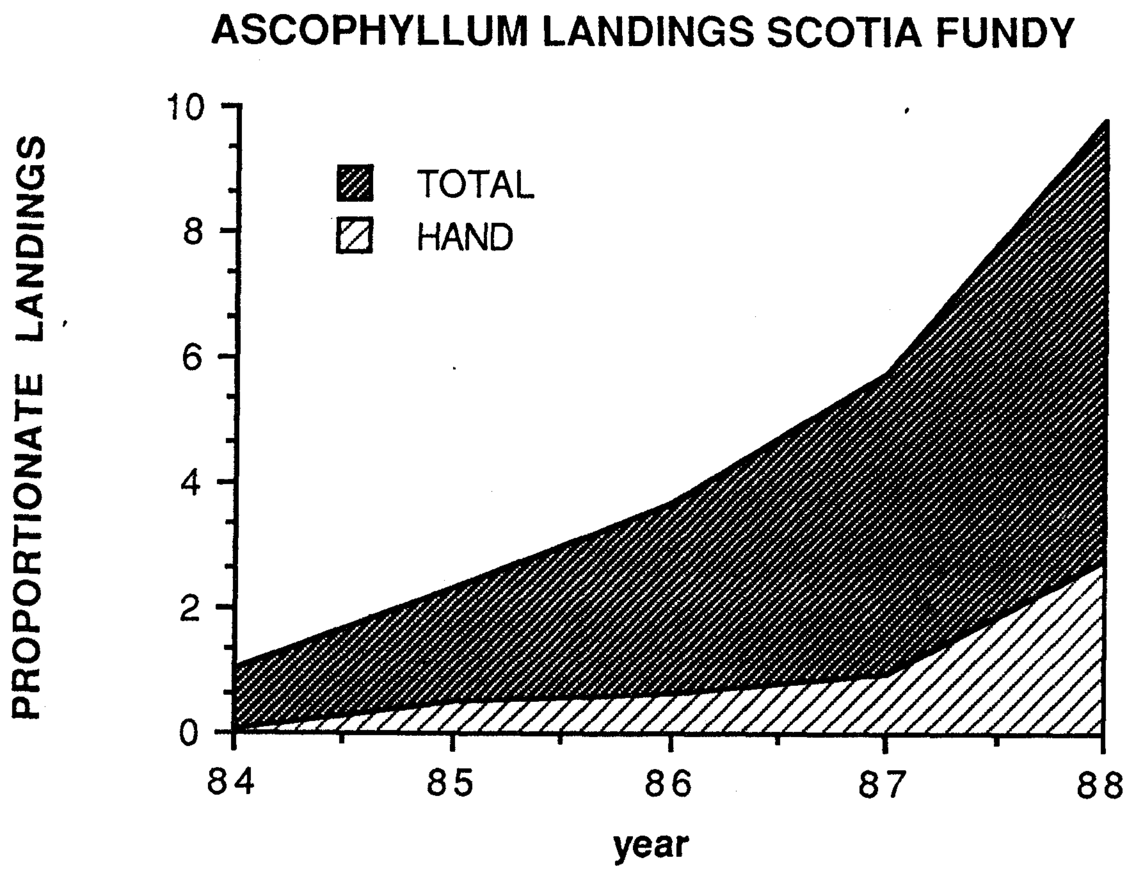

Figure 3. The proportion of *Ascophyllum* harvest in SWNS, mechanically and hand harvested.

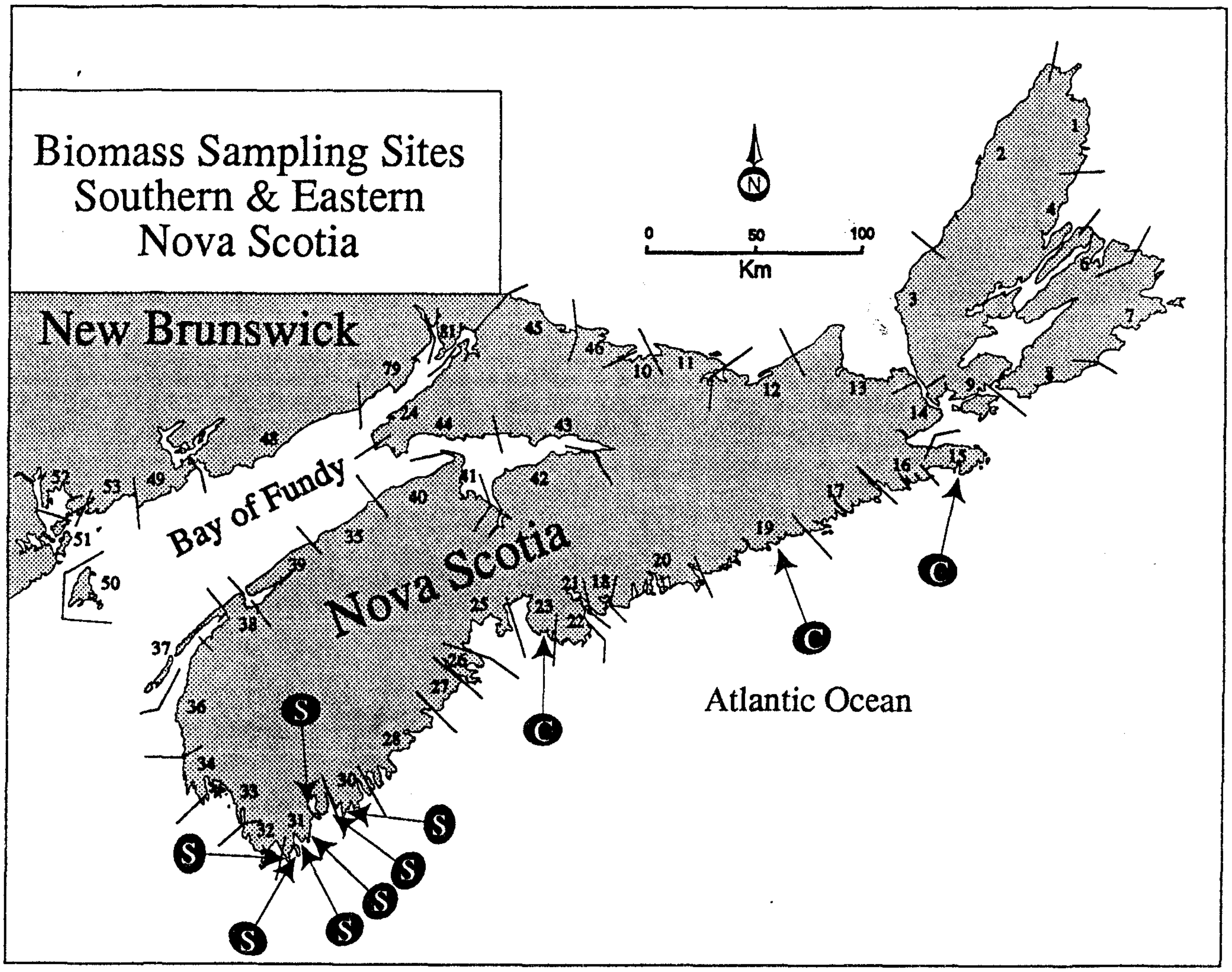

Figure 4. Distribution of *Ascophyllum nodosum* sampling sites on the southern shores of Nova Scotia.C=Cousens,1981 ; S=Sharp,1988.

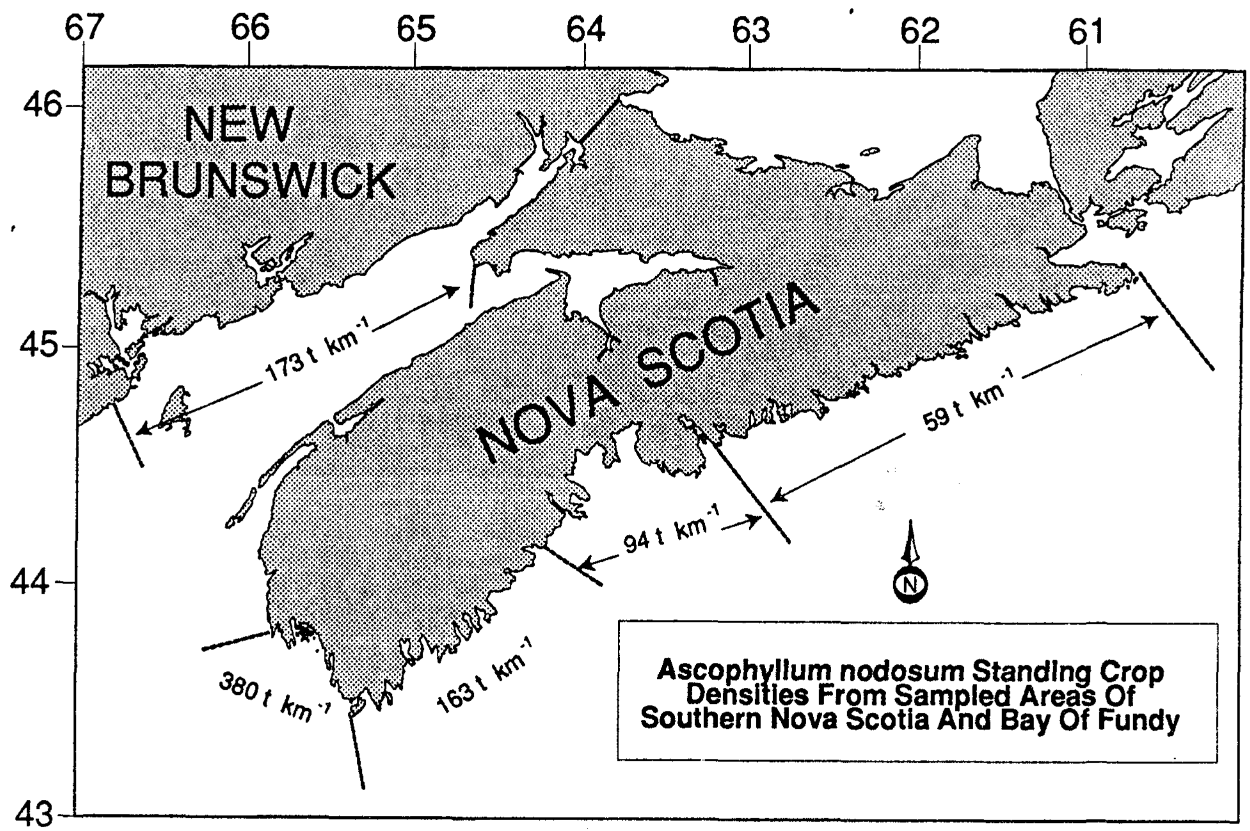

Figure 5. Distribution of *A. nodosum* standing crops (t. fresh weight per km) for sectors of the Scotia Fundy region.

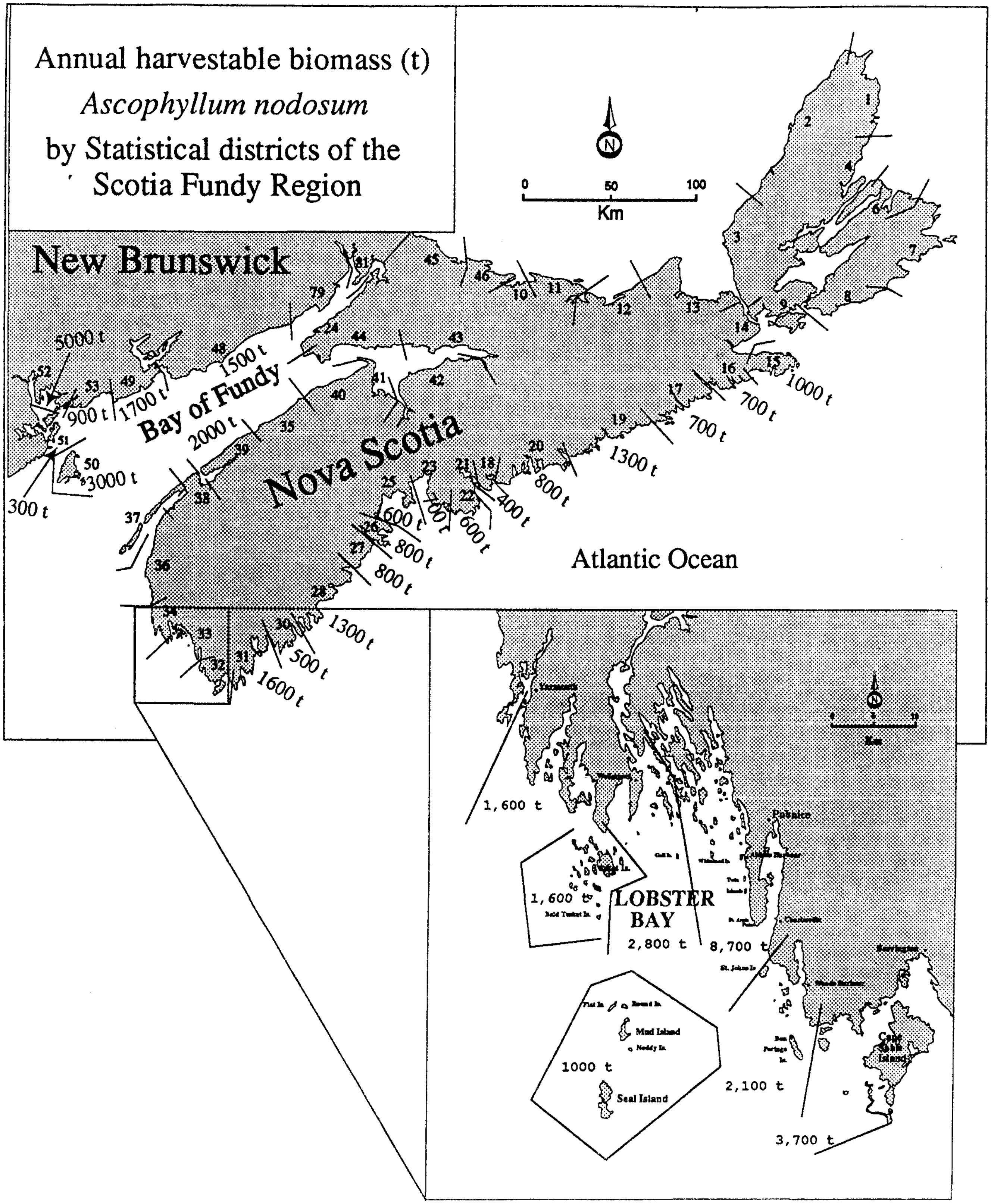

Figure 6. Distribution of annual harvestable standing crops of *A. nodosum* (t. fresh weight) in the Scotia Fundy region.

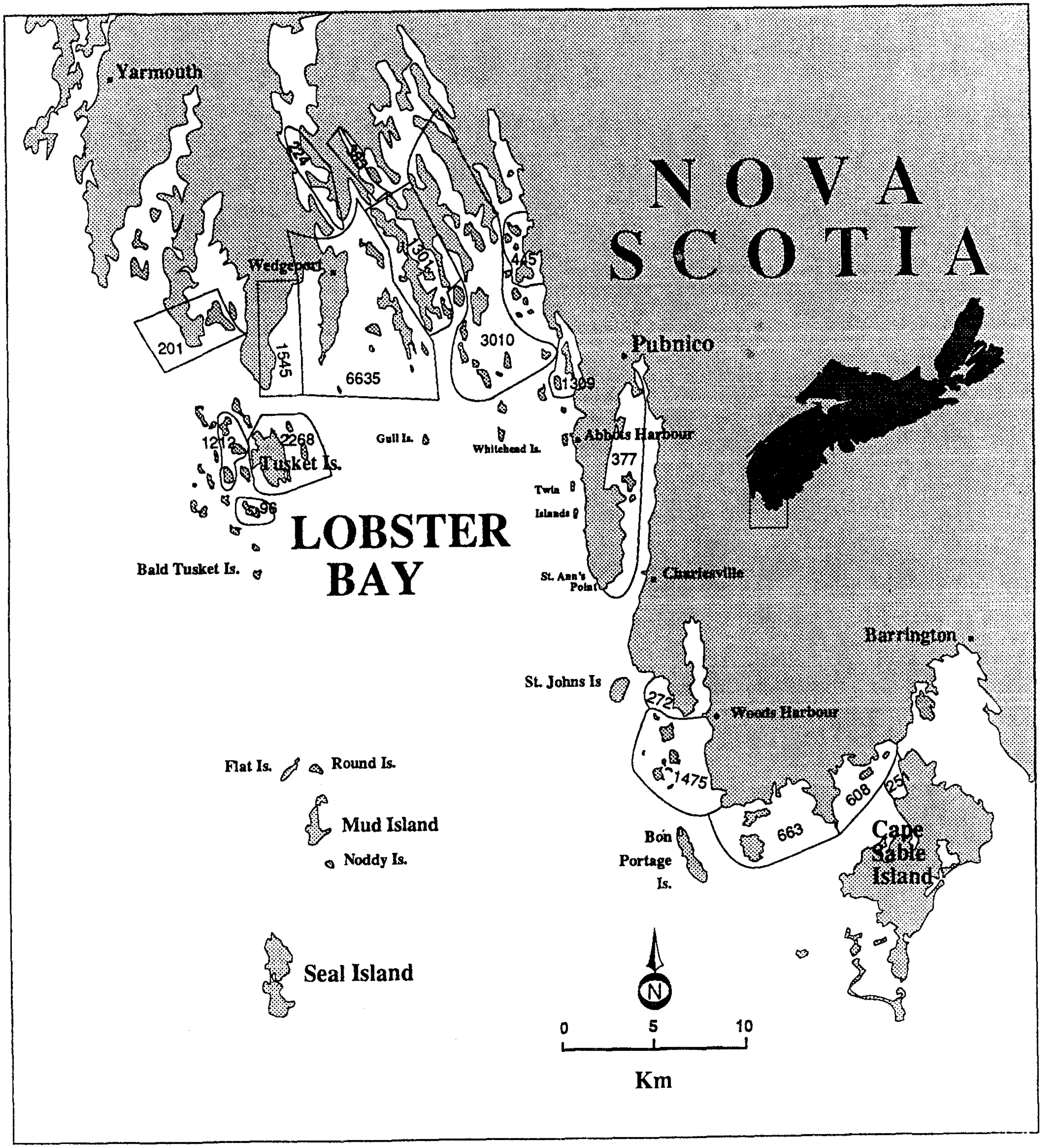

Figure 7. Distribution of *A. nodosum* landings in Lobster Bay (t. fresh weight) ,1988.

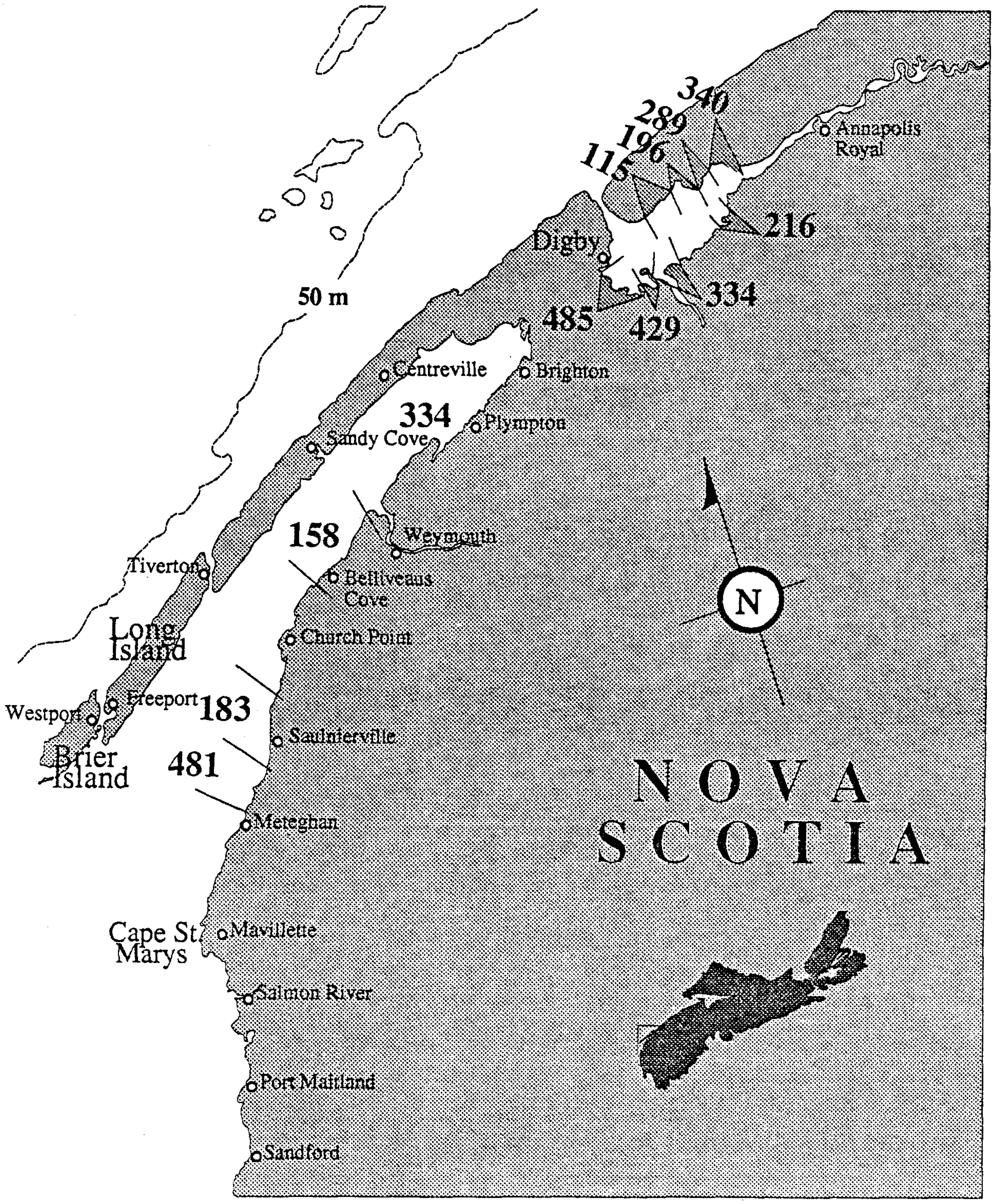

Figure 8. Distribution of *A. nodosum* landings in St. Mary's Bay and Annapolis Basin (t. fresh weight), 1988.

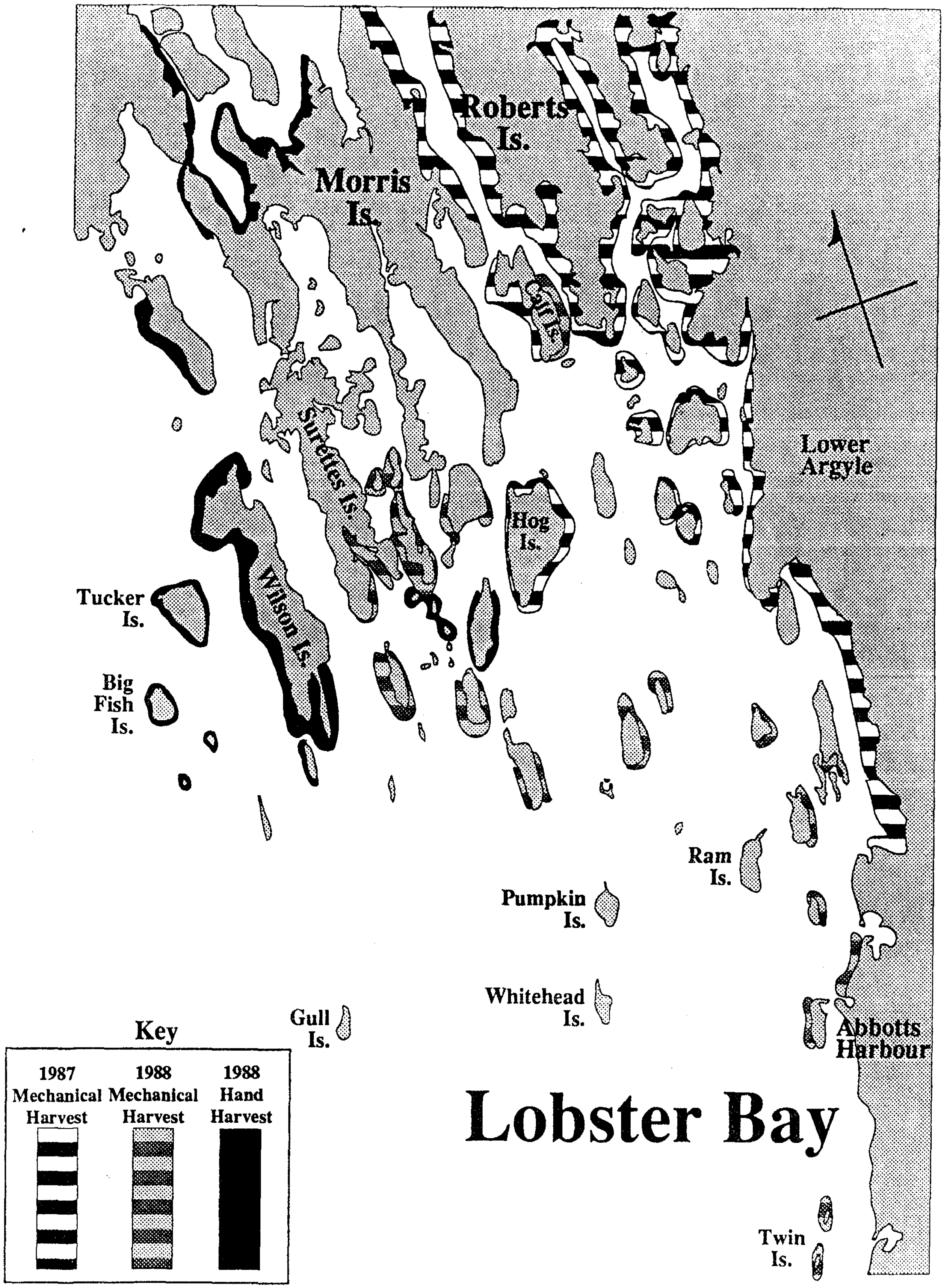

Figure 9. Distribution of harvesting activity in the Argyle area,Lobster Bay, N.S.,1987-1988.

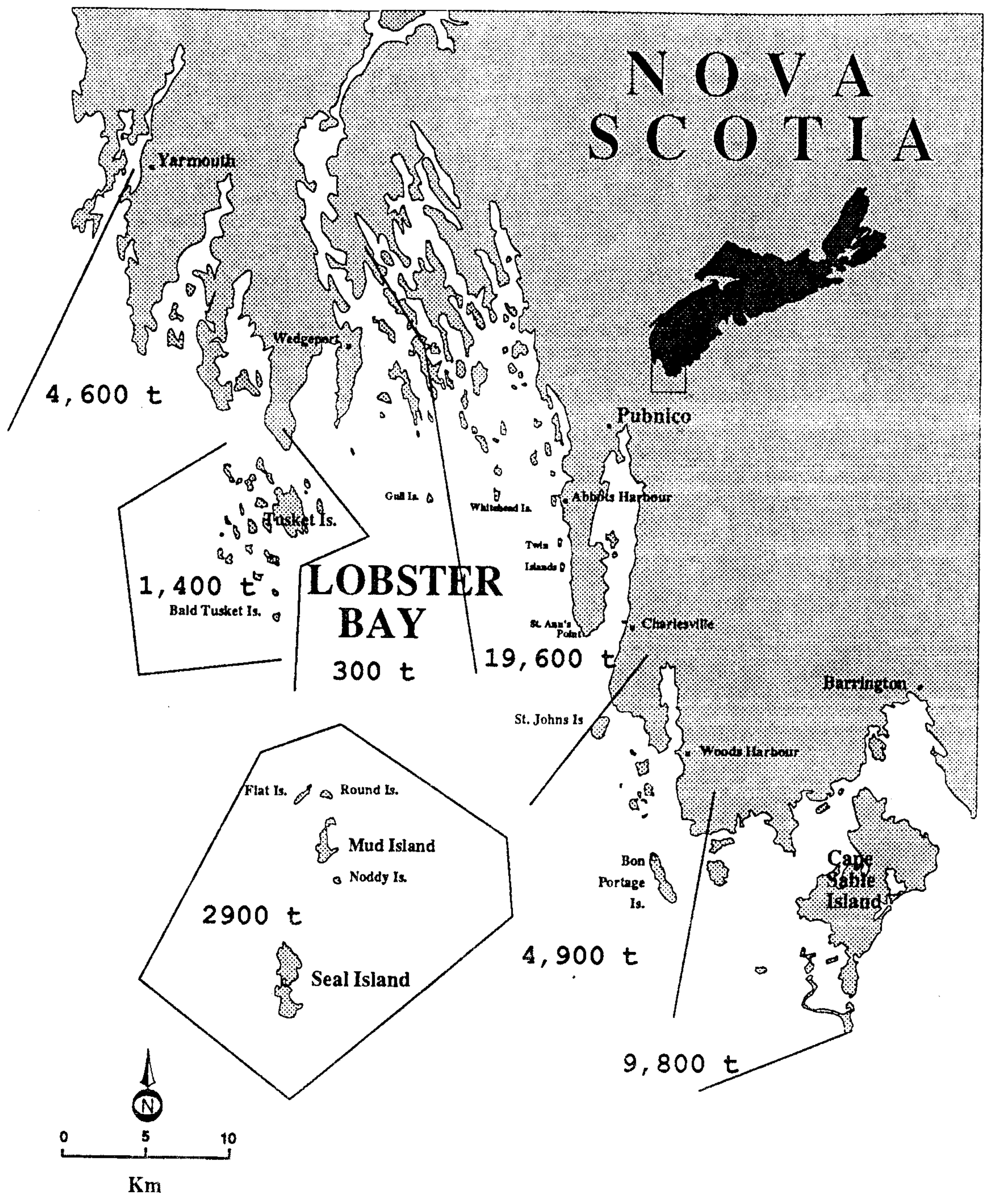

Figure 10. Residual *A. nodosum* biomass in Lobster Bay following the 1988 harvest (t. fresh weight).