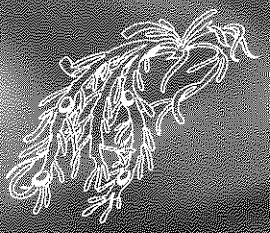
Mapping and Assessment of the Seaweed Resources (*Ascophyllum nodosum, Laminaria* spp.) off the West Coast of Ireland



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MAPPING AND ASSESSMENT OF THE SEAWEED RESOURCES (*Ascophyllum nodosum, Laminaria* spp.) OFF THE WEST COAST OF IRELAND

June 1998

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ABSTRACT

The seaweed biomass survey was designed to gather important information on those seaweed resources that are extensively harvested at present (mainly *Ascophyllum nodosum*) and those that offer a significant potential for future development (Laminariaceae). The first major objective of the project was to measure the intertidal biomass of *Ascophyllum nodosum* at selected sites along the Irish west coast. A total of 258 survey sites of varying size were selected by the survey team. They were considered to encapsulate all of the important regions where *Ascophyllum nodosum* harvesting was currently practiced and/or could take place in the future. Sites were selected using existing harvesting records, detailed map and chart studies and on-site visits. The total coastal area surveyed has the potential to yield 74,845 tonnes (t) of *Ascophyllum nodosum* sustainably per annum. The total amount harvested in 1996 was 35,850 t or some 48% of the total annual potential.

The location and classification of the major Laminarian (kelp) beds off the Irish west coast was the second major objective of the project. Laminarians form the most extensive community inhabiting sublittoral rocky coasts of the North Atlantic. There are five species of the Laminariaceae and Alarinaceae families common to Irish waters, namely; *Laminaria digitata, Laminaria hyperborea, Laminaria saccharina, Alaria esculenta* and *Sacchoriza polyschides*. A process of public and private consultation, in conjunction with a number of field studies, was used to determine the distribution and relative abundance of these species on the west coast of Ireland. An estimate of the area of coastline (from Malin Head, Donegal, to Galley Head, Cork), covered by laminarians indicated that they were abundant at 22% of sites, common at 23%, scarce at 11% and absent from the remaining 44% of sites surveyed.

All of the information gathered from the seaweed survey was been entered into a custom-designed Geographical Information System (GIS). The system is made up of two information 'layers'. The first layer comprises a digitised outline of the Irish west coast from Donegal to Cork at a scale of 1:10,000 (6 inch to one mile). The second information 'layer' derived from data collected during the survey, comprising such details as amounts of seaweed present, harvesting details, accessibility and harvesting potential.

Further details on the Algal Biomass Database are available from:
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CONTENTS

The seaweed distribution maps contained in this report are illustrative and limited by the use of shades of grey to indicate abundance. Larger scale and full colour maps can be obtained by agreement with the ISIO.

SECTION 1.
Mapping and Assessment of the Seaweed Resources off the west coast of Ireland

1.1 The Seaweed Industry

World-wide, over seven million tonnes of seaweed are processed commercially each year (ISIO, 1996). In excess of four million of these tonnes are farmed in areas such as China, Korea, Japan and the Philippines. The total revenue generated by the world seaweed industry is in excess of US$4 billion per annum (ISIO, 1996). The production of seaweed hydrocolloids has had a very important impact on the valorisation of the industry over the past half century, particularly so in Ireland, with the majority of Irish sales of seaweed being used for alginate production.

The Irish seaweed industry annually contributes about IR£5 million directly to the Irish economy, employing some 320 part-time and 120 full-time harvesters and about 50 people in the processing sector. Over 85% of total output is currently exported. Seaweed harvesting and processing has been, and continues to be, a most important economic and social activity in the west of Ireland and, with most of the activity being concentrated in disadvantaged coastal areas, the industry has a very important role to play in the maintenance of rural communities.

Seaweeds are processed in Ireland for a variety of markets and applications, Seaweed Limited, Carrig Fhada Seaweeds, Dolphin Sea Vegetables, Roaring Water Bay Seaweed Co-operative and Quality Sea Vegetables are all involved in the processing and production of sea vegetables for the health and snack food markets. Mountmellick Products and Kerry Algae are active in the agrochemical industry through the production of seaweed extracts. Fameainn Cairn, Kilcullens Seaweed Baths, Connemara Shores, Irises Seaweed Centre and Seavite are involved in providing body care products and services from seaweeds. Arramara Teoranta are concerned with the large scale production of seaweed meal for the alginate industry, while Quest International and FMC International have carrageenan processing facilities based in this country. Finally, Celtic Sea Minerals are the only company in Ireland involved in the extraction and processing of coralline algae (maerl).

1.2 The Irish Seaweed Resource Base

Future sustainable development of our seaweed resources demands a quantitative assessment of the natural resource base. The industry has been supported by stocks of naturally occurring, regenerating seaweeds for over 250 years with the amount and variety of species harvested in this period varying significantly. The most commercially important species in the past 50 years have been the wracks (Fucaceae) particularly *Ascophyllum nodosum* (Linnaeus) Le Jolis. This is a brown seaweed which belongs to the order Fucales,

phylum Phaephycota. This species is better known as knotted wrack or in Irish as Feamainn Bhuí. The species is one of the largest intertidal seaweeds so characteristic of the rocky Irish west coast (Guiry & Hession, 1998). It grows in abundance in areas where it is sheltered from direct wave action. It is easily distinguished from any other species because of its narrow, strap-like, olive-green blades bearing scattered, intercalary air bladders that grow singly along its length (Bold & Wynne, 1978). Most of the harvested biomass is used to produce seaweed meal to supply the European alginate industry.

Laminarians, better known as 'kelps', are large brown seaweeds belonging to the phylum Phaeophycota. There are five kelps common to Irish waters; *Laminaria digitata, Laminaria hyperborea, Laminaria saccharina, Alaria esculenta* and *Sacchoriza polyschides*. Extensive harvesting of kelp takes place in Norway with a total harvest of 166,378 metric tonnes being recorded in 1994 (Gabrielsen, personal communication). *Laminaria hyperborea* is the main species harvested. *Laminaria digitata* is extensively harvested off the Brittany coast, with 53,952 metric tonnes being collected in 1995 (CEVA). Most of the harvested biomass is used to supply the European alginate industry. Alginates are used primarily as thickeners and gelling agents in the food ingredients industry but are also used widely in pharmaceutical products and in textile printing (Guiry & Blunden, 1981).

At present, little use is being made of Irish kelp (apart from the intermittent collection of cast stipes following large winter storms (Guiry & Blunden, 1981). These 'sea rods' (*L. hyperborea*) are dried and supplied in an unprocessed form to the alginate industry through Arramara Teoranta.

SECTION 2
Research Methodology

2.1 Project Objectives

The objectives of the project were as follows:

1. Quantify the intertidal biomass of *Ascophyllum nodosum* at selected sites of commercial interest along the Irish west coast.
2. Identify and assess the major laminarians beds off the Irish west coast, the various species therein and their potential for harvesting.
3. Develop a Geographical Information System (GIS) from the information collected to aid easier data management and retrieval.

2.2 Objective 1 *Quantify the intertidal biomass of* Ascophyllum nodosum *at selected sites of commercial interest along the Irish west coast.*

The coast from West Lough Foyle, Co. Donegal to Glandore Harbour, Co. Cork was selected as the survey area. This area encompasses all of the Irish west coast and was considered to cover all of the significant exploitable *Ascophyllum nodosum* and 'kelp' resources in the Irish Republic. Within this region, a total of 258 individual sites were surveyed. Sites were selected on the basis of two major criteria (biomass presence and biomass accessability).

For each individual site, information on a number of key variables were collected on area infrastructure, the seaweed bed and its potential for harvesting. The information collected was recorded over the area where the GPS readings were recorded. Table 2a lists the information collected. Infrastructure covered two categories the first was the quality of the roads in the area, graded on a scale of 1-3. The number and quality of piers in the same area was the second parameter measured.

The chosen methodology for assessing harvestable algal (*A. nodosum*) biomass is acknowledged as being subjective and difficult to replicate. Site abundance estimates were made by delineating the area covered by *Ascophyllum* (using a GPS system) and then using this to estimate abundance to give a harvestable quantity for the site. These estimates were made by one of three experienced Arramara Teo Site Resource Managers. Estimates thus give a good indication of harvestable quantities (the objective of the project) and are comparable for the whole coastline.

Table 2a:
Data collected on each site examined during seaweed biomass survey

Attribute	Detail collected
Infrastructure	• Quality of roads and/or other access routes to bed • Presence of piers/harbours in vicinity of bed
Seaweed bed	• Longitudinal and latitudinal co-ordinates taken from GPS readings • Length (horizontal) of the bed being surveyed • Depth (vertical) of the bed being surveyed • Quality of the seaweed present • Presence of significant amounts of other seaweeds (including off-shore kelp beds)
Seaweed potential	• Details of harvesting activity on the bed • Potential (or actual in the case of beds being fully harvested) sustainable productivity from the bed • Details of harvesters where available • The growth cycle of the bed • Other details of interest

2.3 Objective 2
Identify and assess the major laminarian beds off the Irish west coast, the various species therein and their potential for harvesting.

2.3.1 Desk study
Admiralty charts covering the west coast from Lough Foyle to south County Cork were used as the main source of topographical information for the study. The general distribution of rocky shorelines, subtidal rock and gravels etc. could be established from the charts. Information on water depths was also available from the charts. Exposure levels were established through information on coastline type, aspect and substrate type from the Admiralty charts. Knowledge of the limiting factors affecting *Laminaria* growth and distribution was applied in the study of the charts. This formed the basis of the qualitative assessment of the general distribution and abundance of the major beds. The major limiting factors to the occurrence of kelp are listed in Table 2b below.

Table 2b:
Factors which affect the occurrence and distribution of Laminarians off the Irish west coast.

Attribute	Detail
Substrate	Substrates composed of rocks and boulders are most suitable for kelp occurrence. Sand, mud and gravel substrates are less stable and do not provide a suitable anchorage for the kelp holdfast.
Illumination	Illumination will generally dictate the lower limits of the kelp forest. Green light penetrates more readily than blue or red and is most useful for photosynthesis by brown algae. The normal depth limit of kelp forests in western Europe lies at about 17-20 m below chart datum (where green light declines to about 1% of its surface value).
Exposure	Exposure to extensive wave action can reduce the abundance or even occurrence of kelp.

An advertisement was placed in the diving magazine 'Sub Sea' in order to gain extra knowledge of distribution from west coast divers. In addition, over 80 diving clubs across Ireland were directly contacted and asked for information on the occurrence of kelp beds along the west coast.

'Aqua-Fact International Ltd.' a marine consultancy company with extensive knowledge and experience of the west coast from previous studies was recruited to complete the desk survey and the topographical analysis. Additional data from researchers personal observations and anecdotal information proved invaluable. A coding system was applied when developing the digitised maps to categorise the distribution and abundance of the kelp beds. Four categories were distinguished as discussed in Table 2c.

2.3.2 Site surveys
On completion of the maps, the accuracy of the coding was checked by visual dive surveys at three locations namely Spiddal, Co. Galway, Mullaghmore, Co. Sligo and Spanish Point, Co. Clare. At each survey point, the anchor of the boat was dropped at random within the laminaria zone. A 20 m leaded rope was then stretched from the anchor point away from the boat, parallel to the shore. All holdfasts within 1 m of the right side of this rope were counted with the resulting figure equal to the number of plants per 20 m^2. The procedure was repeated three times for each location visited. In addition, the nature of the substrate, water depth, the extent of the laminaria zone and the occurrence of other seaweeds were noted (See Appendix 1).

Table 2c:
Categorisation of Laminarian distribution off the Irish west coast.

Category	Description
Abundant	The abundant category was applied to areas of moderate to light exposure to prevailing winds, where water clarity was high, suitable substrate (i.e. rock was extensive) and which were likely to have a good nutrient supply.
Common	The common category was applied to areas more exposed to prevailing winds (greater than force 1 on the Beaufort scale) and also to those areas with variable and mixed substrates of rock and gravel.
Scarce	The scarce category was applied to areas which are fully exposed to prevailing winds (e.g., on the windward side of offshore islands), areas of high turbidity (e.g., estuaries and inner bays), and those areas where the substrate within the required depth range (1 to 15 meters) is of very limited extent, e.g. underwater cliffs.
Absent	The absent category was applied to areas with unsuitable substrate (e.g., muds and sands), to regions of extreme turbidity and also of low salinity (e.g., River Shannon).

2.3.3 General distribution

A percentage estimation based on the reference sites (Spiddal, Spanish Point and Mullaghmore) represented by each category showed that approximately 22% of the Irish west coast is represented by laminarians found in abundance; 23% where laminarians are common; 11% where they are scarce and the remaining 44% represents the area where there are no laminarians present.

2.3.4 Assessment of further mapping techniques

To supplement knowledge of the distribution of the kelp resource and to establish an ability to assess individual beds in future some further mapping techniques were employed. An echo-sounder was extensively tested against spot diving checks for its ability to identify and record the presence of kelp. The experiment took place in Galway Bay on board the NUI, Galway research vessel, R.V. Conamara. In all, the diving team made four separate dives on four types of substrate. The areas measured against the echo-sounder were as described in Table 2d.

Table 2d:
Classification of substrate-type on which the echo-sounder was tested

Area	Substrate description
1	Hard/rocky substrate with no kelp cover
2	Muddy substrate with no kelp cover
3	Area of low intensity of kelp
4	Area of large abundance/density of kelp

High and low frequency readings from the echo sounder were analysed. It was found that the echo sounder not only identified the presence of the kelp, but was capable of giving a reasonably accurate profile of the density and the height of the plants. It was concluded that an echo sounder could be usefully employed in future attempts to study beds in greater detail.

2.4 Objective 3
Develop a Geographical Information System (GIS) from the information collected to aid in efficient data management and retrieval.

2.4.2 Constructing the 'data layers'

A key deliverable of the project was to establish an algal biomass database that would be of immediate and long-term use to all concerned with the seaweed resource in Ireland. To do this, an interactive database updatable over time was developed by the Coastal Resources Centre (CRC) at the Department of Geography at NUI, Cork. In building the GIS database, two 'data layers' were constructed.

The first layer contains a digital map of the entire western coastline of Ireland. The data was obtained by digitising approximately two hundred 6-inch maps of the coastline using the digitising package 'Arc Digitising System'. For the purposes of the project, the coastline was defined as the high water mark as identified on the 6-inch Ordnance Survey maps. Thus the lower reaches of most rivers are included in the database. As the digital database is free from the scale constraints of hard-copy maps, it can be viewed at a variety of scales. The largest scale for which the database can be proven to be accurate is 1:10,000. Maps of smaller scale can be produced (for example 1:100,000), making the database very flexible and allowing for the production of a variety of hard-copy maps

The second layer in the database consisted of the seaweed resource data. At each survey site a hand-held portable Global Positioning System (GPS) and portable data-logger were used to record the variety of attribute data as described in Table 2a. These data were entered into an 'Excel' spreadsheet. The spreadsheets were subsequently linked to the locational data via 'Arc/Info'. The two data sets (locational and attribute) were combined to form one coverage in 'Arc/Info'. Using 'Arc/Info' the attribute data is drawn up on thematic maps. From this database, it is possible to produce maps of the seaweed resources available in relation to any individual attribute or set of attributes required, for example, one can select a variable such as access to the seaweed and query the GIS to highlight the areas which have good/moderate/bad access. It is also possible to produce detailed maps of specific geographical areas containing all attribute data available.

2.5 Evaluation of Algal Biomass Distribution

Figure 2.1:
Coastal area surveyed during the 'Seaweed Biomass Survey of Ireland'.

The survey area covered a total of nine counties (see Figure 2.1 above). The results of the survey are presented in Section 3 on a county-by-county basis. Survey results from objectives 1 and 2 are presented in tandem. It should be noted that in some cases the 1996 harvested totals will exceed the total annual potential. These areas are harvested fully in one year, and cutting is postponed for a further three, four or more years while regeneration takes place. Where partial harvesting takes place on an annual basis the annual sustainable yield is met. The growth cycle of each bed was estimated using a combination of information taken from previous harvesting records (where available), exposure conditions and substrate composition. These details were also used by the resource assessors to estimate the total annual potential. The statistical approach is discussed in Appendix 2.

SECTION 3.
Results of Algal Biomass Survey of Ireland by County

3.1 County Donegal

Table 3a:
***Ascophyllum nodosum* harvested in Donegal in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
8,250	**16,430**	**350**

3.1.1 Introduction

Arramara Teoranta, the largest seaweed processing company in Ireland, has one of its two seaweed processing plants located in Meenmore, Co. Donegal. The harvesting and processing of *Ascophyllum nodosum* is by far the most significant commercial seaweed activity in Donegal. There are also a small number of 'carrageen' (*Mastocarpus stellatus* and *Chondrus crispus*) harvesters in the county. The only major processor is Quality Sea Veg Ltd. which has recently upgraded its processing plant to cater for the increasing demand for carrageen.

A total of 50 beds of *A. nodosum* was surveyed in Donegal. In presenting the results of the survey, data from individual beds is summarised on a regional basis. The resource description starts at Malin Head and continues westwards.

3.1.2 Seaweed resource

Malin Head (West Lough Foyle, Malin Head, Trawbreaga Bay, North Tullagh Point)
The survey began at West Lough Foyle (Mitchells Town to Vances Point) where 50 tonnes (t) of seaweed were harvested in 1996. The area covered extends for approximately 10 km with a maximum bed depth of 5 metres recorded, most of which is very patchy. Access to the resource is very good and there is a pier present in the area. If the region were to be harvested to its full potential, and allowing for a four year growth cycle, 200 t could be extracted each year. There is only one *A. nodosum* harvester in the area with the general quality of the weed being poor. (The area concerned is illustrated with a thick black line in Figure 3.1.)

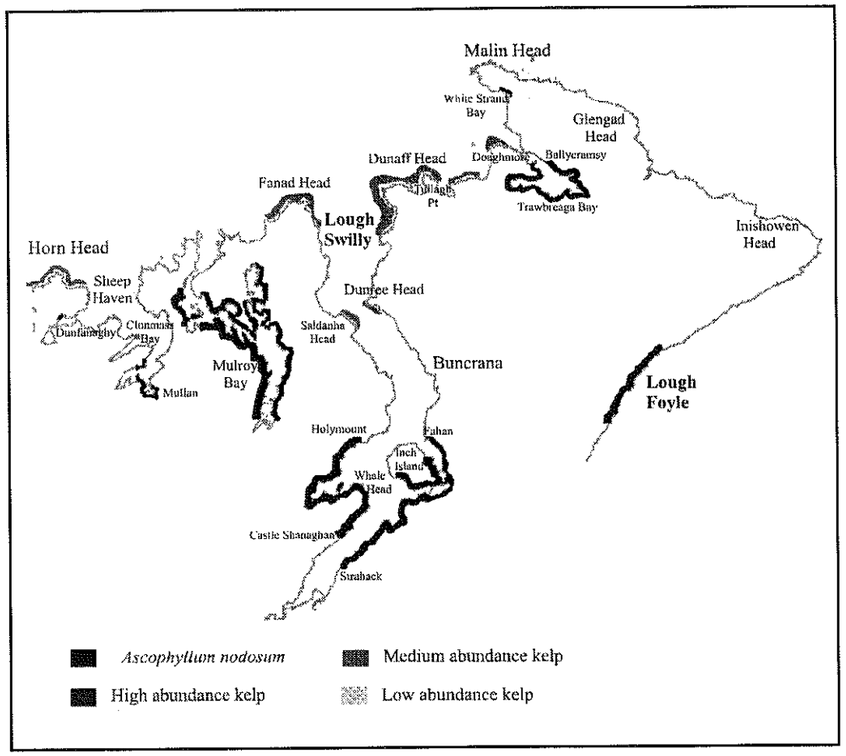

Figure 3.1:
Seaweed Resources of Lough Foyle to Horn Head

White Strand Bay has a pier and very good quality access to a resource which extends over approximately 3 km, and has a potential for yielding about 70 t each year. There has been no production from the area for approximately 15 years. The growth cycle in the Bay is estimated to be four years with average weed quality.

Trawbreaga Bay is a well sheltered area and supports varying amounts of *A. nodosum* from Ballycramsy to Doaghmore—some 30 km in all. The horizontal extent of the bed varies widely, from 10 to 1,000 metres and the growth cycle is estimated to be five years. Due to the level of exposure of the Bay and the presence of fast currents, the growth cycle in the area varies significantly, from 3 to 6 years. 600 t of *A. nodosum* were harvested from the region in 1996. It is estimated that the Bay has a sustainable annual production capacity of 1,000 t. Access to the resource is very good and there are a total of four harvesters cutting consistently in the region. On the western side of Tullagh Point lies Rockstown Harbour—where there has not been any harvesting of seaweed for six years. There is one major bed in the area extending for up to 1 km with an average depth of 10 m. The seaweed present is of average quality, and road access for transportation is very good. There is no pier present in the region. There is one person still listed as a harvester and the area could be producing 50 t of raw material each year if fully utilised.

The starting point for the kelp survey extends westwards from White Strand Bay on Malin Head. Much of the west side of the peninsula is covered by sand which is unsuitable as a substrate for kelp. Areas where kelp is common include Dunaff Bay, Tullagh Bay and Carrickabragha Point.

The eastern shore at the entrance to Trawbreaga Bay has a subtidal region which is very rocky and hosts an extensive kelp bed. Across the entrance to the Bay lies the northerly coast of Doagh Isle, which also has a rocky substrate, on which kelp extends from very shallow waters to depths of at least 13 m. From Ardagh Point to the entrance to Tullagh Point, kelp is very common, with a favourable rocky substrate extending up to 10 m or more. Tullagh Bay itself is largely kelp free as it is mainly consistent of sand.

From the western side of Tullagh Bay, all across Tullagh Point and down to the lower reaches of Dunaff Bay on the entrance to Lough Swilly, kelp is common, mainly because of the very suitable substrate. The beds do not extend far from the coastline in this area as the 'drop-off' to deeper waters is typically quite sudden to depths of 25 m or more.

Lough Swilly

North of Inch Island on the east side of Lough Swilly, there is no occurrence of *A. nodosum* of commercial significance. There is a narrow band of abundant kelp in the region from Dunree Head to Kells Reeks—an area characterised by a rocky substratum.

From Fahan to Strahack in east Lough Swilly, some 8 km, there is an estimated potential for the production of 200 t of *A. nodosum* per annum. The growth cycle in the region is four years. In 1996 a total of 50 t were harvested, with one main harvester supplying from the area. Access to the resource is good and there is a pier present.

The area from Drum, on Inch Island to Moneyhaughly has the potential to produce 500 t of raw material per annum. There are two main harvesters in the region, covering about 22 km. They supplied 125 t of weed in 1996. The growth cycle for the region is four years, and access to the resource is good.

Moving to west Lough Swilly, a 30 km area was surveyed from Castle Shanaghan to Holymount. The seaweed is patchy in most places but is cut regularly. 200 t of seaweed were supplied in 1996, and the total potential estimated for the area is 400 t per annum. The average growth cycle for the region is four years, with parts of the bed ranging in depth from 5–30 m.

Moving further up, east Lough Swilly, on to Saldanha Head, directly opposite Dunree Head, a very abundant kelp growth is recorded, as indicated in Figure 3.1.

Fanad Head and Mulroy Bay

Fanad Head is a very exposed region and there is no occurrence of commercial quantities of *A. nodosum*. There is a good coverage of kelp from above Leel Point to Ballyhoorisky Point, stemming from the suitable substrate of rock and shale. Mulroy Bay is home to some of the richest resources of seaweed in Co. Donegal. A number of beds were surveyed in the Bay, covering approximately 72 km of coastline in total. In general, the access roads to the resource are very good, with a number of piers being present. There are 14 regular harvesters in the area, who supplied 700 t of raw material in 1996.

It is estimated that the Bay could produce a sustainable yield of 2,400 t per annum. Most of the Bay has a four year growth cycle but regeneration is estimated to be 3 years in the Isle of Roy. Most of the resource has never been accessed by the harvesters because of objections from local rights' holders. If the resource were allowed to be developed to its full potential in the region, it would be a huge boost to the income of local harvesters and would have a very significant bearing on the level of activity in the Arramara plant in Dungloe.

Sheep Haven

Significant quantities of *A. nodosum* are found at Mullan in the inner reaches of Sheep Haven. A large biomass of weed extends for about 10 km to Rinnarispy. The access roads are generally good but there is no pier in the area and some places require boat access. Much of the area has not been harvested for many years. It has the potential to produce 300 t per annum. 100 t were harvested from the region in 1996.

Clonmass Bay has a relatively low seaweed abundance, with approximately 3 km in total having weed present. Much of the seaweed is patchy and very thin with bed depth never extending to more than 6 m. Access is very good and there is a pier locally. 15 t of seaweed were supplied from the region in 1996 and it is estimated that this could be increased to 60 t per annum. There is only one harvester operating in the region at present. All the weed from Mullan to Clonmass Bay is estimated to have a re-growth period of three years.

Further out at Dunfanaghy there is significant growth of *A. nodosum*. The weed in the area differs greatly from the weed in the rest of the Bay—requiring a regeneration time of 6 to 7 years. The total potential for the area is estimated at 10 t per annum—a similar yield to what was harvested in 1996. Access by road to the area is good, but there is no pier present. There are two harvesters in the region. The biomass produced has never been large, due mainly to unsuitable tides.

Horn Head to The Rosses

There in no significant biomass of *A. nodosum* on Horn Head but there is a very large coverage of kelps. There is good coverage from Duncap Isle, on the east side of the Horn as far as Pollaguill Bay. At this point the kelp disappears until McSwynes Gun is reached. The peninsula has a heavy kelp coverage with the biomass dropping off across Tramore Bay (see Figure 3.2)

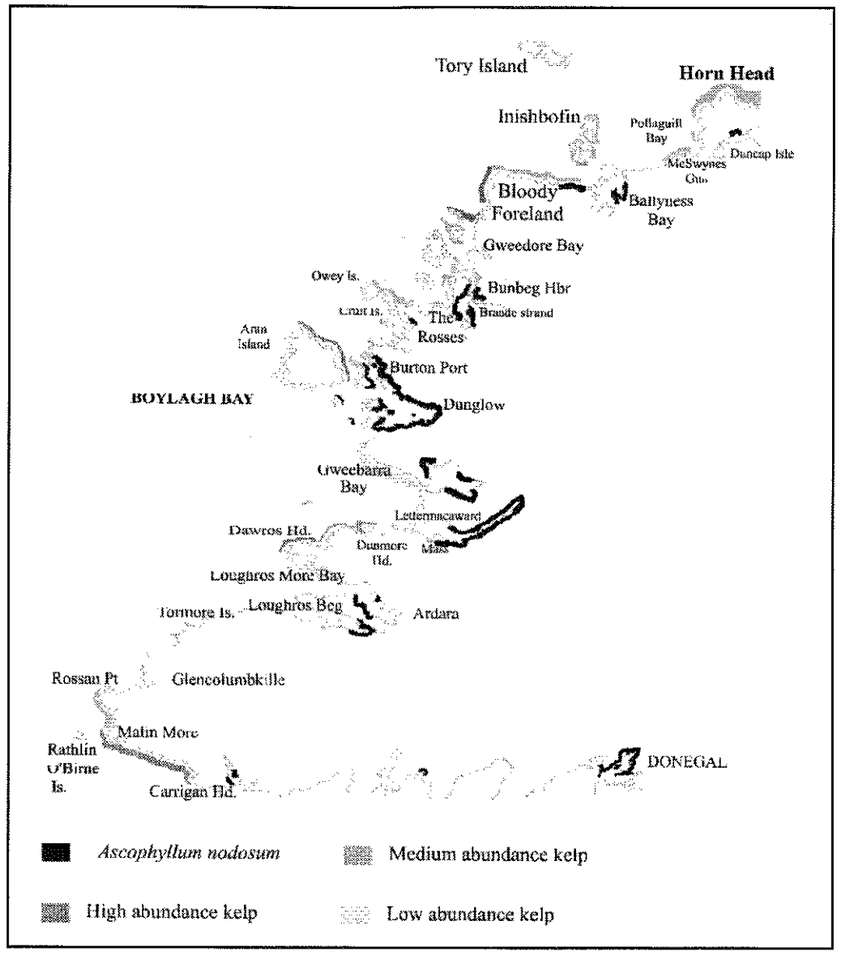

Figure 3.2:
Horn Head to Carrigan Head

Ballyness Bay is an area of very slow *A. nodosum* growth. Over 5 km is covered by seaweed and the growth cycle varies from four to six years. The total potential for the area is 20 t per annum, with 10 t being extracted by its two harvesters in 1996. Parts of the area have been covered in stones laid down by people to encourage growth of the seaweed, but the biomass remains thin.

To the east of Curran's Port and extending around Bloody Foreland there is an abundance of very large beds of kelp. The islands around Gweedore Bay host a number of large beds. The area between the mainland and the islands is very rich in kelp forests.

An area of approximately 5 km between Bunbeg Harbour and Gweedore River is harvested regularly by one harvester. A total of 20 t was cut in the area in 1996. 150 t per annum is

the total estimated potential. Access to the resource is good, and there is a pier in the area. 10 t of seaweed were harvested in 1996 from the mouth of the Gweedore River. Four regular harvesters operate in the area. Access is good despite the fact that there is no pier present.

The *Ascophyllum* resource of East Braade Strand (south to Annagary) covers a distance of 5 km. There is no pier in the area and road access is bad. 300 t of seaweed were harvested there in 1996. Given a four year growth cycle, the region is capable of producing 200 t per annum. The same harvesters operate in Bunbeg Harbour and Gweedore River.

West Braade Strand (i.e., Annagary to Carnboy) produced 200 t of *A. nodosum* in 1996 and has a total potential of 100 t per annum. Access to the 8 km stretch, (much of which has been man made in the past through laying stones on the strand) is very good. There is a pier present and there are five regular harvesters working in the area. The seaweed is estimated to have an average of a four year growth cycle.

There are three main beds which make up most of the intertidal biomass in 'The Rosses'. Kincaslough is the most important area followed by Cruit Island. Road access to the resource is good for all three areas, but there are no landing piers present. Collectively, the three beds make up a distance of 5 km of very patchy seaweed which yielded 40 t of high quality raw material in 1996. At most, the area encompassed could yield 60 t each year.

Dunglow Bay

Dunglow Bay and the islands therein are the most productive areas in Donegal for *A. nodosum*. In all, ten major beds in the area were surveyed. Approximately 4,700 t of *A. nodosum* were harvested from the area in 1996. An average four year growth cycle is estimated for the whole area.

Sally's Lough to Termon covers a distance of approximately 23 km and yielded 500 t of seaweed in 1996. The weed here is of exceptional quality, with little by way of access problems due to the high standard of local roads and the presence of a pier. There are 22 harvesters listed for the area. There is potential to yield up to 4,000 t per annum if utilised fully. There is little by way of a significant kelp biomass off the mainland.

The Islands

The inner islands of the Bay (see Figure 3.3) are well sheltered and very rich in seaweed biomass. Harvest from the islands is transported to the mainland by boat. Road transport to the biomass is not as significant a factor as on the mainland. The collection points for the seaweed on the mainland are accessible by good quality roads. There is only one pier on the islands surveyed which is located on Edernishfree Island. There are 33 harvesters listed for all of the islands.

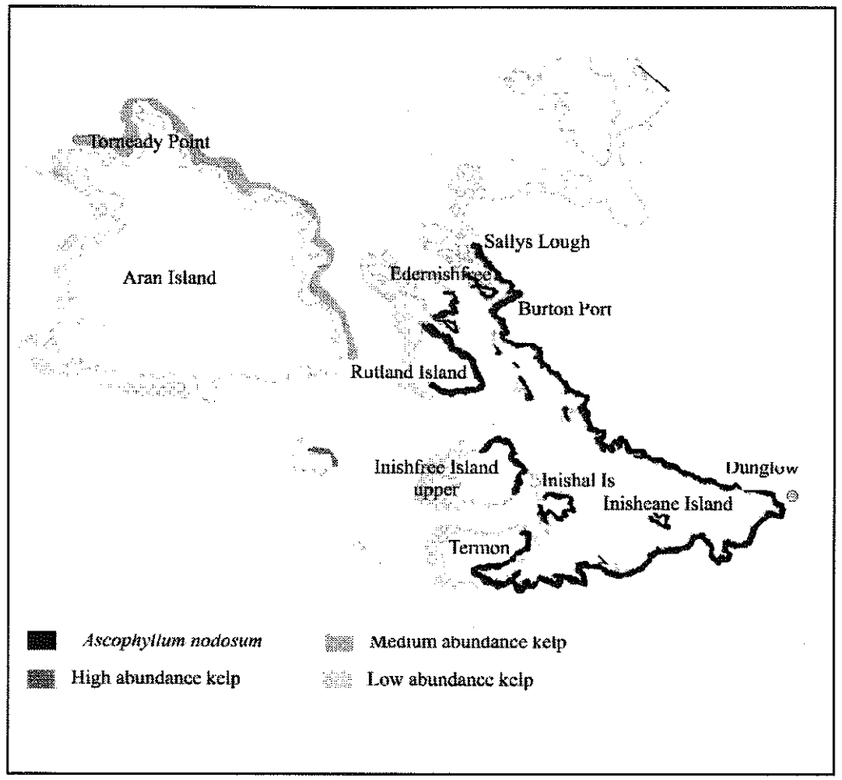

Figure 3.3:
Dunglow Bay

Edernishfree produced 250 t of *A. nodosum* in 1996, which equals its maximum annual potential. The biomass of the area covers a distance of 2 km. The beds in the area are no more than 5 metres deep but are of very high quality.

Inishcoo and Eighter Island collectively produced 100 t of *A. nodosum* in 1996. The maximum potential is estimated to be 150 t per annum. In all, the biomass extends for approximately 5 km and varies in depth between 5 and 10 metres.

Rutland Island has 5 km of *Ascophyllum* covered coast. The bed depth is between 5 and 10 metres, and the potential for the area is estimated at 400 t per annum which equates to that which was harvested in the area in 1996.

Some of the weed on Inishmeal Island is too difficult to reach, which leaves about 1 km of accessible weed. The total potential for the island is 250 t per annum, and it seems as though the area will not be harvested again for 3 to 4 years as 1,000 t were cut in 1996.

Inishfree Island Upper yielded 1,000 t of *A. nodosum* in 1996, equalling its annual potential. The harvestable biomass is spread over a 5 km distance with typical bed depth varying between 5 and 15 metres. The area is located mainly on the sheltered side of the island. There is also a very large abundance of *Fucus serratus* here.

Inishal Island is completely surrounded with seaweed and has a potential of 1,000 t per annum. The 1996 harvest yielded 600 t. The depth of the beds varies from 5 to 20 metres.

Inisheane Island and the remaining islands surveyed in the area produced 860 t of seaweed in 1996. Their combined estimated potential is 1,170 t per annum. All of these islands have good weed cover and this includes other seaweed types such as *Fucus* spp.

Despite the fact that there is little by way of a significant kelp biomass adjacent to the mainland, a number of the islands have very large associated kelp beds.

From Torneady Point to Rannagh Point on the west side of Aran Island, kelp is very common. From Torneady Point to Clougheor Point on the east side of Aran Island, kelp is present in a very large abundance—due mainly to the relative shelter from the direct force of the Atlantic and the hospitable substrate.

Inishkeeragh and Illancrone have a similar surrounding of kelp with the southern sides of the islands being free of any significant kelp biomass.

Inishfree Upper and Termon both have light coverings of kelp on the western side, with no coverage of significance east to the mainland. A number of areas surrounding Crohy Head on the mainland host light coverings of kelp.

Trawenagh Bay and Gweebarra Bay

Trawenagh Bay was divided into east, west and south for the purposes of the survey. The quality of the seaweed in the general area is poor. Meenacross was the first survey site in the Bay (Trawenagh east) where the weed extends for approximately 4 km. 100 t of *A. nodosum* was harvested in the area in 1996, where there is an estimated potential of 250 t per annum. There is no pier in the area and road access to the biomass is not very good. There are 5 harvesters active locally. Typical bed depth varies from 5 to 20 metres.

Drumlaghdrid Hill (Trawenagh west) yielded 100 t of seaweed in 1996 and its total potential is estimated to be similar to that of Trawenagh Bay east—albeit weed coverage only extends for 2 km and the typical bed depth varies from 5 to 10 metres. The enhanced potential is due in the main part to the fact that people laid out stones in the past to boost yield. There are currently 3 full time harvesters in the area.

Derrylough or Trawenagh Bay south has three full time harvesters and they harvested 100 t of *A. nodosum* in 1996. The biomass potential for the area comes from an 8km area with beds typically 5 to 10 metres in depth. The area has also been 'planted' with stones and there are 3 harvesters working there.

There is a very light covering of kelp which extends from Crohy Head to the entrance of Trawenagh Bay. There is also a light bed at the top of Dooey Point. Inishkeel is almost completely surrounded by a dense bed. From Portnoo on the mainland to the tip of Dawros Head there is a high abundance of kelp.

Over the 14 km from Lettermacaward to Maas in Gweebarra Bay a potential of 200 t per annum of *A. nodosum* exists. 100 t were harvested in 1996 by the 5 listed harvesters in the area. Typically, the bed depth is between 2 to 8 metres, and the area has also been 'planted' with stones in the past to increase yield. There is a landing pier in the area and road access to the seaweed is very good. The seaweed is also of very high quality.

Loughros More Bay

Loughros More Bay yielded a total harvest of 150 t in 1996. At full production, the Bay could yield 270 t per annum. There are three main harvesting zones in the Bay, namely, Rossbeg, Derryness and Crannegboy. The weed quality in the area is very good and there is a pier present. Generally speaking, road access to the resource in the area is not a major problem. Much of the harvested material from Crannegboy is towed to Derryness for collection.

The abundant kelps that extend to Dawros Head are a common occurrence at Loughross More Bay (see Figure 3.2). The Bay is extensively covered in kelp due to the very suitable substrate.

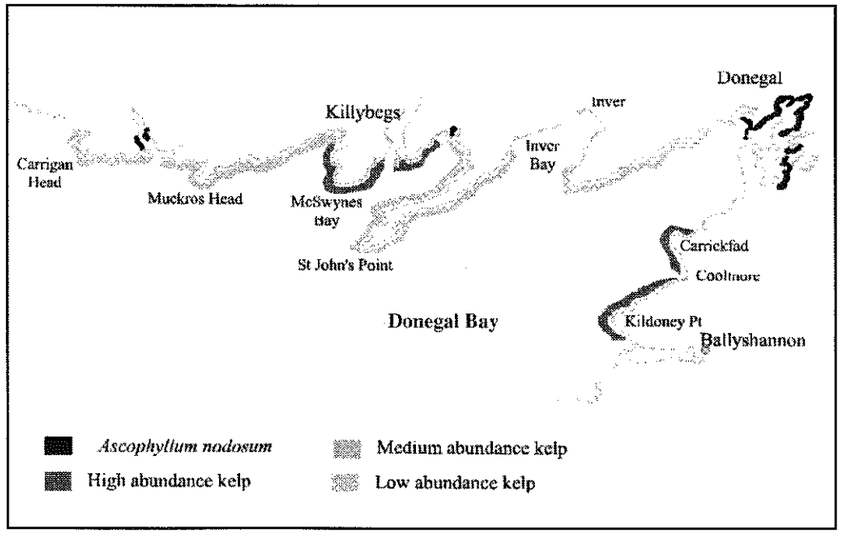

Figure 3.4:
Carrigan Head to Ballyshannon

Loughros Beg Bay

A very significant biomass of *A. nodosum* occurs from Shanaghan to Laconnell—a distance of about 7 km. The growth cycle for the Bay is four years and the weed is of very good quality. There are four harvesters in the area who harvested 100 t from in 1996, with the annual potential of th area being 70 t.

Laconnell to Carrigan Head

The exposure of the peninsula encompassed between these two points dictates that stocks of *A. nodosum* are scarce and not of any commercial significance.

From Rossan Point to Carrigan Head, kelp is present in abundance and growth to depths of 15 m is recorded from Malin Beg to Carrigan Head.

A 2 km area surrounding Teelin Pier, which has good quality access and weed, has a potential for producing 50 t per annum of *A. nodosum*. 15 t were harvested from the area in 1996 which has a growth cycle of four years. There is one harvester listed in the area. From Derrylahan to Cashel, (opposite Teelin Pier)—also a distance of 2 km—a per annum potential of 50 t is recorded. The growth cycle for the area is four years and the weed quality is very good. There are no harvesters listed in the area and there was no harvest from the area in 1996.

McSwyne's Bay

Only a 1 km area from Bruckless to Dunkineely in McSwyne's Bay has a significant coverage of *A. nodosum* (see Figure 3.4). The area has a potential of about 80 t per annum, and a growth cycle of three years. The area yielded 30 t of seaweed in 1996 but it is not harvested on a regular basis. There is a pier in the area and good quality road access.

Donegal Bay

The first area visited in Donegal Bay covered beds over a 14 km distance from Ballyboyle to St. Ernan's. The weed in the area has a growth cycle of 3 years and has a potential of producing 80 t per annum. The bed depth in the area varies from 2 metres to 30 metres and the weed itself is of good quality. There are six harvesters operating locally and 50 t of weed were harvested in the area in 1997.

There is no pier in the area around Rossmore and road access to the resource, spanning a distance of 3 km is not very good. The area has the potential to produce 200 t per annum, yielding 50 t in 1996. The growth cycle for the area is four years and possibly a little longer due to the presence of the adjoining islands. The weed is of very good quality and grows in beds of between 5 and 10 metres in depth.

A. *nodosum* coverage surrounding Mullanasole is very dense. The beds are between 5 to 10 metres on average and extend over a distance of 4 to 5 km. 300 t of seaweed were harvested in the area in 1996, with the estimated annual potential being 600 t per annum. A growth cycle of four years is estimated for the area.

Kelp coverage from Carrigan Head to Donegal Bay

From Muckros Head to the mouth of Inver Bay a common coverage of kelp is recorded. Inner Teelin and Killybegs Harbour are the only two places within the area where kelp does not occur. Drumanoo Head has an extensive coverage of an abundant growth of kelp, as does the neighbouring Carntullagh Head. The inner reaches of Inver Bay are largely free of kelp due to the unsuitable substrate and from Dooring Point right into Donegal Bay, kelp is again recorded, albeit in lesser abundance. There is no occurrence of kelp in the inner reaches of Donegal Bay.

Donegal Bay to Bundoran

A considerably large kelp bed is found around the Carrickfad peninsula. It is an isolated bed due to the unsuitable substrate covering most of the adjoining subtidal region. From Coolmore to Kildoney Point, large beds of kelp occur in abundance. They disappear again at the entrance to Ballyshannon. From Aughrus Point to the Leitrim border there is a very large kelp bed which extends for a considerable distance into the intertidal zone due to the presence of an extended rocky substrate.

3.2 Counties Leitrim and Sligo

Table 3b:
***Ascophyllum nodosum* harvested in Leitrim and Sligo in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

County	Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
Leitrim	**0**	**0**	**0**
Sligo	**0**	**430**	**11**

3.2.1 Introduction

The relative exposure of the coasts of these two counties is the main contributing factor to the low occurrence of *Ascophyllum nodosum*. However, the rocky substrate is largely covered with beds of kelp. The Leitrim-Sligo area was traditionally very active in the gathering of kelp or sea rods (*Laminaria hyperborea*). This is an activity that has diminished in recent years.

3.2.2 Seaweed resource

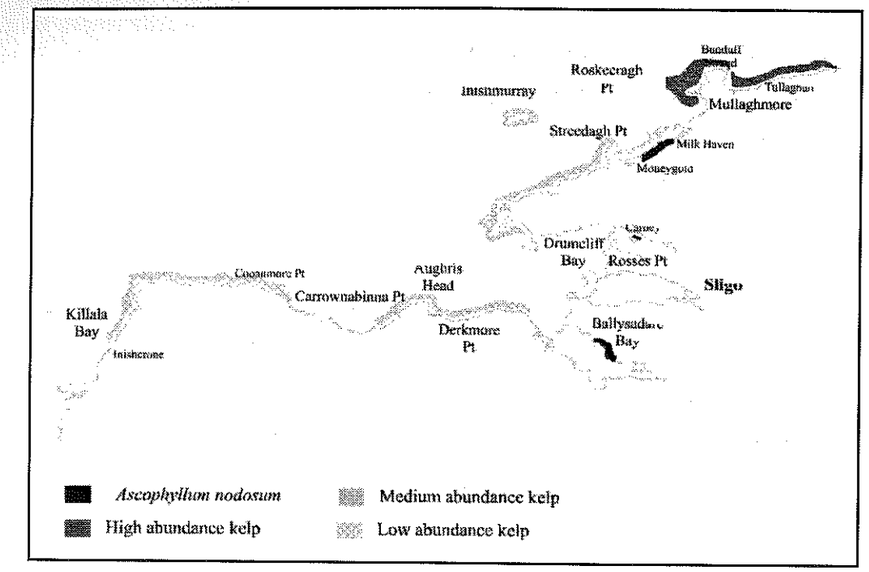

Figure 3.5:
Mullaghmore to Killala Bay

County Leitrim

There is no occurrence of commercial quantities of *A. nodosum* along the Leitrim coast. West of Tullaghan, one of the larger kelp beds in the north-west region starts and extends to Bunduff Strand, where the substrate changes from rock to sand. The Leitrim coastline has a large freshwater input which is not conducive to the growth of kelp.

County Sligo

There is good kelp coverage over most of the Sligo coast, starting at the Sligo/Leitrim border and extending to Bunduff Strand (as mentioned above). The east side of Mullaghmore is characterised by a sandy substrate extending from Bunduff Strand and thus is largely free of kelp. The northern face of Mullaghmore has a very heavy coverage of kelp (see also Appendix 1). From Roskeeragh Point to Streedagh Point the substrate is mainly composed of sand, thus there is no kelp present along this area of coast. From Streedagh Point to Roskeeragh Point and the Islands to the south, kelp is common, with the exception of Cloonagh Bay, which is largely kelp free.

Drumcliff Bay, Rosses Point and Ballysadare Bay are all largely kelp free. Beds occur again at Derkmore Point to Aughris Head. Aughris Head to Cooanmore is kelp free. From Cooanmore to Inishcrone in Kilalla Bay, kelp is very common, with a largely uninterrupted bed extending between the two points. The inner reaches of Kilalla Bay are kelp free, with beds re-occurring all around Kilcummin Head in County Mayo.

Grange

From Moneygold to Milk Haven, a distance of about 4 km, *A. nodosum* is abundant, with a potential of about 200 t per annum. The presence of a landing pier and good quality roads allows for good access to the resource. There was no harvesting activity here in 1996. The bed depth varies considerably from 10 metres to 50 metres with some specific areas having very thick coverage. The weed in the area has an average growth cycle of four years. There are four listed harvesters in the region one of whom is also listed for Drumcliff Bay and Ballysadare Bay.

Drumcliff Bay

The Carney peninsula is the only area in Drumcliff Bay with significant amounts of *A. nodosum*. There is no pier in the 2 km covered, but road access is good. The bed depth is not more than 10 metres and is largely continuous around the peninsula, but not all is accessible by foot. There was no harvesting in the area in 1996 and the annual potential is estimated to be 130 t per annum.

Ballysadare Bay

Ballysadare Bay has good commercial quantities of *A. nodosum*. The area with weed coverage extends for approximately 5 km, with a typical bed depth of about 10 metres. The biomass is of good quality in the area, albeit thin, and has a growth cycle of three to four years. Road access to the resource is good. There is no pier in the area. There is a potential of 100 t per annum from the area, with no yield for 1996. There is one listed harvester for Kellystown.

3.3 County Mayo

Table 3c:
***Ascophyllum nodosum* harvested in Mayo in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
4,400	**16,600**	**300**

3.3.1 Introduction

Ascophyllum nodosum has been harvested in County Mayo for a number of years. Clew Bay Seaweeds was formerly the main seaweed processor in the Clew Bay area, where much of the seaweed biomass is located. Arramara Teoranta have always maintained a supply from Mayo and are now the major processors, utilising 4,400 tonnes in 1996.

3.3.2 Seaweed resource

North Mayo

A 6 kilometer distance between the northern and southern shores of Scruwaddacon Bay was surveyed, (see Figure 3.6). There are no records of harvesting having taken place here in 1996 and it is estimated that there is a sustainable harvest potential of 25 t per annum. The substrate is mostly comprised of stones or shingle, and in places is more suitable for the growth of *Fucus spp.* than *Ascophyllum.*

There is no significant kelp coverage along the northern shores of Mayo.

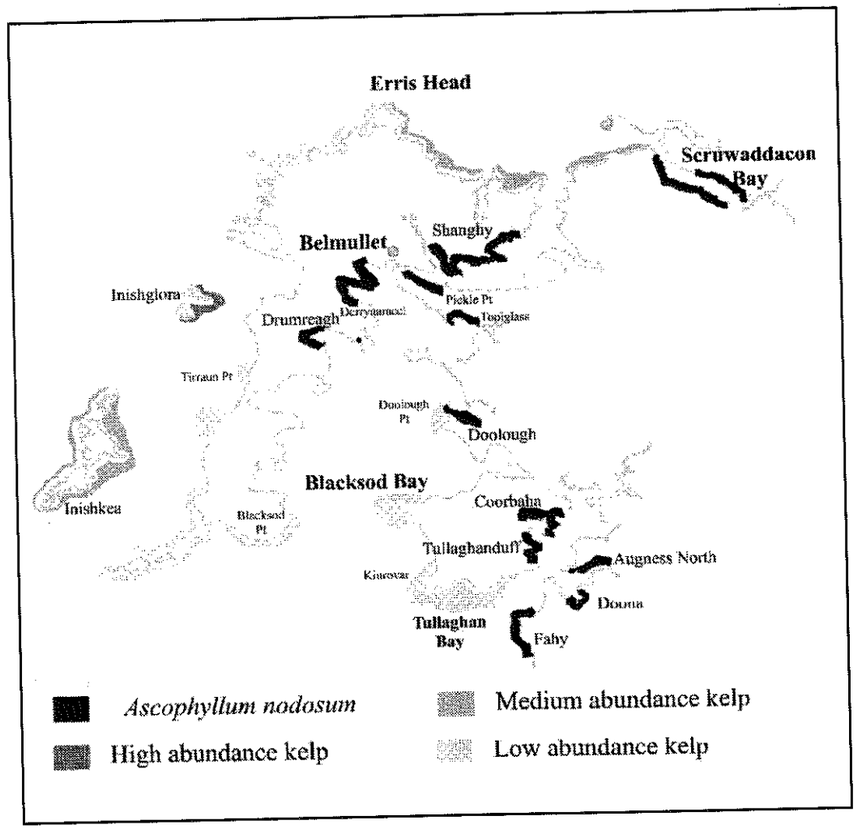

Figure 3.6:
The seaweed resources of North Mayo

Belmullet

The eastern shores of the Belmullet peninsula are sheltered and have a number of *Ascophyllum* beds. A 10 metre bed at Shanaghy supplied 50 t in 1996, equalling the calculated sustainable per annum potential for the area. From Derrynameel to Belmullet *A.*

nodosum, *F. vesiculosus* and *F. serratus* are all common. This is mainly due to the presence of stones and shingle on the shore. The Drumreagh region provided 40 t of *Ascophyllum* in 1996 and it is estimated that the sustainable yield for the region is marginally lower than this, being no more than 25 t per annum. There are 6 harvesters operating in the area.

On the western side of Belmullet, there are a number of patches of low-abundance kelp. The variance in bed density is largely depth related. Inishglora has a dense bed on its eastern, more sheltered aspect. Inishkea has a scattering of medium abundance beds covering all of its coastline with more extensive crops found on the eastern shores. Broad Haven Bay and the surrounding areas have a low to medium abundance of kelp.

Blacksod Bay

There are a number of *Ascophyllum* beds along the coast at Blacksod Bay. On the eastern side of the Bay, the substrate consists mainly of mud, sand or shingle. From Pickle Point to Belmullet, 50 t of *Ascophyllum* were harvested in 1996. The estimated yield is also 50 t per annum. 100 t of *Ascophyllum* were harvested from Toolglass in 1996, this being close to the total estimated potential of 125 t per annum.

The kelp resources of the area are similar to the eastern coast of Belmullet. There are a number of low abundance beds which are generally located along headland areas where there is a suitable substrate. The most dense bed is found along the Kinrovar headland at the mouth of Tullaghan Bay.

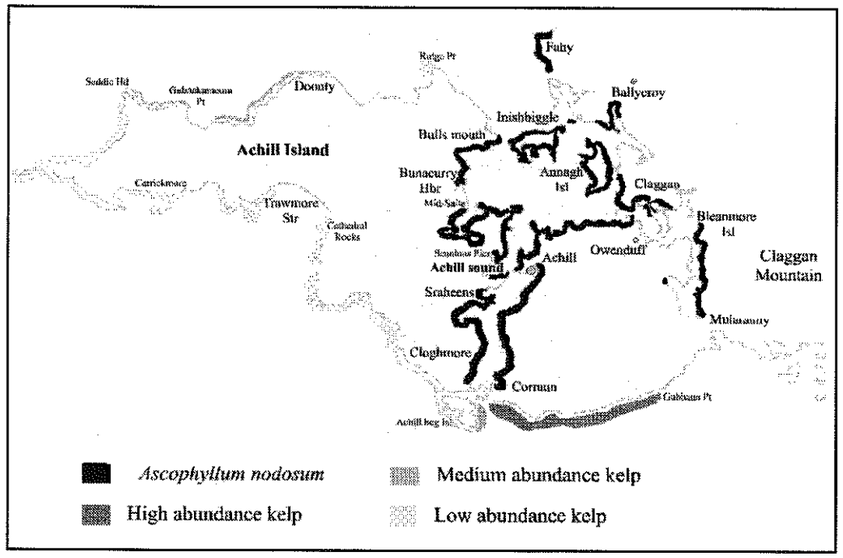

Figure 3.7:
Seaweed resources of Achill Island and surrounding area

Tullaghan Bay

There are five areas along a 13km stretch at Tullaghan Bay which have been harvested for *Ascophyllum*. Tullaghanduff has a potential to provide 150 t per annum. Coolbaha to the north has a potential to sustainably yield 100 t per annum while Augness, Doona and Fahy have a potential to yield in the region of 25 t per annum each. There is one landing pier located in the area and is found at Fahy Castle. Road access is generally considered to be good.

Ballycroy, Claggan and Bleanmore Island to Mularanny

The area immediately surrounding Ballycroy could yield 100 t of *A. nodosum* per annum. Growth in this area is considered to be quite slow with the estimated regeneration cycle being five years. An estimated per annum yield of 100 t per annum is harvestable from Claggan. The growth cycle here is also 5 years. There is no landing pier located in the area but road access is considered to be good. From Bleanmore Island to Mularanny, a 70 tonne per annum potential is estimated. In places the shore is fairly steep and the weed zone is consequently narrow.

Owenduff to Corraun

To the north of Owenduff, along the coast to Achill, there is an estimated annual potential of 80 t per annum. No *Ascophyllum* was harvested from the Achill/Corraun region in 1996. The regeneration period for the local biomass is estimated to be in the region of six years.

Achill Island

The *Ascophyllum* resources of Achill Island are concentrated on the eastern shore between the Island and the mainland (see Figure 3.6). The southern, western and northern shores of Achill Island are very exposed and consist of mostly steep cliffs. From Bulls Mouth to Cashel there is a potential to harvest 30 t of *Ascophyllum* per annum. Further south from Mid-Saile to Scanlons Pier up to 200 t per annum is the harvest potential. This area covers a distance of 5 km, and is accessable via a local landing pier. Although some *Ascophyllum* is recorded from Achill Sound, the resource is estimated to be of no commercial importance. From Sruheen to Cloghmore there is a record of *Ascophyllum* with the regeneration cycle estimated to be as long as 10 years. Approximately 50 t per annum is the maximum sustainable yield from the area.

Inishbiggle and Annagh Island

The islands of Inishbiggle and Annagh—between the north eastern shore of Achill and Ballycroy on the mainland—have good *Ascophyllum* growth. Inishbiggle has a potential to yield 200 t per annum while Annagh Island has a potential to supply in the region of 300 t sustainably per annum. A smaller island to the east which has a 1 km length of coastline has the potential to supply 100 t of *Ascophyllum* per annum. Inishbiggle is the only island from the group which has a landing pier. The growth cycle for each of the islands is estimated to be four years. This is considered quite fast for the Achill area where 5-10 year growth cycles are not uncommon.

The coastline of Achill Island has narrow beds of mixed kelp. At Ridge Point on the northern shore there is a localised large bed of low-abundance kelp. There is no kelp resource between here and Doonty point. From Doonty point, medium-abundance kelp beds are found in patches to Saddle Head. The kelp resource from Saddle Head to Trawmore strand reduces marginally in abundance until eventually the substrate becomes unfavourable for kelp growth. Where the substrate becomes suitable again, low abundance kelp beds are found and continue to Achill Beg Island. On the eastern shore of Achill Beg the kelp density increases and from Corraun to Gubbaun Point one very high abundace kelp bed is found.

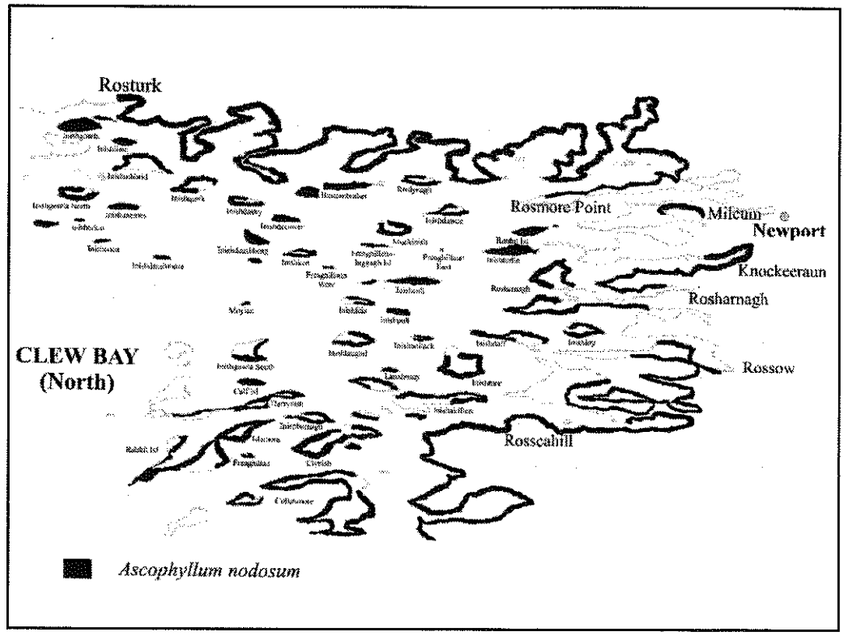

Figure 3.8:
Seaweed resources of Clew Bay (north).

Clew Bay

Clew Bay is well sheltered by its numerous islands (see Figure 3.8). A total of 57 islands were surveyed in the Bay. None of the islands surveyed have a landing pier. Harvesting took place in 1996 on all islands surveyed, with the exception of Inishlim. The sustainable harvest potential for each is considered to be larger than the quantity which was removed. In 1996, a total of 385 t of *Ascophyllum* was harvested from the islands located on the north side of Clew Bay. The substratum of the Bay consists mainly of stones or pebbles and is of the flat, narrow, shingly type. Due to the absence of boulders and rocks, the surface area for weed growth is limited.

The Islands of north Clew Bay

The islands of north Clew Bay yielded 335 t of *Ascophyllum* in 1996 with the potential for over 1,800 t of *Ascophyllum* to be sustainably harvested here per annum. The islands which were included in the survey of north Clew Bay include Inishdawee, Roslynagh, Illananmbraher, Inishdasky, Muckinish, Inishquirk, Inishtubbrid, Inishlim, Inishgowla, Inisherkin, Inishnacross, Inishcooa, Inishdeashmore, Inishdeashbeag and Inishdoover. All of the islands mentioned have an estimated 4 year regeneration cycle.

The Islands of mid Clew Bay

Similarly, the islands from Newport to Westport have the potential to yield a greater biomass than has been recorded from the 1996 harvest. In 1996 approximately 2,600 t of *Ascophyllum* were harvested from the combined 46 km length of coastline. It is estimated that the total area could sustainably yield in excess of 13,000 t of *Ascophyllum* per annum. Collanmore Island is located centrally in Clew Bay and alone has an estimated potential to yield 1,000 t per annum. By comparison, there are a number of islands that could yield less than 10 t sustainably per annum They include Inish Deugh north of Murrisk strand and Moylan Island which lies to the extreme west of Rossow.

The coastline of mainland Mayo

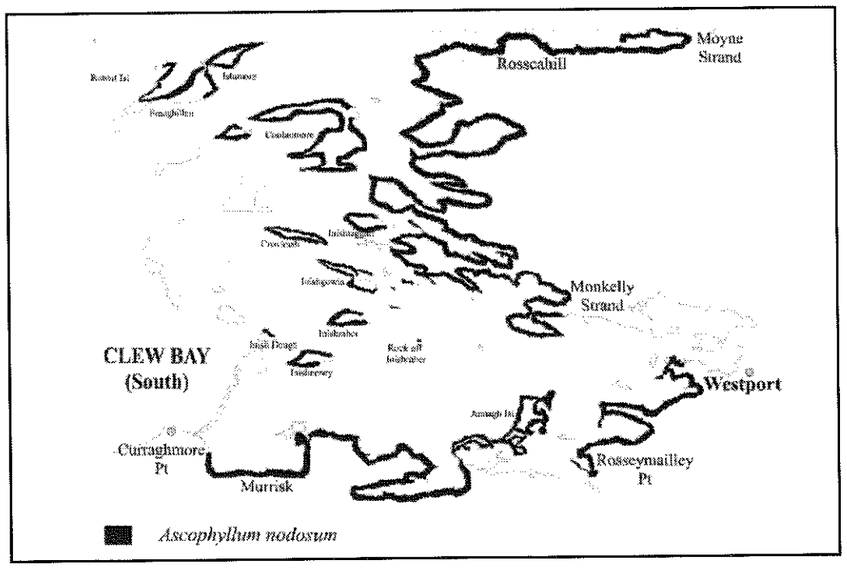

Figure 3.9:
The seaweed resources of south Clew Bay.

The *Ascophyllum* resource that lies along the coast of Mayo from Rosturk in the north to Rosmore Point could yield 600 t of *Ascophyllum* per annum. All suitable substrate in the area is covered, which in total, incorporates 20 kilometers of coastline. A 5 km stretch of

coastline at Milcum—east of Newport—has a harvest potential of 50 t of *Ascophyllum nodosum* per annum. There is a pier located at Milcum House and road access is considered to be good. To the south of Newport, from Knockeeraun to Rosharnagh, there is a 60 t estimated sustainable potential from a 10 kilometer shoreline. From Rossow to Rosscahill there is an estimated 800 t of *Ascophyllum* which could be sustainably harvested per annum. Access is good, and a landing pier is also present. A six year regeneration cycle has been calculated for the *Ascophyllum* from each of the regions surveyed along the Mayo coastal mainland.

South Clew Bay

The 10 kilometer coastline from Rosscahill to Monkelly Strand, could sustainably yield 80 t of *Ascophyllum* per annum. The regeneration cylce of the *Ascophyllum* from the region is 6 years. From Westport to Rossmalley Strand there is an estimated maximum sustainable potential of 300 t per annum. The regrowth period is calculated to be in the region of 8 years. The maximum bed depth in the area is 40 meters and access is good due to the fact that there are a number of landing piers locally. There is a pier located at Old Head and Leckanvy and also one on the Westport side of Murrisk.

The Islands of south Clew Bay

The islands of south Clew Bay have the potential to yield approximately 1,330 t per annum. In 1996, only half this amount was cut. Inisheeny could yield approximately 200 t while Inish Deugh could yield at most 3 t. Annagh Island, which is located in the heart of Westport Bay, is estimated to have the potential to yield 70 t of *Ascophyllum* annually, with 15 t being harvested there in 1996. The regeneration period for the Island is 4 years which is similar to that of the other islands of Clew Bay.

3.4 County Galway

Table 3d:
***Ascophyllum nodosum* harvested in Galway in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
21,205	**37,470**	**350**

3.4.1 Introduction

Galway county has more extensive resources of *Ascophyllum nodosum* than any other county in Ireland. Consequently, it comes as no surprise to find that most of the seaweed harvesting activity in Ireland is located in Galway as is the largest seaweed processing plant in the country. The coastline is extremely conducive to rapid growth. The seaweed

zones are much larger than in most parts of Mayo as the substratum consists of boulders and rocks for the most part. Generally speaking, a three to four year regeneration cycle is standard for Galway. Since Arramara Teoranta opened their processing plant in Kilkerrin, details of seaweed harvesting and potential have been kept for the Connemara region. These records have been made available for the first time to the survey team by Arramara Teoranta. Although Galway has long been the most significant *Ascophyllum* producing county in Ireland, there are some large areas where the biomass diminishes. This study has found that for most of these areas, large, dense beds of kelp occupy the subtidal regions, making the coast of Connemara one of the richest areas in Ireland for seaweed potential as well as utilisation.

3.4.2 Seaweed resource

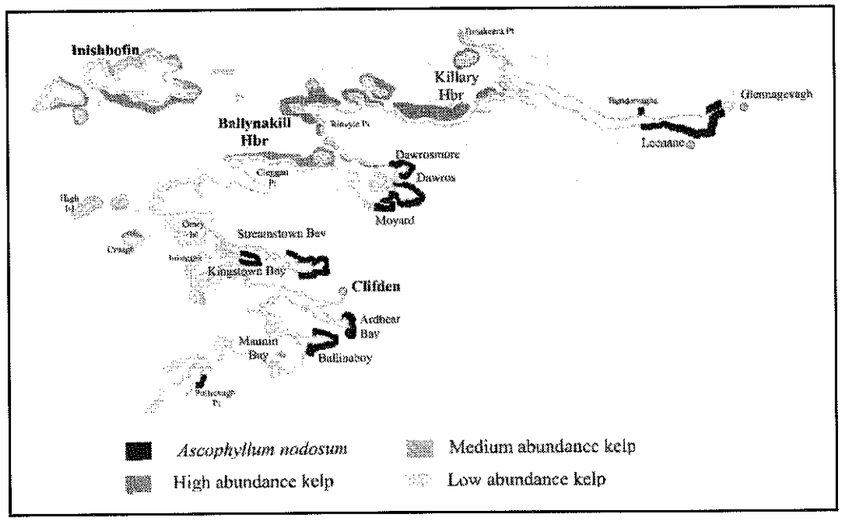

Figure 3.10
Seaweed resources from Killary Harbour to Clifden

Killary Harbour

On the Galway side of Killary Harbour, there is a 6 km expanse of good quality *Ascophyllum* with the capacity to yield of up to 500 t per annum. From Lennane, the area coverage is marginally lighter, due to the increased exposure and steep cliffs alternating with long sandy beaches. Access to the *Ascophyllum* resource is good, with two piers and a slipway located along the coastline.

From Tonakeera Point to the mouth of Killary Harbour there is a medium abundance of mixed kelp while around Inishdegil More and Illaunmore there is a high abundance. Along the coast from the mouth of Killary Harbour to Rinvyle point, large kelp beds are prevalent. From Renvyle Point to Dawrosmore the kelp is still present in abundance but it is patchy and the beds are not as vast.

Ballynakill Harbour

The *Ascophyllum* resource in Ballynakill Harbour is presently being cut by two full time harvesters. The area supplied approximately 500 t of seaweed in 1996, which equates to the calculated per annum sustainable yield. The area covered extends for approximately 3 km and has a maximum bed depth of 10 metres. Road access is considered adequate, and there is a landing pier in the area.

From Dawros to Moynard there is a 7km belt that will supply 500 t of *Ascophyllum* per annum. The maximum bed depth recorded is 5 m.

On the southern shore of Ballynakill Harbour to Cleggan Point is a wide stretch of medium abundance mixed kelp. As substrate suitability diminishes, so too does the availability of the weed. A low abundance of kelp covers the coast again to the mouth of Streamstown Bay where the substrate type is more suitable.

Streamstown Bay to Clifden

A 5 km length of inner Streamstown Bay is heavily covered with good quality *Ascophyllum* to a depth of 10 meters. The harvestable potential of the area is 1,000 t per annum while only 500 t was cut in 1996. The area is very accessible and there is a pier present.

Kingstown Bay has a 2 km *Ascophyllum* stretch that supplied 250 t in 1996 and has the potential to supply 500 t per annum. The region and the resource is extremely accessible. One seasonal harvester is listed for the area. Both locations have a four year regeneration cycle.

The kelp distribution in the area is variable with all suitable substrate being covered with low abundant mixed kelps. The islands including High Island and Friar Island have medium abundance kelp occurrences while the northern shore of Cruagh has very dense beds of high-abundance, mixed kelp.

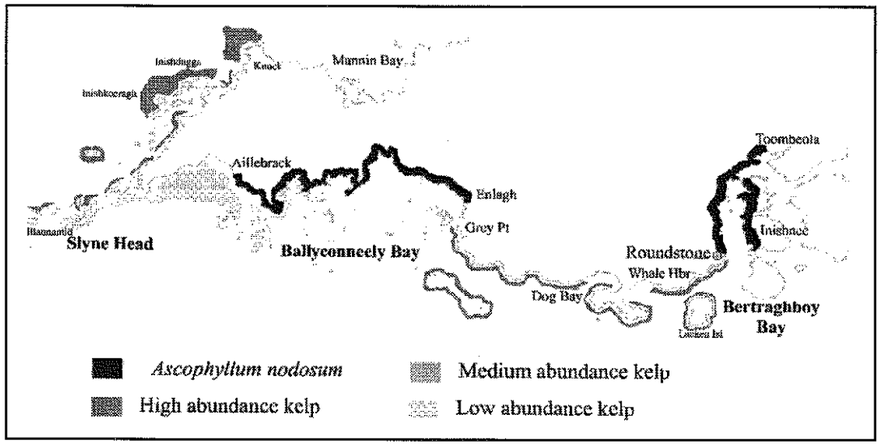

Figure 3.11:
Seaweed resources from Mannin Bay to Bertraghboy Bay.

Clifden to Pollrevagh Point

There is a sustainable potential of 500 t per annum of *Ascophyllum* to be cut from a 2 km area of Ardbear Bay. The maximum depth of *Ascophyllum* is 10 metres. A 5 km area of Mannin Bay yielded 150 t in 1996 and has the potential to yield 150 t per annum. Two seasonal harvesters are active in the area and the maximum bed depth is 10 metres. The resource in this locality has a four year growth cycle.

The distribution of kelp between Clifden and Pollrevagh Point is low although all suitable substrate has some coverage.

Mannin Bay to Slyne Head

There is no recorded significant growth of *Ascophyllum* between Knock and Slyne Head (see Figure 3.11). This is due to the high exposure of the area resulting in a shore line which is extremely barren.

There is an abundant kelp resource in the area with *Laminaria hyperborea* being the most prevalent. A high abundance of mixed kelp beds are found at Knock Head and on the western aspect of Inishdugga and Inishkeeragh. The resource diminishes further down the coast to Slyne Head, but is still highly abundant.

Slyne Head to Ballyconneely Bay

No commercially significant *Ascophyllum* beds have been recorded between Slyne Head and Aillebrack. There is a high *Ascophyllum* resource in Ballyconneely Bay. Along a 15 km stretch from Aillebrack to Enlagh, 1,000 t were cut in 1996. A four year growth cycle is recorded for the area and there is potential for a harvest of approximatley 2,000 t per annum. In the Bunowen region there are five steady harvesters and in Aillebrack three winter cutters are currently operating.

Kelp beds are common in the region, albeit they are not abundant.

Ballyconneely Bay to Bertraghboy Bay

Ascophyllum nodosum and *Fucus vesiculosus* are very abundant from Ballyconneely Bay to Rosaveel. *Fucus serratus* is also common in places. Between Grey Point and Roundstown there is no significant *Ascophyllum* resource. From Roundstown Harbour to Toombeola, 1,500 t of *Ascophyllum* were harvested in 1996 where the maximum bed depth is 20 metres. The area concerned includes the western shore of Inishnee. The estimated sustainable potential is also 1,500 t per annum. A three year regrowth period is estimated for the area. There is a pier present in the region and access is generally considered good. A total of ten harvesters are located in the area. Six are listed as seasonal cutters while four are winter cutters only.

Kelp is highly abundant from Grey Point to Roundstone including Lacken Island.

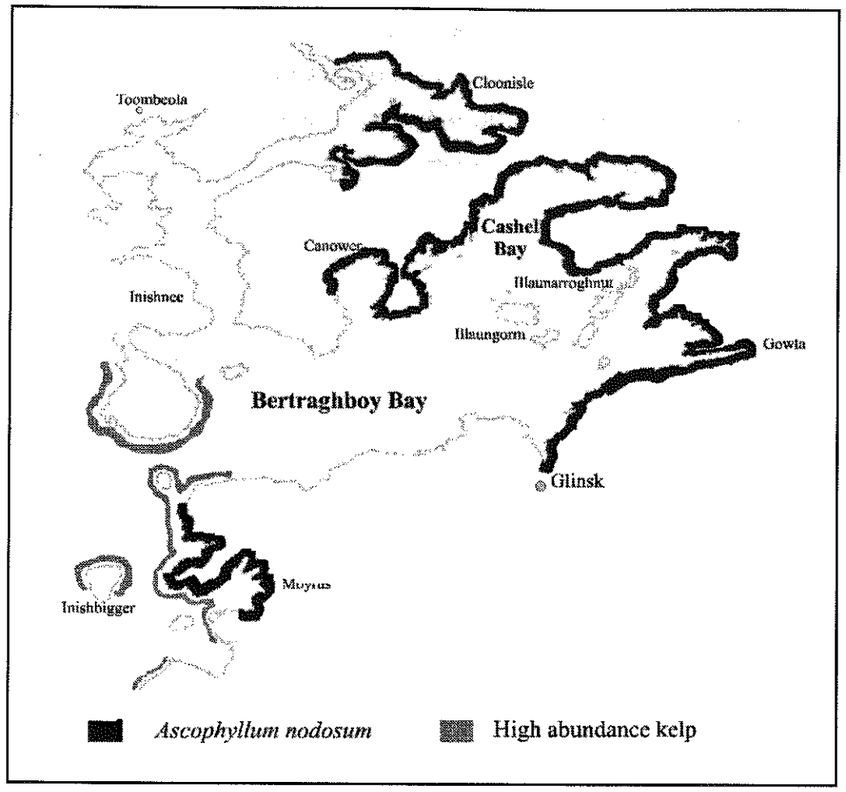

Figure 3.12:
Seaweed resources of Bertraghboy Bay and Cashel Bay.

Bertraghboy Bay and Cashel Bay

The inlet adjacent to Cloonisle (to the north of Bertraghboy Bay) encompasses a biomass which spreads over 7 km and has the potential to produce 2,000 t of *Ascophyllum* per annum. In 1996 approximately 400 t were taken from the area.

From Canower to Glinsk, good quality *Ascophyllum* grows in abundance. In 1996, a total of 2,500 t were extracted from the area—with the potential to harvest up to 4,000 t per annum. The maximum depth of *Ascophyllum* in this area is 20 m and is easily accessible by road and pier.

Good quality *Ascophyllum* is found growing along a 6 km area at the mouth of Bertraghboy Bay to the southern shore of Moyrus Bay. In 1996, 350 t were harvested from the area which equates to its total annual potential. The area is very accessible, and a landing pier is also present. The anticipated regeneration cycle for the resource is three years with the maximum bed depth reaching 50 metres.

The kelp beds of Bertraghboy Bay are abundant but they are not very deep. The southern tip of Inishnee has a narrow dense bed of mixed kelp. The area between the mouth of Bertraghboy Bay and Moyrus Bay, contains a dense bed of mixed kelp.

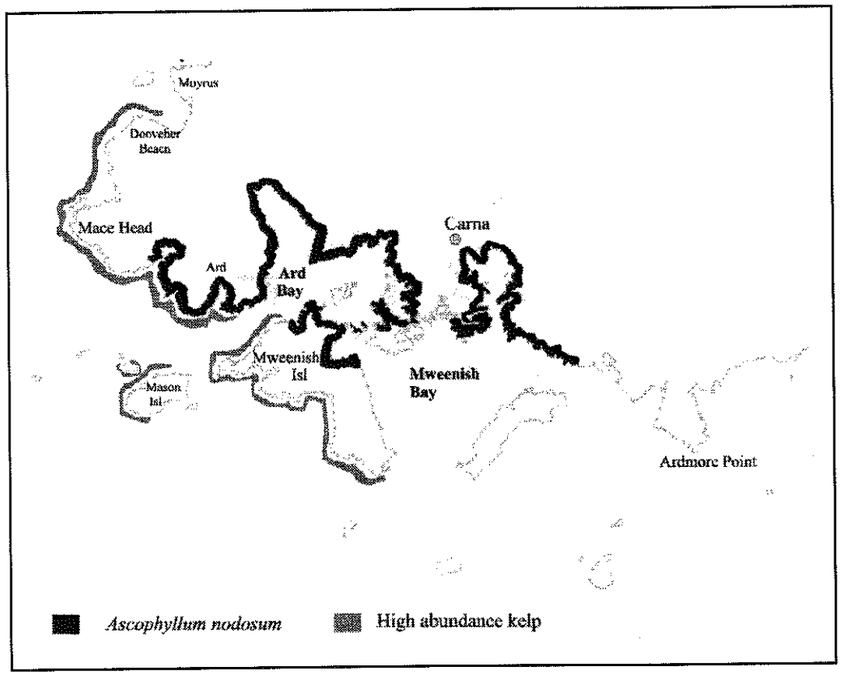

Figure 3.13:
The seaweed resources from Moyrus Bay to Ardmore Point.

Moyrus Bay, Ard Bay and Mweenish Bay

The kelp beds present in Moyrus Bay extend around Mace Head to Ard. They also cover the western aspect of Mason Island and Mweenish Island (see Figure 3.13).

The *Ascophyllum* resource in the area is very extensive. A 22 km length from the western end of Mace Head to Mweenish Island and including the northern shore of Mweenish Island has a harvest potential of 1,000 t per annum. The quality of *Ascophyllum* from the area is very good. Bed depths are recorded to extend as deep as 40 m. The area is very accessible and a number of landing piers are located in the region. No landing pier is located on Mweenish Island however.

The stretch of coastline to the east and west of Carna has a harvest potential of 450 t per annum of good quality *Ascophyllum.* Road access is relatively good and there are a number of landing piers in the area—all of which are in need of repair. A large number of of harvesters are found in the Carna region.

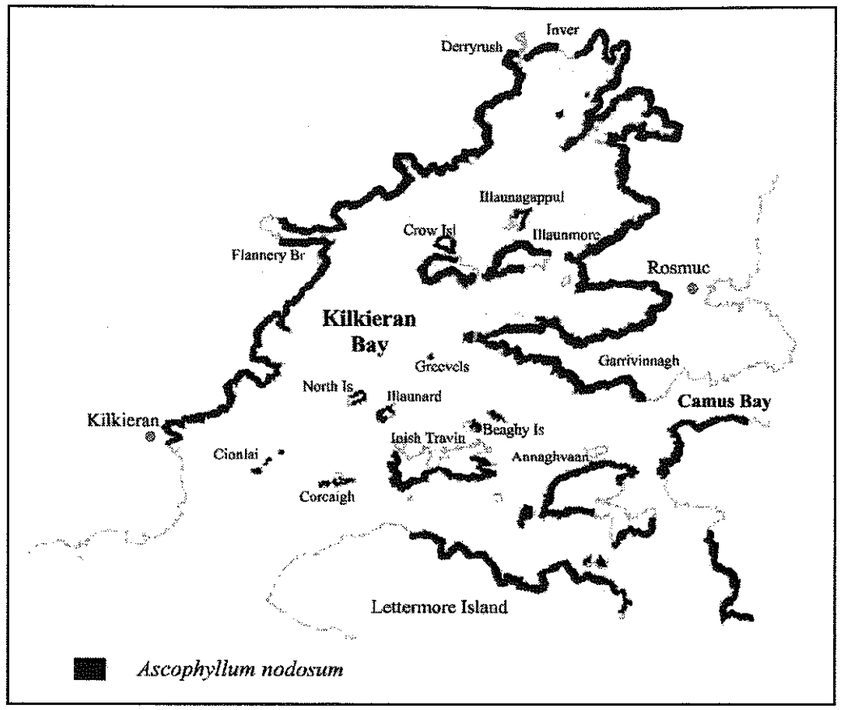

Figure 3.14:
Seaweed resources of Kilkieran Bay and Camus Bay

Kilkieran Bay and Camus Bay

Kilkieran Bay is the location of Ireland's largest seaweed processing factory owned by Arramara Teoranta. Arramara is the sole purchaser of *Ascophyllum* in Connemara taking an average of 600 t of fresh weed each week. The company employs in excess of 120 harvesters in the surrounding area.

The *Ascophyllum* resource is very extensive along the coast of mainland Kilkieran Bay (see Figure 3.14). The 12 km distance from Kilkieran to Inver holds a potential harvest of 3,000 t of *Ascophyllum.*

The 17 km length of coastline from Inver to Garrivinnagh supplied 2,600 t of *Ascophyllum* in 1996. There exists a potential supply of 5,200 t of *Ascophyllum* per annum from this region. The maximum bed depth in the area is 60 metres. There are a number of landing piers in the area and road access is considered to be good.

The Islands of Kilkieran Bay including Illaunagappul, Illaunmore and Crow Island to the north and Illaunard, Cionlai, Corcaigh, North Island, Inish Travin and Beaghy Island contributed over 1,900 t of *Ascophyllum* in 1996. The potential of the area is 2,675 t of good quality *Ascophyllum* per annum. The area of coastline which is covered extends for approximately 20km.

The northern shore of Lettermore Island, Annaghvaan and the area of shore on the southern side of the mouth of Camus Bay incorporates 11 km of coastline. The *Ascophyllum* resource harvested from the area in 1996 totalled 1,000 t. The tonnage available for a sustainable annual harvest is 350 t per annum. Landing piers and road access are considered to be good.

There is no occurrence of significant amounts of kelp in the greater Kilkieran Bay area.

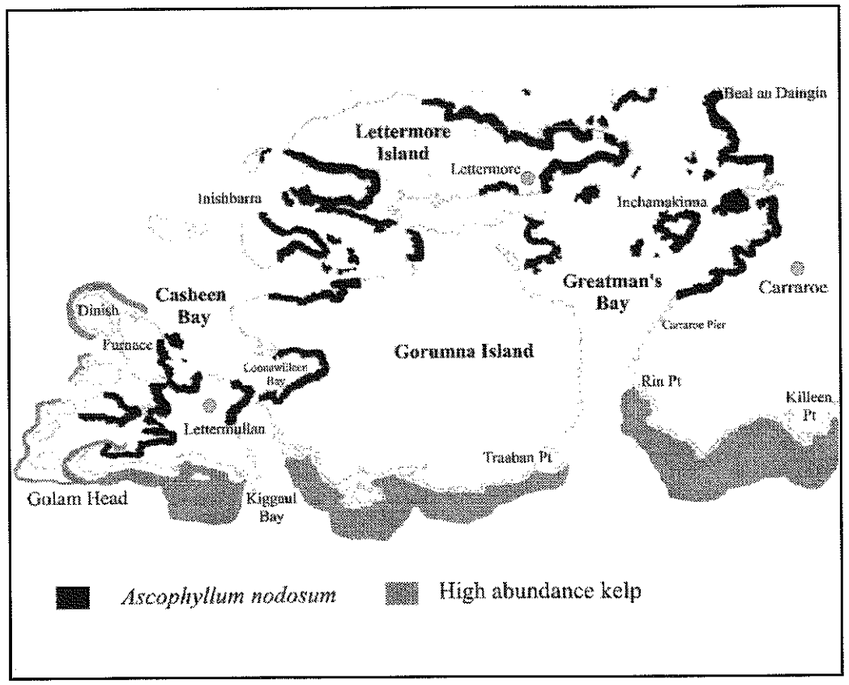

Figure 3.15:
The seaweed resources of Casheen Bay and Greatmans Bay

Casheen Bay and Greatmans Bay

The *Ascophyllum* resources from Casheen Bay to Greatmans Bay have a total potential of 4,275 t per annum. The resource grows on much of the coastline of Lettermore Island, Inishbarra and areas of Gorumna Island (see Figure 3.15). The western shores of Lettermullan and its associated small islands also sustain significant *Ascophyllum* growth.

The kelp resources off the southern shores of Kilkieran Bay are present in large abundance. The resource comprises dense beds of mixed kelp which cover all suitable substrate. The beds located off the southern coastline of Gurumna Island from Traaban Point to Kiggaul Bay, Lettermullan and the western coasts of the islands lying off Golam Head and Dinish are vast. The southern shore of Carraroe from Rin Point to Killeen Point are also generously covered with a highly abundant kelp resource.

Béal an Daingin to An Crumpaun

In 1996 the 14 km length of coastline from Béal an Daingin to An Crumpaun yielded 500 t of *Ascophyllum*. The island of Inchamakinna also yielded 500 t. The sustainable potential is estimated to be 350 t per annum for the latter and 700 t per annum for the stretch of coastline from Beal an Daingin to An Crumpan.

Lettermore Island

The shores of Lettermore (and Lettermullen) are very wide in places giving rise to large quantities of *Ascophyllum*. Harvesting is very intense in the region. The southern shore of Lettermore supplied approximately 40 t of weed in 1996—equating the calculated sustainable yield per annum. The growth cycle is five years for this area.

The Island of Lettermullan produced 750 t of *Ascophyllum* in 1996 which is also considered to be the sustainable harvest for the region. The Island of Inishbarra located between Lettermore and Gorumna Island has a potential for 750 t per annum of *Ascophyllum*. No harvesting is recorded from here in 1996.

Gorumna Island

Ascophyllum growth of Gorumna Island is divided between two areas on the western shore. Coonawilleen Bay supplied 250 t of *Ascophyllum* in 1996 while to the north of the island a total of 300 t were harvested. The harvested area includes the small islands south of Inishbarra and covers a total of 5 km of coastline. Access to the resource is reasonable and a landing pier is present locally.

Lettermullan

Most of the Lettermullan Island coast (similar to Lettermore) is covered in one type of seaweed or another. The westerly and the easterly shores of Furnace Island have a sustainable yield of 750 t of *Ascophyllum* per annum.

Camus Bay

There are no significant commercial kelp resources recorded from Camus Bay (see Figure 3.16).

Approximately 1,000 t of good quality *Ascophyllum* were harvested in 1996 in Camus Bay. The distance covered was over 20 km and includes the islands of Clynagh and Inisheltia. There is potential harvest of 3,000 t to be extracted from the area. Access to the resource is considered good and a landing pier is present. There is a total of nine seasonal cutters operating in the area.

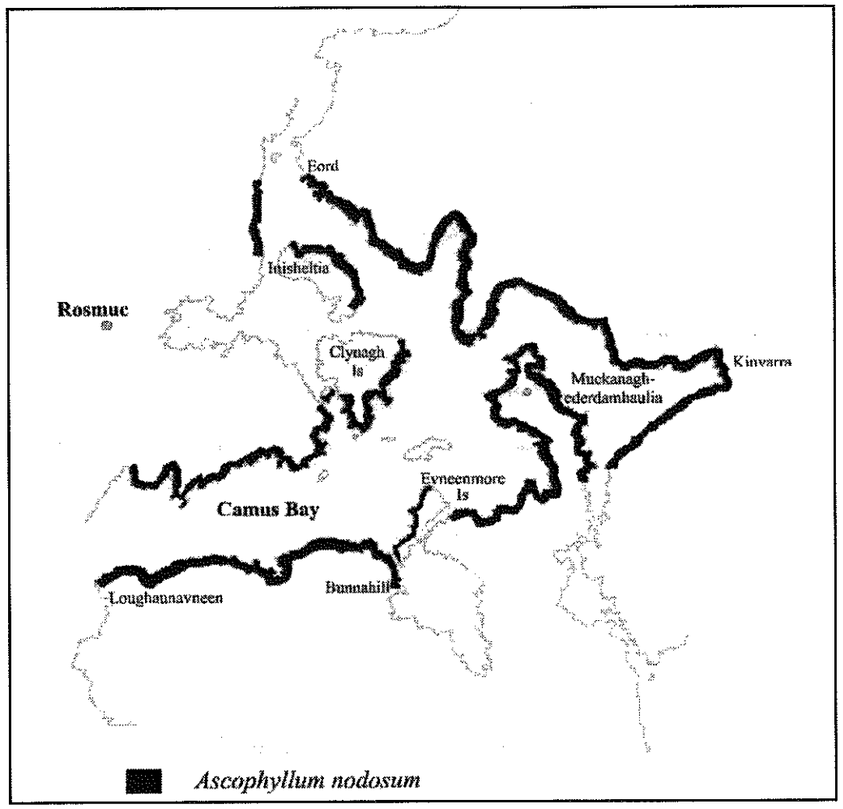

Figure 3.16:
The seaweed resources of Camus Bay

Cashla Bay to Spiddal

Inner Cashla Bay from Garryroe to Rossaveel incorporates 11 km of coastline which in 1996 supported a 1,000 t yield of *Ascophyllum*. The resource could supply 700 t of *Ascophyllum* sustainably each year. The cove below Rosaveel supplied 125 t of *Ascophyllum* in 1996 and has the potential to supply 300 t per annum. Access to the area is considered good and there is a pier locally.

From the mouth of Cashla Bay to Castle Point a large belt of high abundance mixed kelp is present. This gardually diminishes to a medium abundance and becomes patchy along the shore to Spiddal. A large bed of medium abundance kelp is present on the Furbo side of Spiddal.

Inner Galway Bay

The *Ascophyllum* resources of the inner Galway Bay region are limited, which can, in part, be attributed to the high levels of unsuitable soft and muddy substrate. Oranmore Bay incorporates an 8 km stretch from Roscam Point to Bay View. 250 t of *Ascophyllum* were

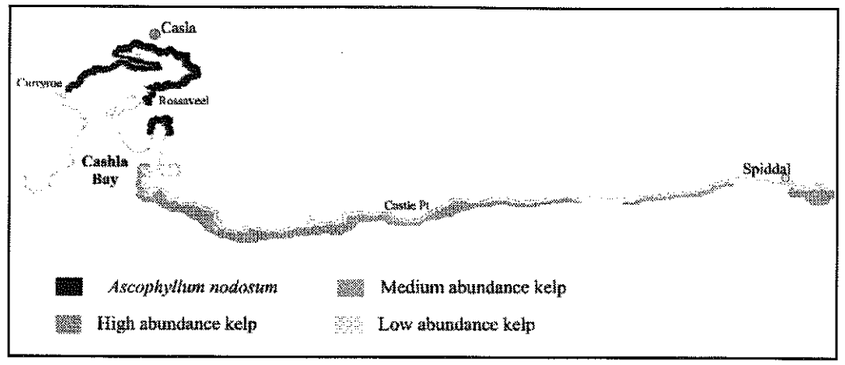

Figure 3.17:
The seaweed resources from Cashla Bay to Spiddle

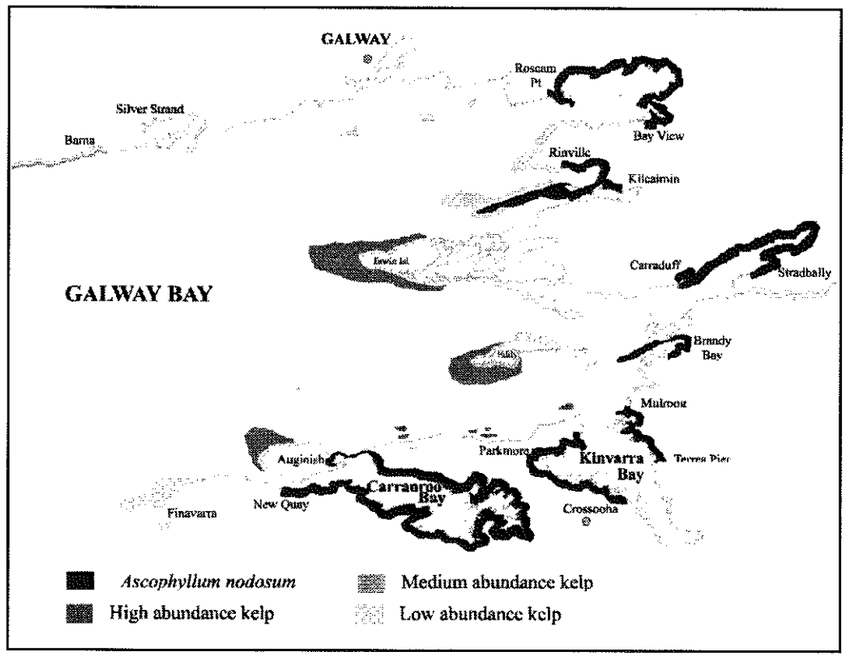

Figure 3.18:
Seaweed resources of Inner Galway Bay

harvested here in 1996. The area has the potential to yield 200 t per annum sustainably. The area from Carraguff to Stradbally can produce 20 t of weed annually while slightly more than this was harvested in 1996. The Brandy Bay area produced 50 t of *Ascophyllum* in 1996 and it is estimated to hold a similar per annum potential.

Kinvarra Bay

Kinvarra Bay yielded 500 t of *Ascopyllum* in 1996. It could yield 800 t sustainably per annum. The area surveyed covers a total of 9 km—3 km from Mulroog to Terrea Pier and 6 km from Crossooha to Parkmore.

Auginish Bay

From Auginish to New Quay, a total of 100 t of *Ascophyllum* were harvested in 1996. The maximum bed depth recorded was 10 m and there is an estimated potential to cut 250 t from the area. Access to the resource is good and there are a number of piers present in the region.

Along the Renvyle coast kelps are present, although they are extremely light and of low abundance. The kelps found off Kilcaimin Head, Eddy Island and Tawin Island on the other hand occur in large, abundant beds. *Fucus* spp. are also found in considerable quantities.

The kelp beds found off Auginish Head are composed predominantly of *Laminaria hyperborea*. The beds in the region are dense and of high-abundance. The abundant beds which start here diminish marginally along the Finavarra coast where the beds are of low abundance.

Aran Islands

The *Ascophyllum* survey did not extend to the Aran Islands. Kelp is common around the Islands for the most part. On the eastern side of Inishmore, Inishmann and Inisheer there are large, dense beds of high abundance, mixed kelp. On the western shores the beds are less dense and considerably less abundant.

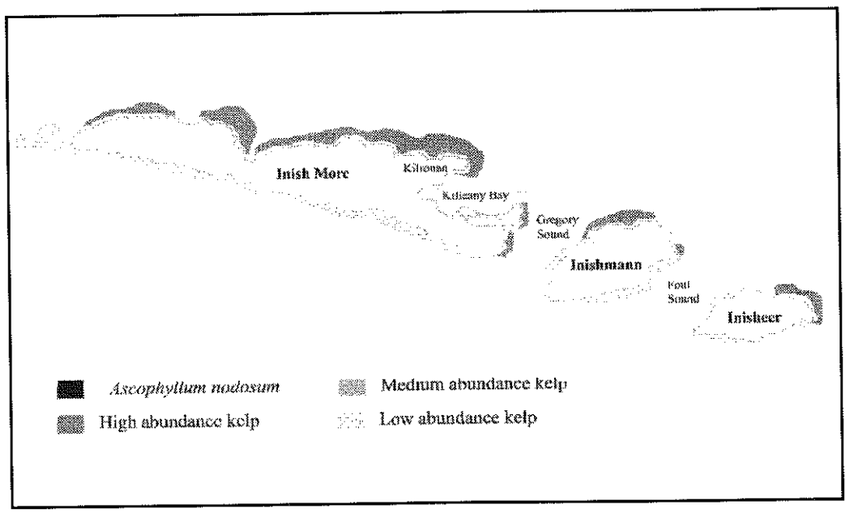

Figure 3.19:
Seaweed resources of the Aran Islands

3.5 County Clare

Table 3e:
***Ascophyllum nodosum* harvested in Clare in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
100	1,140	57

3.5.1 Introduction

The Clare coast is largely unsuitable for *Ascophyllum nodosum* growth. Steep cliffs, expanses of deeply cut limestone and high exposure in west Clare contrast with the barren mud flats and salt marshes of the Shannon Estuary. There are however a number of small areas which have harvesting potential.

3.5.2 Seaweed resource

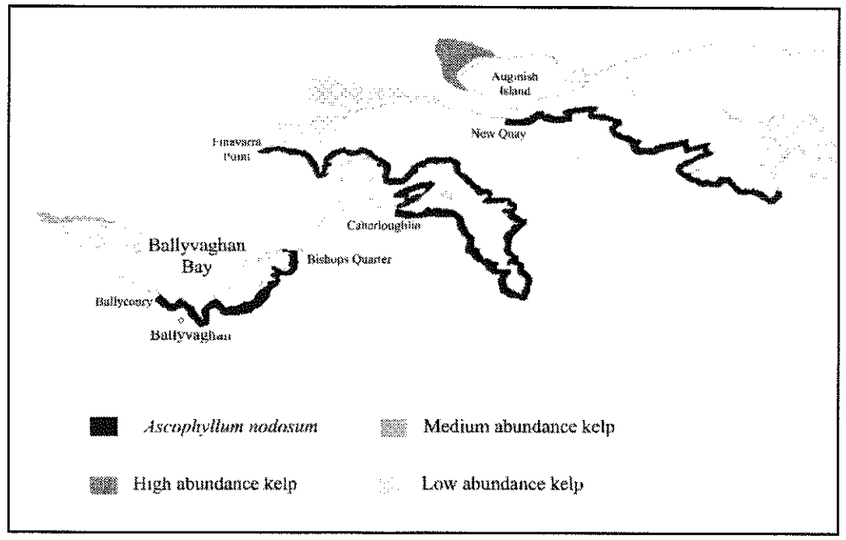

Figure 3.20
Seaweed resources of North Clare

Auginish Island to Ballyvaughan

From Auginish Island to New Quay, 100 t of *Ascophyllum* were harvested in 1996 (see Figure 3.20). The maximum bed depth recorded was 10 metres and there is an estimated potential to cut 250 t per year from the area. Access to the area is good and there are a number of piers present in the region.

From Finavarra Point to Caherloughlin, a 15 km length of coastline was surveyed. It was found to consist mainly of mixed weed and *Ascophyllum*. An estimated 100 t of the latter could be extracted from the area annually. Road and pier access was considered good for the area.

Access to the resource located from Bishop's Quarter beach to Ballyvaughan is also good and has an annual 400 t harvest potential. This is 300 t greater than what was cut from the area in 1996. The growth cycle for the resource is estimated to be four years.
There are no further records of a significant *Ascophyllum* resource between Ballyvaughan and the Shannon Estuary.

The kelp cover over the area is varied. From Black Head to Doughmore Bay there are many large patchy beds of medium abundance mixed kelps. The subtidal area off Kilkee is also host to significant medium abundance mixed beds.

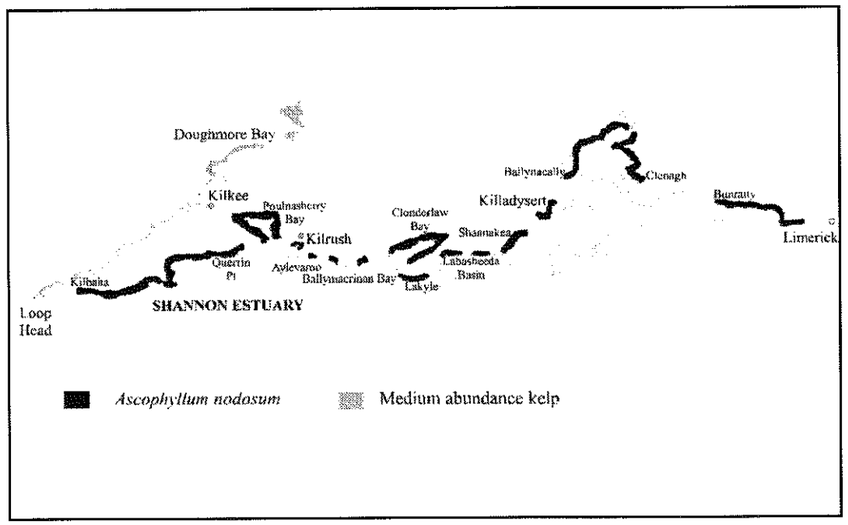

Figure 3.21:
Seaweed resources in the Shannon Estuary, County Clare.

Shannon Estuary

Ascophyllum nodosum is found along the Shannon Estuary from Loop Head to Bunratty (see Figure 3.21 above). The harvest potential for the entire area is 720 t per annum. Many areas that have *Ascophyllum* growth are considered to contain sufficient resources to make them viable for harvesting activity. These areas include Poulnasherry Bay, Ballymacrinan Bay and Besborough. There is no record of *Ascophyllum* having been cut here in 1996. There are landing piers present in Kilbaha, Kilrush and Ayleharoo and a number further east towards Limerick.

3.6 County Limerick

Table 3f:
***Ascophyllum nodosum* harvested in Limerick in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
0	**210**	**20**

3.6.1 Introduction

The coastal area of Limerick is all situated within the Shannon Estuary. This is a region which is largely unsuitable for *Ascophyllum nodosum* growth. There are a number of *Ascophyllum* beds present but many of these are not of sufficient size to sustain significant harvesting activity.

3.6.2 Seaweed resources

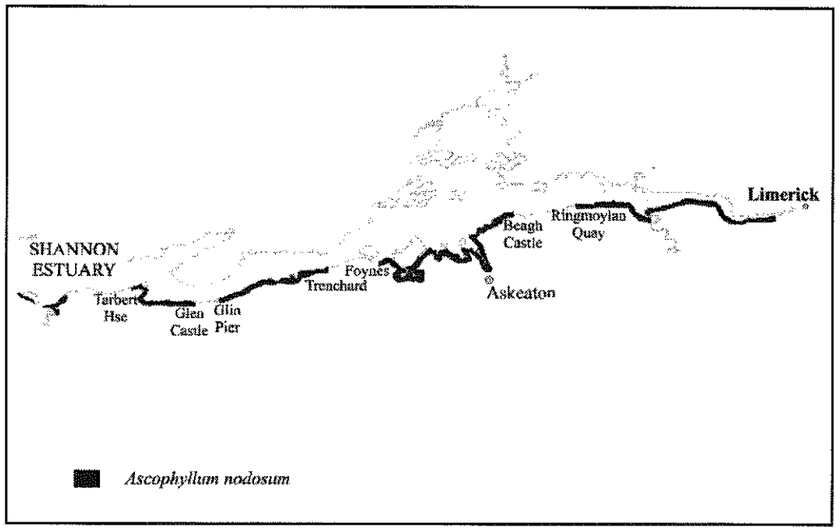

Figure 3.22:
Seaweed resources in the Shannon Estuary, County Limerick.

Limerick

A distance of 22 km of Limerick coast was surveyed. *Ascophyllum* was present over much of the area and an estimated 110 t of the resource could be sustainably harvested per annum (see Figure 3.22 above). There is no record of any harvesting having taken place in

Limerick in 1996. The biomass is generally very accessible and there are good quality piers found in all the main *Ascophyllum* locations.

There are no records of significant kelp growth from the Limerick coast.

3.7 County Kerry

Table 3f:
***Ascophyllum nodosum* harvested in Kerry in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
1,800	**1,140**	**90**

3.7.1 Introduction

Dense beds of accessible *Ascophyllum nodosum* are not common for most of County Kerry. Kenmare River is an exception where there is a widespread coverage of high-quality biomass. Large amounts of *Fucus* spp. are more common to Kerry due to the suitability of the substrate for these species.

A combination of ideal exposure conditions and substrate availability throughout most of the county, (excepting the inner reaches of the numerous bays) results in the coast of County Kerry being extensively populated by large kelp beds. *Laminaria digitata* is common on the lower rocky regions while large populations of *Laminaria hyperborea* occur further into the lower intertidal and subtidal areas.

Arramara Teoranta do not harvest *Ascophyllum* in County Kerry, mainly because of the cost of transport from Kerry to their plant in Kilkieran, Co. Galway. Kerry Algae are the only significant commercial users of seaweed in the region. The company is involved in the development, manufacture and marketing of a range of value-added seaweed extracts and powders for use as biostimulants for plant growth. The company utilise the seaweed resources off the Kerry coast extensively and are also consumers of considerable amounts of seaweed meal produced by Arramara Teoranta. Over 90% of the company's current output is exported, mainly to other EU countries and the Middle East.

Kerry Algae are currently building an alginate production facility in Ardfert, County Kerry. This will inevitably lead to an increase in demand for the intertidal seaweed biomass on the south-west of Ireland and elsewhere. It will also lead to the development of the kelp resources of the region which are very extensive along the coasts of Kerry and Cork.

3.7.2 Seaweed resource

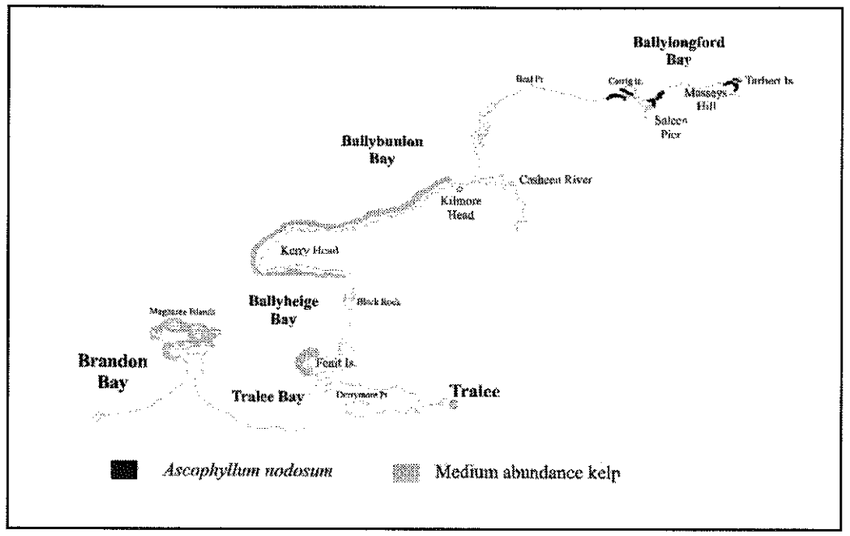

Figure 3. 23:
The seaweed resources of County Kerry from Tarbert Island to Brandon Bay

Tarbert Island to Carrig Island

An 8 km stretch from Glin Castle to the Tarbert car ferry terminus was the first area surveyed. Typically, the substrate in the region is composed of mud, sand and shale. There is a landing pier in the area and road access to areas where seaweed occurred was considered as generally good. The amount harvested in the area is not known but most of the weed surveyed consisted of old plants. The potential for this area was not quantified and not regarded as very large. An Forás Taluntais, in its previous seaweed survey of 1965, described the area as "barren as it consists of either cliffs as along Ballybunion and Dingle Peninusula or sandy beaches as found between Ballyheigue and Fenit and also along the Dingle peninsula".

The biomass coverage of Masseys Hill extended for a total of 1 km. There was no landing pier in the area but there was some road access to the seaweed. The area is not considered to hold much potential as a commercial source of seaweed. It could yield a low tonnage but it is unlikely that it is worth harvesting.

The entrance of Ballylongford Bay to Saleen Pier covers a distance of approximately 2 km. Road access is not considered good but there is a landing pier present. The area surveyed had a very large coverage of *Fucus* spp. The Bay itself is composed of a mixture of mud, sand and rocks which at best, support only minor amounts of *Ascophyllum*. It is estimated that the growth cycle for the seaweed of the area is four years and it could yield up to 10 t of *Ascophyllum* per annum.

The remainder of outer Ballylongford Bay leading north to Carrig Island, is a rocky area which has little coverage of *Ascophyllum* and is not considered to have any significant commercial potential.

Ballybunion Bank to Black Rock

There are no significant occurrences of kelp along the inner reaches of the Shannon Estuary, with the first large beds beginning along the Ballybunnion Bank. The beds here are of low density but are very extensive. The area from Ballybunion town to Kilmore Head (mouth of the Casheen River) has no kelp beds, due to the unsuitable topographical features of the Bay. From Kilmore Head, all around the Kerry Head peninsula to Ballyheige Castle, there are very large occurrences of low abundance kelp. The majority of Ballyheige Bay is relatively kelp free apart from a large occurrence just off Black Rock.

Tralee Bay to Brandon Bay

Inner Tralee Bay has no kelp growth, but the entrance to the Bay has a large biomass in medium abundance. The west face of Fenit Island hosts a number of large kelp beds which have an abundant coverage near the coast, that diminishes moving west.

Rough Point has a very heavy coverage of kelp with the Seven Hoggs or Maharee Islands being completely surrounded by extensive beds of medium abundance weed. The extensive occurrence is due in the main part to the presence of a very suitable substrate. Brandon Bay does not have any significant coverage of seaweed, either intertidally or subtidally.

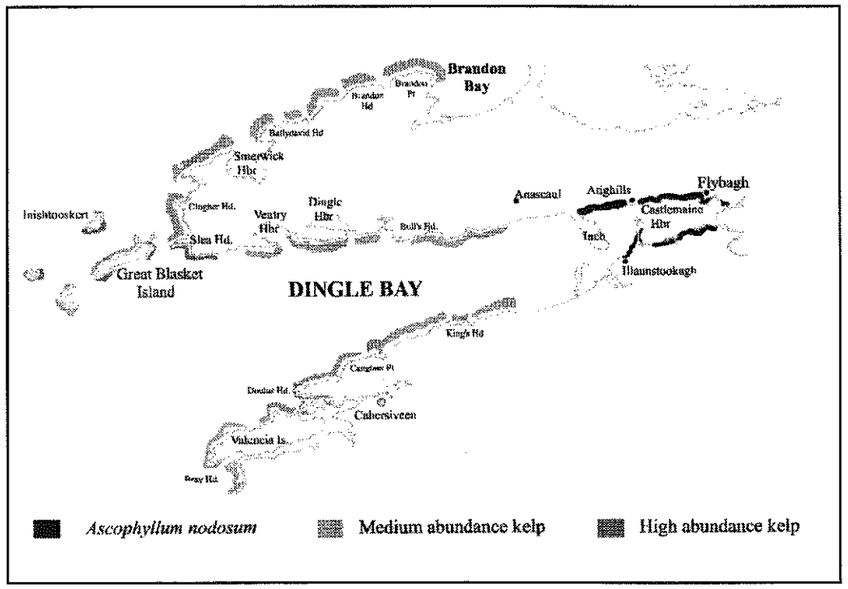

Figure 3.24:
The seaweed resources of County Kerry from Brandon Bay to Valencia Island

Brandon Point to Slea Head

From Brandon Point to the westerly tip of Slea Head, there is a continuous low abundance kelp coverage excepting the areas of Sauce Creek, Brandon Creek, Smerwick Harbour and other intermittant inlets where the substrate is unsuitable (see Figure 3.24 above). The Great Blasket Island has a very large coverage of kelps on both its east and west faces. The relative shelter of the east face of the island allows for the biomass to be very dense. The Island of Inishtooskert to the north, Tearaght to the west and Inishnabro and Inishvickillane to the south-west also have large off-shore kelp beds.

Slea Head to Anascaul

Kelp coverage continues for most of the north side of Dingle Bay. It begins on the south face of Slea Head in high-abundance and is of medium-abundance on the approach to Ventry Harbour. The medium-abundance continues to Dingle Harbour and at its outer reaches the biomass declines. Continuing the approach to Castlemaine Harbour, kelp occurrences are common in all areas excepting those adjacent to the many small inlets along the route. The kelp beds disappear on the approach to Anascaul and are absent for the rest of north Dingle Bay including all of Castlemaine Harbour.

From Inch to Atighills, the intertidal seaweed cover consisted of *Fucus spp.,* and to a lesser extent *Ascophyllum*. The accessible biomass of *Ascophyllum* recorded in the area was not considered commercially significant.

The area from Atighills to the ferry pier outside Flybagh yielded a similar result. There is a mixture of *Ascophyllum* and *Fucus* spp. in the area but there is also a considerable amount of mud and silt which rendered the region largely unsuitable for significant harvesting activity.

From Flybagh to Illaunstookagh in the inner reaches of Castlemaine Harbour, *Ascophyllum* was present in very small amounts. The area is largely unsuitable for commercial *Ascophyllum* extraction. The remainder of Dingle Bay to the end of Ballinskelligs Bay is too exposed for significant occurrences of *Ascophyllum* (see Figures 3.23 & 3.24)

From the inner reaches of Dingle Bay to Ballinskelligs Bay, a very significant coverage of medium abundance kelp exists which is only interrupted briefly in places such as Cooncrome Harbour and the Portmagee Channel, east of Valentia Island.

Valencia Island to Vedanona

From Long Island, immediately south of Valencia to Puffin Sound, there is a medium coverage of kelp (see Figure 3.25). The west face of Puffin Island has a restricted low abundance of kelp, primarily due to the high exposure of the location, while the east side of the island shelters a very extensive, abundant biomass of mixed kelps. The extensive abundance of kelp is present for the most part as far as Bolus Head.

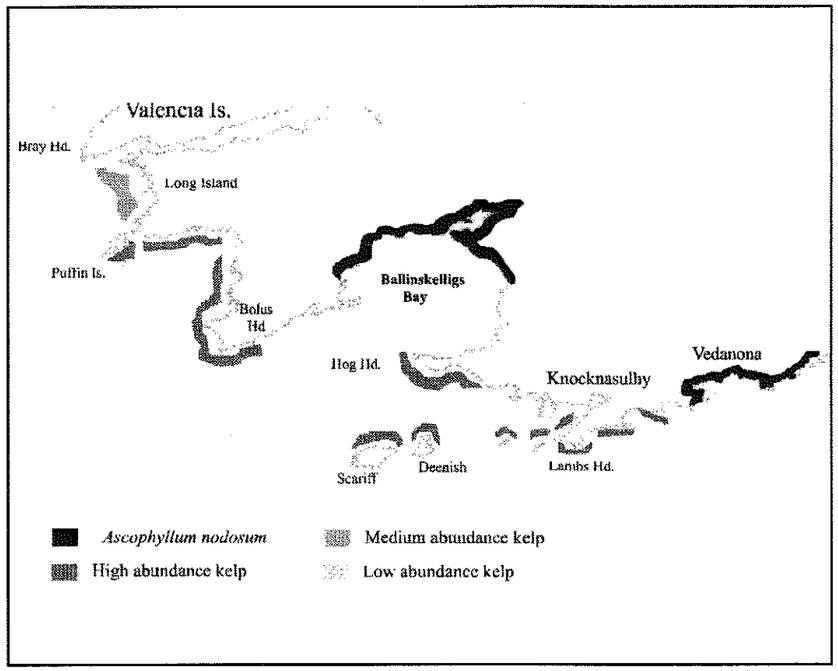

Figure 3.25:
The seaweed resources of County Kerry from Valencia Island to Vedanona

Ballinskelligs Bay is not suitable for the growth of *Ascophyllum*. Insignificant amounts of the resource are present due mainly to a combination of high exposure and unfavourable substrate. Ballinskelligs Bay is also largely free of kelp. Hog Head Island is the next area where kelp is recorded. From this point to Vedanona, further into Kenmare River, there is a high abundance of dense kelp beds.

Knocknasulhy to Vedanona, via West Cove, a distance of about 5 km, is suitable for *Ascophyllum* growth and is estimated to have the potential to produce 130 t of raw material per annum. There is a considerable occurrence of *Fucus* spp. in the area. Road and pier access to the seaweed is good.

Vedanona to Rossmore Island

From Vedanona to Parknasilla Hotel, a distance of about 8 km, the *Ascophyllum* beds vary in thickness from 1–6 m (see Figure 3.26). The weed quality is good, and it is estimated that at least 50 t per annum could be extracted from the area. There is a pier located at Gleesk which has good road access.

The kelp beds described thus far to Vedanona continue to the many islands near Garinish. These Islands are surrounded by extensive beds of abundant mixed kelps. Kelp coverage does not extend west of Rossdohan Island into Kenmare River.

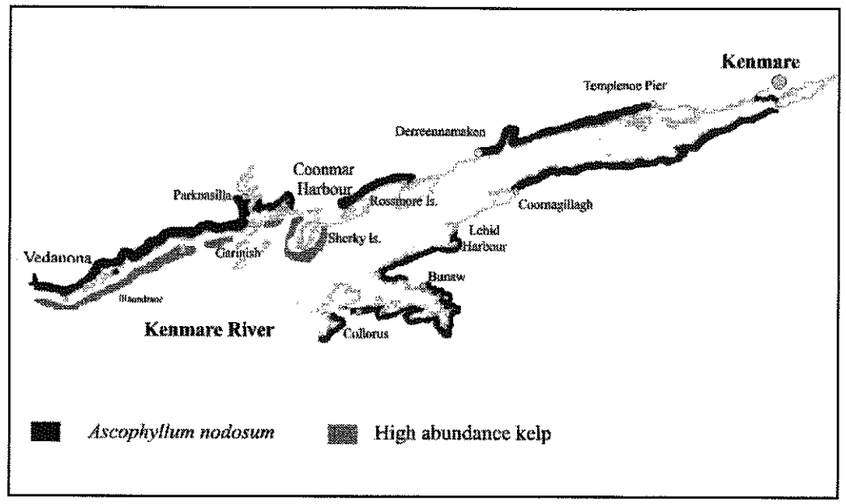

Figure 3.26 :
The seaweed resources of County Kerry from Vedanona to Collorus

The area from Coonmar Harbour to Rossmore Island has a very good coverage of *Ascophyllum*. The area is accessible by road and there is also a pier present. The weed is of excellent quality and it is estimated that this 2 km stretch could sustainably yield up to 150 t of material per annum.

Derreennamaken to Kenmare Pier

Derreennamaken to Templenoe Pier, a distance of over 5 km, has the potential to produce 90 t of *Ascophyllum* per annum. The weed is also of high quality and could be expected to regenerate within 4 years of harvesting.

Coornagillagh to Kenmare Pier, a distance of about 10km, has a very high abundance of *Ascophyllum*. The depth of the weed varies from 2–10 metres and given an average growth cycle of four years, this area could sustain the production of 500 t of raw material per annum.

Lehid Harbour to Collarus

Lehid Harbour has good landing facilities for seaweed. The site has a 2 km coverage of *Ascophyllum* and could sustain the production of 60 t per annum.

Bunaw to Collarus (including Derreen and Lauragh) covers most of Killmakilloge Harbour—the southern most part of County Kerry which has an *Ascophyllum* biomass. Seaweed depth varies from 1–10 metres in the area and has the potential to yield up to 100 t of high quality biomass per annum.

Kenmare River (Kenmare Bay) is currently extensively harvested by Kerry Algae. 1,800 tonnes of *Ascophyllum nodosum* was harvested in the Bay in 1996.

3.8 County Cork

Table 3g:
***Ascophyllum nodosum* harvested in Cork in 1996, the potential sustainable yield per annum and the length of coastline which the resource covers.**

Tonnes harvested in 1996	Potential sustainable yield in tonnes per annum	Length of coastline covered (km)
0	1,425	90

3.8.1 Introduction

The distribution of dense intertidal seaweeds in County Cork is more evenly spread than in neighbouring Kerry. Kenmare River, Bantry Bay, Dunmanus Bay and Roaringwater Bay are all rich in intertidal seaweeds. The widespread occurrence of *Fucus* spp. found in Kerry is also very common for many parts of Cork.

The vast kelp beds which occur off the Kerry coast extend into Cork. In fact, the majority of the subtidal regions along the Cork coast possess very dense kelp beds. The species composition of this kelp is similar to other regions of Cork and Kerry, as lengthy bands of *Laminaria digitata* populate the rocky lower intertidal regions and other species occur in the deeper areas. Dive studies off the Skeam Islands also showed that the deeper kelps such as *Laminaria hyperborea* were very heavily covered in epiphytic seaweeds such as *Palmaria palmata.*

3.8.2 Seaweed resource

Ardgroom Harbour to Ballycrovane Harbour

The seaweed survey of Cork began along the Kenmare River (see Figure 3.27). The area from the pier at Ardgroom Harbour to Cappul Bridge holds the potential for the production of 60 t of *Ascophyllum* annually. From here to Ballycrovane Harbour there is little by way of commercial quantities of *Ascophyllum*.

The area from Dogs Point to Kilcatherine Point and on into Ballycrovane Harbour is extensively covered in large, high abundance mixed kelp beds. There were some locations where the kelp reduces in abundance due to unsuitable substrates, but Kenmare River remains one of the most densly populated areas with kelp in Ireland.

The *Ascophyllum* in Ballycrovane Harbour was very long at the time that the survey was carried out and had not been cut for some time. The area covered in seaweed is only a few hundred metres in distance but the biomass is very dense and occurs in depths from 6 to 30m. It was estimated that about 20 t per annum could be harvested from this region.

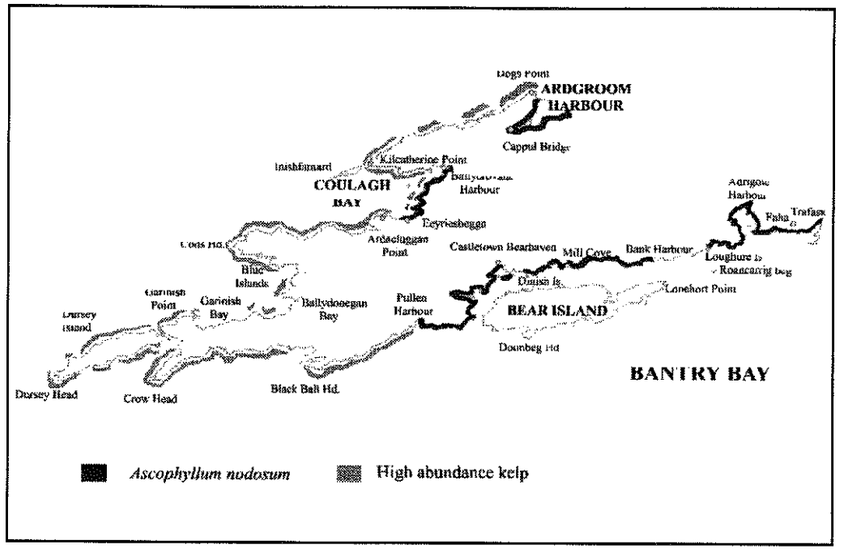

Figure 3.27:
Seaweed resources of County Cork from Ardgroom Harbour to Trafrask

Eeyriesbegga to Dursey Island

Eeyriesbegga was the last area in Kenmare River to be surveyed for *Ascophyllum* and no significant biomass is recorded here. There are extensive kelp beds recorded from Ballycrovane Harbour to Eeyriesbegga. From Eeyriesbegga to Ardacluggin Point the substrate is unsuitable for kelp growth. The biomass reappears in very large masses from Ardacluggan Point, is largely unbroken around Cods Head, and continues on into the Blue Islands.

These very extensive, abundant beds of kelp occur all around the peninsula and also around Dursey Island. There are areas where the biomass decreases, such as Ballydonegan Bay and Garnish Bay. The area is not considered to have a significant potential for *Ascophyllum* production.

Dursey Head to Castletown Bearhaven

From Dursey Head to Pullen Harbour, kelp beds of large abundance are common. There is no significant potential for *Ascophyllum* harvesting in the area. Pullen Harbour to Castletownbere Pier has a mixed density of *Ascophyllum* with bed depths reaching up to 5 metres in some places. The potential of the area is 80 t per annum.

The coast of Dinish Island has, for the most part, a heavy coverage of *Ascophyllum*. It is estimated that there is also 80 t of good quality weed to be harvested from the area per annum.

Castletown Bearhaven

'Celtic Sea Minerals' is the only commercial harvester of calcified seaweed (maërl) in Ireland. They harvest approximately 5,000 t of maërl per annum off Lonehort Point on the east side of Bear Island. Castletown Bearhaven is the main processing centre for the company who are developing value-added products from this unique material.

'Irises Seaweed Centre' is also located in Castletown Bearhaven. The centre uses limited amounts of the local resource but has been successful in helping to develop the body-care services aspect of the industry considerably in Ireland in the past five years.

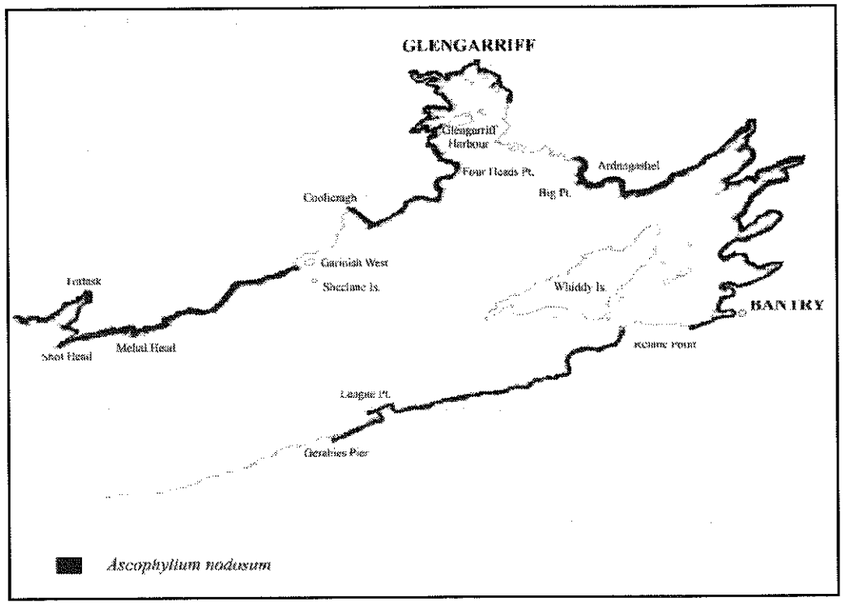

Figure 3.28:
Seaweed resources of County Cork from Trafrack to Glanalin

Mill Cove to Faha

From Mill Cove to Bank Harbour Pier (incorporating Rossmackowen and Coarrid Point), a distance of approximately 4 km, there is estimated to be a potential yield of 90 t of *Ascophyllum* each year. Many of the sheltered areas along this piece of coastline are lightly covered in old weed and much of the substrate is composed of shingle which is not conducive to dense growth.

From the mainland area facing Loughure Island to Faha, (which incorporates Adrigole Harbour) the seaweed varies from being dense and of high quality on the rocks at the Bay entrance to sparce and of low quality in the most exposed areas. The total harvestable potential for the area is 40 t per annum.

Coolieragh to Glengariff Harbour

The 7 km coastline from Coolieragh to Glengarriff Harbour has a very dense seaweed cover, of both *Fucus* spp. and *Ascophyllum*. It is estimated that the area could yield up to 250 t of the latter per annum.

Ardnagashel to Gerahies Pier

Ardnagashel to Bantry is very heavily covered in *Fucus* spp., having a potential of 30 t per annum of *Ascophyllum*. Relane Point to Gerahies Pier is similarly covered in large amounts of *Fucus* spp., with a number of expansive rocky areas supporting *Ascophyllum*. The potential for the area is 10 t per annum. The weed in this general area is of good quality and should have a regeneration time of 4 years.

Gerahies Pier to Glanalin

From Gerahies Pier to Glanalin, intertidal seaweed coverage is low. The subtidal regions along the area are densely covered in abundant beds of kelp. The beds extend around the peninsula and lead as far as Carrignacappul Head.

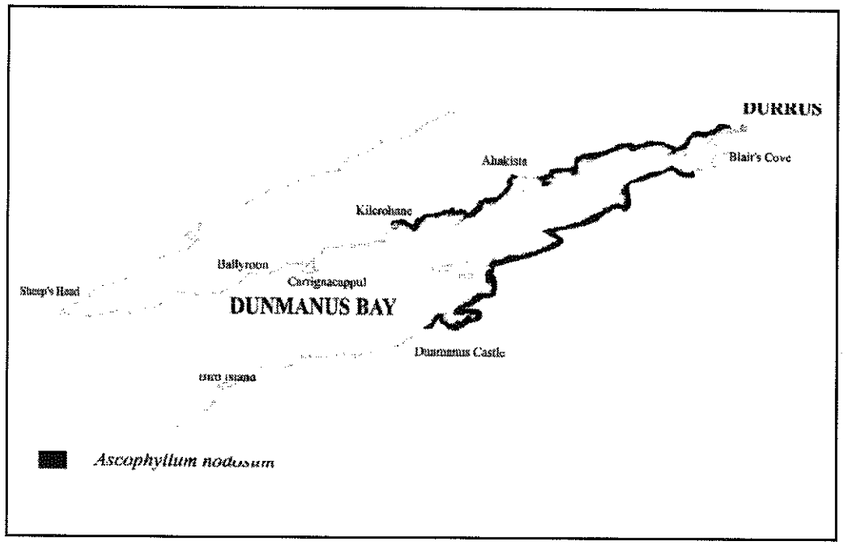

Figure 3.29:
Seaweed resources of Dunmanus Bay

Dunmanus Bay from Kilcrohane Pier to Durrus

The presence of *Ascophyllum nodosum* is recorded from Kilcrohane Pier to Durrus on the north side of Dunmanus Bay. The composition of the substrate was variable along the area, consistenting mainly of shale and rock which is condusive to the growth of *Ascophyllum*. There is estimated to be a sustainable harvest of 260 t per annum of good quality weed in the area. There is also a sizeable quantity of *Fucus* spp. in the area, being more localised to the muddy areas.

Blairs Cove to Dunmanus Castle

Blairs Cove to Dunmanus Castle (on the south side of Dunmanus Bay) is mainly composed of bare rock and mud where *Fucus* spp. commonly occur. For the most part, there is little by way of significant amounts of *Ascophyllum* present. The remainder of Dunmanus Bay is found not to be of commercial significance as an *Ascophyllum* source.

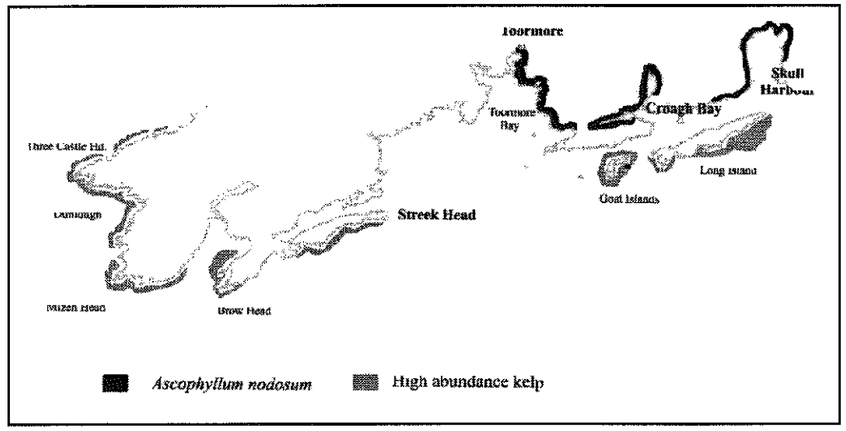

Figure 3.30
Seaweed resources of West Cork from Three Castle Head to Skull Harbour

Three Castle Head to Skull Harbour

The subtidal regions of outer Dunmanus Bay from Dunkelly to Streak Head are heavily covered in mixed kelps in large abundance. The abundance of kelp decreases around Toormore Bay. The Bay has a thin coverage of *Ascophyllum nodosum*, with a potential to yield about 10 t per annum for the inner regions. Much of the biomass that does occur in the region comprises very old weed. The outer reaches are too exposed for a large biomass to occur. There are good landing facilities in the Bay.

Crooagh Bay, to the north of Long Island, also has good landing facilities and, due to its relatively sheltered location, contains a heavy biomass of *Ascophyllum nodosum*. The weed is of good quality and the Bay has a potential of 50 t per annum.

Much of Skull Harbour is composed of bare rock and has no significant amounts of seaweed. It is capable of yielding 30 t of *Ascophyllum* per annum and has good landing facilities for the weed.

Roaringwater Bay

Moving into Roaringwater Bay, the kelp beds again become abundant. Goat Island Little is almost completely surrounded by large amounts of kelp with the west and south sides of Long Island heavily covered also. Castle Island to the east has a large covering of kelp on the west and south faces, with the three Calf Islands to the immediate south being completely surrounded by very dense kelp.

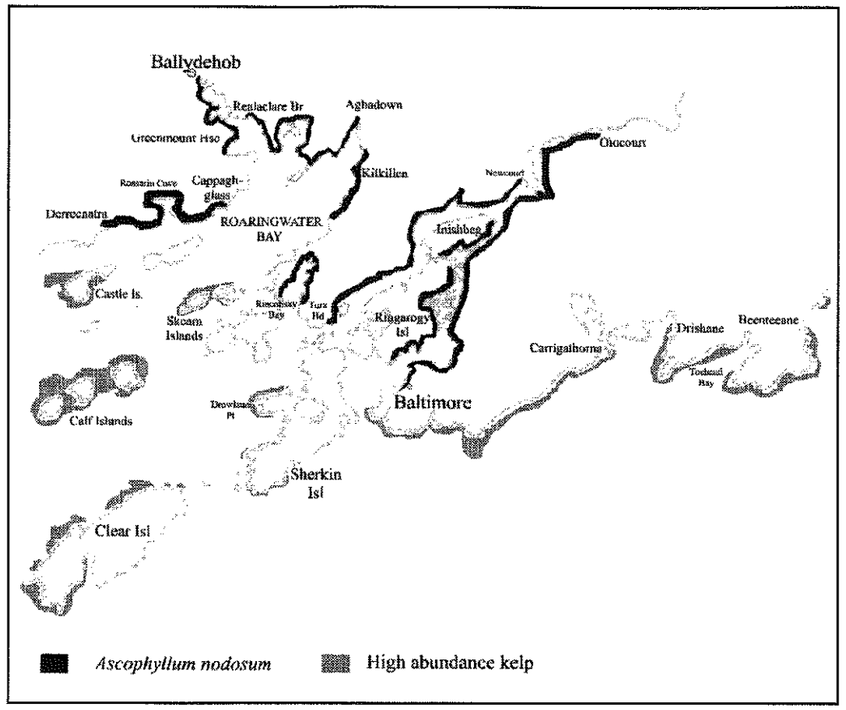

Figure 3.31:
Seaweed resources from Skull Harbour and Roaringwater Bay east to Toehead

Skeam West has a heavy covering of kelp as does the west side of Skeam East. The western faces of Clear Island and Sherkin Islands are also heavily covered in kelp. There are minor occurrences of kelp in the inner reaches of Roaringwater Bay, mainly confined to the more exposed rocky intertidal regions, for example, along the Goose Island Channel.

Dereenatra to Ballydehob

From Dereenatra to Cappaghglass there is a potential for about 80 t of *Ascophyllum* to be harvested per year. There is good access to much of the biomass due to the presence of a landing pier. There was also a significant amount of *Ulva* recorded in the area.

From Greenmount House to Ballydehob the annual harvestable biomass is 80 t. Harvesting in the area is made difficult due to the widespread occurrence of mixed weed and the fact that most of the entrance to Ballydehob Bay is composed of mud.

Ballydehob to Leap including Aghadown, Kilkileen and Turks Head

From inner Ballydehob Bay to Bealaclare Bridge there is also a good coverage of *Ascophyllum*, and it could sustain up to 80 t of harvesting per annum. The area is very muddy but the presence of a continuous line of rocks along the coast provides a suitable substrate for the occurrence of considerable amounts of weed.

From Realaclare Bridge to Aghadown the presence of mud continues to be a limiting feature. The area immediately around the castle has a very good coverage of seaweed which accounts for most of the 40 t of harvestable biomass per annum from the area.

The 2 km around Kilkileen was the next area that is potentially a source of *Ascophyllum.* There is a considerable amount of *Himanthalia elongata* in the area and a considerable coverage of *Fucus* spp. The general area could produce up to 30 t of seaweed per annum.

From Cunnamore to Turk Head, enclosing Rincolisky Harbour, there is a sustainable yield of 50 t of *Ascophyllum* per annum. The weed in the area is of high quality. The area is very rich in other seaweeds, with intermittant occurrences of kelp.

The coastline from Turk Head to Newcourt could yield up to 60 t per annum. Much of the substrate in the area is muddy but there are landing facilities available. The area from Newcourt to Baltimore could provide 60 t per annum, covering the remainder of mainland surrounding Ringarory Island.

The final area covered by the survey team was that between Glandore Harbour to Leap. The area could yield up to 40 t of *Ascophyllum* per annum. It also hosts a mixed population of *Fucus* species.

SECTION 4.
Conclusions and Recommendations

4.1 Conclusions

Ascophyllum nodosum

Over the past fifty years, the harvesting and processing of *Ascophyllum nodosum* has been the mainstay of the Irish seaweed industry. It is an activity that continues to provide much needed employment and income for coastal communities along the western seaboard. Considering the level of activity which the resource has supported over this past half century, it is encouraging to conclude that not only can the resource sustain current harvesting levels, but they could be doubled.

Arramara Teoranta are the major processors of *Ascophyllum* in Ireland, and have been responsible for the large scale development of this resource to date. The company recently celebrated its 50th anniversary by predicting that the next fifty years would see a successful continuation and expansion of their current activities. Given the strong commercial performance of the company in recent years, it would certainly seem that the mainstay of the current industry is safe.

Table 4.1:
***Ascophyllum nodosum* harvested by county in 1996, the potential sustainable yield and the length of coastline surveyed.**

County	1996 harvest (wet tonnes)	Potential (wet tonnes)	Length of coastline surveyed (km)
Donegal	8,250	16,430	350
Leitrim	0	0	0
Sligo	0	430	10
Mayo	4,400	16,600	300
Galway	21,200	37,470	350
Clare	100	1,140	60
Limerick	0	210	20
Kerry	1,800	1,140	90
Cork	0	1,425	90
Total	35,850	74,845	1220

The success of a number of other seaweed processing companies has also contributed to the unprecedented growth recorded for the industry in recent years. Kerry Algae is one such company, that is currently in the process of establishing an alginate plant in County Kerry. This report concludes that there is certianly enough by way of raw material available to sustain such a plant in addition to facilitating future expansion plans of Arramara Teoranta and the other companies in the industry.

Kelp

It is obvious from the present survey that Ireland has an enormous natural kelp resource covering approximately 56% of the west coast. This abundance comprises the five kelp species which are native to Irish waters (*Laminaria digitata, L. hyperborea, L. saccharina, Sacchorhiza polyschides* and *Alaria esculenta*).

In high wave-exposed areas, kelp biomass is generally low and large communities are not formed at depth. In areas where sand and mud are predominant on the substrate and in most estuarine regions, kelp coverage is restricted. In less exposed areas of the coast, where the substrate is suitable, large, dense beds are very common.

The kelp resources off the Irish west coast constitute one of our most valuable natural assets. Kelps have a very important role to play in the marine ecosystem, providing food and shelter for a whole host of other marine life. They have an important contribution to make to the amenity value of the Irish west coast—in maintaining its rich biodiversity and unique attractions to the ever increasing tourism industry.

To date, however, the full harvest value and potential of this resource has scarcely been identified and certainly not realised. Over four million tonnes of kelps are utilised (from farmed and naturally occurring stocks) worldwide each year. The economic implications for coastal communities and industry are considerable. The west of Ireland has many disadvantages with which to contend. Foresight and vision are required to look beyond those factors that impede our economic development and focus on those unique assets we possess in abundance. The millions of tonnes of kelp off our west coast is one such asset which could, subject to managed development, constitute a very important element in the economic future of the west of Ireland.

4.2 Recommendations

Seaweed Forum

The Irish seaweed industry had a turnover in excess of IR£5 million in 1997. This constitutes a 100% increase in sales value over the past four years. Capital investment in the industry over the period has been strong as has the level of investment in research and development.

The recent announcement by the Minister for the Marine and Natural Resources of the establishment of a 'Seaweed Forum' was greeted in the industry with enthusiasm.

It is recommended that the proposed Forum be instituted as soon as possible. It is suggested that it comprise a broad spectrum of industry members representing each of the main areas of activity including seaweed hydrocolloids, seaweed body care, sea-vegetables and seaweed extracts.

There are a number of key issues on which such a Forum should make recommendations to Government. Such issues include:

Seaweed access rights

The position with regard to seaweed access and harvesting rights in many cases is unclear. In order for full access to the seaweed resources to be achieved, a radical overhaul of the current situation needs to be instigated. There are currently thousands of tonnes of harvestable seaweeds being lost to seaweed rights disputes. No company would consider investment when the provenance of a resource is in doubt.

Licencing legislation

The situation with regard to seaweed harvesting licences needs also to be addressed urgently. A number of models from other countries are currently under review by the Irish Seaweed Industry Organisation (ISIO).

Maintenance responsibility of slipways and piers

At present, responsibility for the maintenence of many slipways and piers is disputed with the net result being that maintenance costs, by necessity, are being incurred by individual processing companies. Clarification of this issue is of immediate concern to the industry.

Appointment of a Seaweed Development Officer

At present, there is no State Agency, or individual within the Irish State Sector with a direct responsibility for the development of the seaweed sector. The ISIO, funded by the NUI (Galway) and the seaweed industry, is the only representative voice for the sector. In order for the industry to liaise with the State Sector it is essential that a dedicated Seaweed Development Officer should be funded.

Responsibilites of individual Government agencies

Current Government policy on the development of the seaweed sector is unclear. Given the issues facing the development of this sector (up-scaling, development of mariculture practices, new legislation) and the potential economic benefits, it is incumbent on Government to formulate a development policy and clarify the roles of the various State Research and Development Agencies in supporting this policy.

APPENDIX 1:
Kelp diving study results

Spiddal, Co. Galway

Transects were laid approximately 0.5 km west of Spiddal Pier at low water. The laminarians zone occurred as a belt approximately 100 m wide and ran parallel to the shore from the low water mark. The belt of laminarians was not uniform in distribution but was broken up by patches of sand which varied in size and shape. The shore consisted of boulders of varying size and these extended below the low waterline and made up the substrate on which the laminarians were attached. The weed occurred in depths ranging form 1 m at the shore to 9 m at its outer edge at low water. The limiting factor for weed cover was the availability of suitable substrate. Plants varied in size with bunches of small saplings dispersed among the large stipes. Densities of large plants varied between 70–100/20 m^2 (4–5 m^2) which increased to 200–300/20m^2 (10–15/m^2) when saplings were included. The distribution of the adult plants was relatively even through the transect with the saplings occurring in bunches. *L. digitata* and *L. hyperborea* were the main species present with the occasional *L. saccharina* and *S. polyschides* individuals.

Three additional transects were taken at the outer edge of the laminarian zone. Plants were mostly adults and their distribution over the transect was patchy. Densities varied between 23 and 29/20m^2 (circa. 1/m^2).

Spanish Point, Co. Clare

Transects were laid near Spanish Point, Co. Clare, at low water in October, 1996. The laminarian zone extended from the shore to offshore reefs where depths increased suddenly going from, 10 m to 30 m. The limiting factor for weed cover in this area was depth and exposure. The transects were laid in 12–15 m of water.

The shore consisted of stepped flagstone which descended to and below the low water mark and continued out of the reef. Three transects were laid between the shore and the outer reef. The majority of plants were adult with occasional saplings present. Densities of large plants varied between 60-70/20 m (circa 3 m^{-2}), their distribution was relatively even through the transect. *L. digitata* and *L. hyperborea* were the main species present with occasional *L. saccharina* individuals. Red algae were common throughout the area.

Mullaghmore, Co.Sligo

Transects were laid off Mullaghmore Point, Co. Sligo, at low water in December, 1996. The laminarian zone extended from the shore to approximately 15m depth. The limiting factor for weed cover in this area was depth and substrate. The transects were laid in 8–15 m of water.

The shore consisted of stepped flagstone which descended to the low water mark after which the sea bottom consisted of large boulders of varying size. Three transects were laid between the shore and the 15 m depth mark. The majority of plants were adult with occasional saplings being present. Densities of plants in 5–10 m depth varied between 97–110/20 m^2 (circa. 5/m^2), their distribution was relatively even through the transect. *L. digitata* and *L. hyperborea* are the main species present. In deeper water (15 m), densities were much reduced, varying between 10–20/20 m^2, and plants were significantly smaller.

APPENDIX 2:
Statistical analysis

Statistical Approach

For five sites, data existed on the actual harvested biomass for a period of ten years. The rate of biomass removal at all of these sites were considered to represent the maximum sustainable yields of the beds. It was thought, therefore, that comparison of the estimates of potential sustainable productivity for these beds with the actual figures would give an indication of the accuracy of those estimates. In addition, by developing a statistical relationship between the esimated and measured productivity at these sites, the accuracy of the estimate of total sustainable harvest could be assessed, and appropriate confidence limits be calculated for that estimate. Subsidiary variables are commonly used in survey sampling designs (Mendenhall *et al.,* 1986). In this case, a ratio estimator was used, where total harvestable yield was estimated by developing a ratio between estimated sustainable potential productivity and the measured harvested biomass at the five sites. Ratio estimators are most effective when the relationship between the response variable, y (in this case, annual sustainable harvest of seaweed and the subsidiary variable, x (estimated potential sustainable harvest) are linear through the origin, and the variance of y is proportional to x. These conditions were met reasonably well in the present case. However, ratio estimators can be biased in cases when $n < 30$. Here, $n = 5$. The total sustainable annual harvest of seaweed was calculated according to the formula;

$$\tau\exists_y = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i}(\tau_x) = r\tau_x$$

x_i = estimated potential sustainable harvestable seaweed of site i;

y_i = actual annual harvested biomass, averaged over ten years, for site i;

τ_x = total estimated potential sustainable harvest of seaweed;

$\tau\exists_y$ = calculated sustainable harvest;

The estimates of potential sustainable harvestable biomass, summed over the five sites, was 3,480 tonnes: the sum of the average (over 10 years) annual harvests for these areas was 2,554 tonnes. The estimate for harvestable seaweed, summed over all sites of the study area was 74,953 tonnes. Therefore the total calculated harvestable seaweed was calculated as:

$$\frac{2{,}554}{3{,}480} * 74{,}953 = 55{,}009\ tonnes$$

The variance associated with this estimate is calculated as:

$$s^2 = \tau_x^2 \left(\frac{1}{\mu_x^2}\right) \frac{\sum_{i=1}^{n} (yi - rxi)^2}{n-1} = 56.968{,}617 \; tonnes^2$$

Here, τ_x is estimated by $\bar{x}$; and $n = 5$.

95% confidence bounds on the calculated harvestable seaweed are calculated as:

$$\tau\exists_y \pm t_{0.05,4} * \sqrt{s^2}$$

Therefore, on the basis of the data collected, we can state with 95% confidence, that the total annual sustainable harvest of seaweed is no greater than 75,965 tonnes.

APPENDIX 3:
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APPENDIX 4:
Current Seaweed R&D Projects

Marine algae research projects currently being funded under the Marine Research Measure (Operational Programme for Fisheries 1994–1998) administered by the Marine Institute and part funded by the European Union's Regional Development Fund include:

Strain selection of edible brown seaweed as a key dietary component of high value shellfish

Martin Ryan Marine Science Institute, NUI, Galway

Development of a new seaweed-based hydroseeding process for soil stabilisation and vegetation

School of Science, Institute of Technology, Tralee
Kerry Alginate Ltd.
Kerry County Council

Processing systems for commercially utilised sea vegetables

Irish Seaweed Industry Organisation
Carraig Fhada Seaweeds Ltd.

The distribution of maerl beds around Ireland and their potential for sustainable development

Aquatic Services Unit, NUI (Cork)
Irish Seaweed Industry Organisation
Martin Ryan Marine Science Institute, NUI (Galway)
Irish Hydrodata Ltd.
Celtic Sea Minerals Ltd.

Mapping and assessment of exploitable algal biomass off the west coast of Ireland

Irish Seaweed Industry Organisation
Martin Ryan Marine Science Institute, NUI (Galway)
Arramara Teo.
Coastal Resources Centre, NUI (Cork)

Strain hybridisation field experiments and genetic fingerprinting of the edible brown seaweed *Alaria esculento*

Depart of Botany, NUI (Galway)
Taighde Mara Teo
Irish Seaweed Industry Organisation

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Chris Hession

Manager, Irish Seaweed Industry Organisation (ISIO)

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