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The sustainable harvesting of *Ascophyllum nodosum* (Fucaceae, Phaeophyceae) in Ireland, with notes on the collection and use of some other brown algae

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Abstract Ireland has a long history of seaweed utilisation, with accounts of its use as a food dating to at least the twelfth century. *Arramara Teoranta* (literally "Seagoods Ltd.") was established by the Irish Government in the late 1940s to continue the long tradition of sustainable seaweed harvesting in the west of Ireland, which began with kelp ash production from kelp kilns around 1700 and which continued sporadically until 1948. Initially, *Arramara* purchased dried sea rods (*Laminaria hyperborea*) and kelp fronds (mostly *Saccharina latissima*) and these were exported for alginate production in Scotland. Kelps were gradually replaced by *Ascophyllum nodosum*, a perennial wrack found in the intertidal of the North Atlantic and which is particularly common on sheltered shores in the west of Ireland. This wrack has been cut sustainably by hand in Ireland since at least the late 1940s. Figures for annual production from the main purchaser, *Arramara*, show that 2,000–7,000 dry weight tons (about 8,000–28,000 wet tons) have been cut in Ireland each year from 1964 to date. Whilst exports for alginate production ceased in 2009, 5,000–6,000 dry weight tons are currently being produced for the animal feed, horticulture, aquaculture, and cosmetics markets.

Keywords *Ascophyllum* · Harvesting · History · Ireland · Sustainable use

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Introduction

Ireland has a long history of the utilisation of seaweed (see Ó hEocha 1958; Guiry and Blunden 1981; Guiry 1997; Guiry and Hession 1998; Harper 1974; Kelly et al. 2001). There is evidence of seaweed being gathered as food since at least the twelfth century (Ó Madagáin 1994), and kelp burning was a critical component of the economy of the west of Ireland in the eighteenth and nineteenth centuries O'Sullivan and Downey (2010) recognised three phases in the Irish seaweed industry since the 1700s: (1) the Alkali Phase (1700–1820), during which kelp ash was used in soap-making, dying, paper and glass-making, and in bleaching linen; (2) the Iodine Phase (1820–1940), during which the ash was a source of iodine for medicinal and photographic purposes; and (3) the Alginate Phase (1940s onwards), during which the whole seaweed was processed for the extraction of thickening agents for food and cosmetics.

From the late 1940s, the collection and processing of a number of alginate-producing seaweeds, of which *Ascophyllum nodosum* was the most important, was the business of a State-owned company, *Arramara Teoranta* (http://www.arramara.ie). The material destined for alginate processing was sent to Scotland initially by ship and later by road and ferry, and no extraction plant was ever built in Ireland despite several attempts. The sustainable harvesting of *A. nodosum* in Galway as a soil conditioner preceded the establishment of *Arramara* by at least a century (Baardseth 1955). After the establishment of *Arramara*, sustainable harvesting quickly spread to Counties Galway, Mayo and Donegal. By using simple techniques of 4–5 years' fallowing and leaving sufficient material for regeneration, the harvested Irish *Ascophyllum* populations have produced a sustainable yearly harvest of 5,000–28,000 tons wet weight for *Arramara* until the present day.

A brief history of seaweed use in Ireland

Both drift and attached seaweeds (mostly kelps and wracks) have been gathered on the coast of Ireland for centuries as a critical supplement for the impoverished post-glacial soils of the west of Ireland stripped of their coastal bogs, probably in Neolithic times, and as human food and feed for animals. Seaweeds were also an economic resource: in the eighteenth and nineteenth centuries, kelp was gathered and burnt in kelp kilns on the west, north and north-eastern coasts of Ireland (Kirwan 1789; Harper 1974; McErlean 2007) to make kelp ash, sold initially as a source of nitrates and phosphates for use as a fertiliser and in soap-making, as a bleaching agent in linen manufacture, and, after its discovery (in kelp) in 1812, as a source of iodine. The first report of exports of kelp ash dates from 1702 when 118 tons were exported from Ireland rising to a peak of 5,410 tons in 1809 (cited in Harper 1974). As in the Western Isles and Orkney Islands, Scotland, kelp ash became a reason for some landlords in the west of Ireland to impose rack rents on their costal tenants and was a source of great anguish and anger (Robinson 2011).

Kinahan[1] (1869, p. 336) reported that "the average quantity of … kelp [meaning kelp ash] sent yearly from the shores of Yar-Connaught [Connemara] is 2,500 tons …" suggesting that at least 100,000 wet tons of kelp were used in its manufacture. The cast kelp, according to Kinahan, was gathered by everybody, but attached kelp was cut by men in boats and transported by women and children, often carrying heavy loads up steep coastal paths on their backs (Fig. 1).

Kinahan (1869, p. 336) also says that "On many of the outlying islands off the coast of Yar-Connaught there are huts which, during the summer months, are inhabited by herds of women, solely for the purpose of carrying up, spreading, and saving the weed thus procured." Kelp-burning was in existence in Ireland from about 1700 (Harper 1974) and may have been introduced into Scotland from there (Clow and Clow 1947). Richard Kirwan (1733–1812), an eminent early Irish chemist, was the first person to establish the amount of alkali in kelp with any certainty (Kirwan 1789). The burning of kelp in the mid-west, particularly in Connemara and on the Aran Islands, persisted until about 1948 and the remains of kelp kilns can still be found in the remoter parts of mid-western Ireland (Robinson 2011).

At least 35 entities are recognised by Mac Con Iomaire (1938) as being used in one form or another in Connemara, specifically in the *Muigh Inis* (*Maínis*) area near Carna. Most of these were used as food and the modern equivalents in Irish (*Gaeilge*), English and Latin are given by Guiry (2012, pp. 184–187), who lists 67 Irish names for seaweeds drawn from reliable sources, some of which are in use since at least the twelfth century.

Because of the long history of seaweed utilisation in the mid-west and north-west of Ireland, particularly in areas disadvantaged economically, it is not surprising that the Irish State sought in the late 1940s to encourage the development of an indigenous seaweed industry. To this end, the Irish Government set up a state-sponsored company initially known as Alginate Industries (Ireland) Ltd, which was incorporated in 1947. The company name was changed in 1955 to *Arramara Teoranta*. The name literally means in English "Seagoods Ltd.", derived by eliding *Earraí na Mara*.[2]

In 1947–1948, the eminent Norwegian scientist Egil Baardseth was funded by the Institute for Industrial Research and Standards (an Irish Government body, later incorporated into the Industrial Development Authority) to carry out a study of the "Regrowth of *A. nodosum* after harvesting". Whilst Dr. Baardseth submitted his report in 1949 (type script at NUI Galway), it was not published until 6 years later (Baardseth 1955). In his report, Baardseth (1955, p. 1) says that he utilised a site at Grattan Road in Galway as "this shore had an extensive and remarkably luxuriant growth of *Ascophyllum*. Farmers come every year in the spring to cut and take away several cart-loads of *Ascophyllum* as manure. They then let the harvested areas rest for about 3–5 years, after which a new harvest of *Ascophyllum* is gathered". This seems to be the earliest report of the sustainable harvesting of *Ascophyllum* in the area; but it also appears that this practise was the inspiration for the sustainable use of *Ascophyllum*. Baardseth was able to recognise the "patches" of shore that had been harvested 1–5 years previously and to compare the regrowth of *Ascophyllum* in these patches and in doing so to show that sustainable harvesting was possible provided the "cutters" leave behind sufficient material: "It may be asked whether an area which has been harvested and reharvested several times in succession may not at last become deprived of its vegetation of *Ascophyllum* or at least to have its productivity gradually lessened. There is not the slightest danger of this happening, it seems, as long as holdfasts and stumps are left behind after each cutting. The annual harvesting of this species in Eire [*sic*] is century-old without degeneration phenomena ever being noticed. In other words, the cutting itself does not make the new weed weaker in any way and the main reason for this must be sought in the great regenerative power of this species".

[1] George Henry Kinahan (1829–1908) was Senior Geologist with the Geological Survey of Ireland.

[2] A number of Acts of the *Oireachtas* [Irish Parliament] relate to the share ownership of this company: Alginate Industries (Ireland) Limited (Acquisition of Shares) Act, 1949 and 1954 and *Arramara Teoranta* (Acquisition Of Shares) Act, 2002, each of which are available at http://www.acts.ie

Fig. 1 Nineteenth-century illustration from Kinahan (1869) showing men cutting seaweed in the surf and women and children carrying the wet weed in baskets up steep coastal paths where it was spread for drying prior to being burnt in kelp kilns

Baardseth's conclusion that *Ascophyllum* could be repeatedly harvested has been borne out by the fact that this seaweed has been sustainably cut by hand in Ireland on an industrial scale since the establishment of Arramara Teoranta. In the present paper, we describe the harvesting of *Ascophyllum* in Counties Donegal, Mayo and Galway from 1964 to 2012 together with information on the collection and use of some other brown algae.

Materials and methods

Annual figures for the collection of *A. nodosum* (1964–2012), *Laminaria hyperborea* stipes (1949–1997) and *Saccharina latissima* fronds (1959–1966) were obtained from the company records of *Arramara Teoranta*, together with a breakdown of harvests of *Ascophyllum* from 11 areas in Counties Galway and Mayo in the mid-west of Ireland from 2005 to 2011: Kinvarra, Co. Galway; *Cuan Chill Chiaráin* (Kilkieran Bay), Co. Galway; Carna and *Maínis* (Mweenish), Co. Galway; Cashel and Roundstone, Co. Galway; Ballyconneely, Co. Galway; *Rosmuc*, Co. Galway; *An Cheathrú Rua* (Carraroe) and *Leitir Mór* [Lettermore], Co. Galway; *Leitir Mealláin* (Lettermullan), Co. Galway; Clew Bay, Co. Mayo, *Acaill* (Achill); and *Béal an Mhuirthead* (Belmullet), Co. Mayo.

Ireland is divided into administrative counties; the region known as Connemara in English and *Conamara* in Irish is entirely in County Galway.

Nomenclatural authorities for Latin binomials are unnecessary here and may be found in AlgaeBase (Guiry and Guiry 2013).

Ascophyllum is known in Ireland as *Feamainn Bhuí, Feamainn Bhuí Bhoilgíneach* in Irish (Guiry 2012), and as Knotted Wrack and "Asco" in English. Egg Wrack is a name applied in Britain to this species that we have not heard in Ireland. In Northern Ireland, Bladderwrack is seemingly applied both to *A. nodosum* and *Fucus vesiculosus* (McErlean 2007).

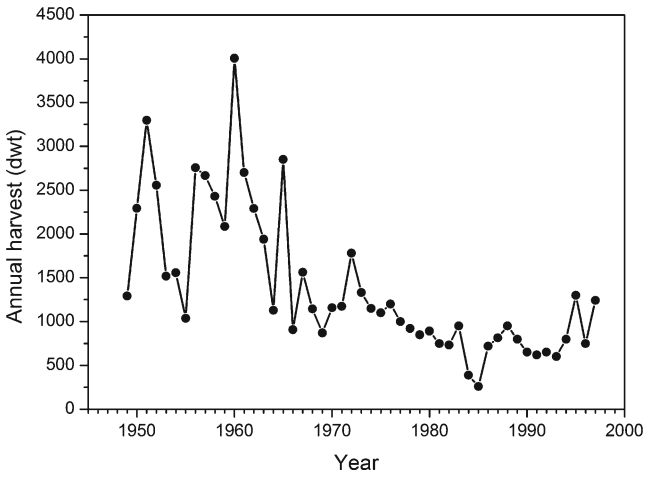

Fig. 2 Annual purchases of sea rods (*L. hyperborea*) by Arramara Teoranta, Connemara between 1949 and 1997 (*dwt* dry weight tons)

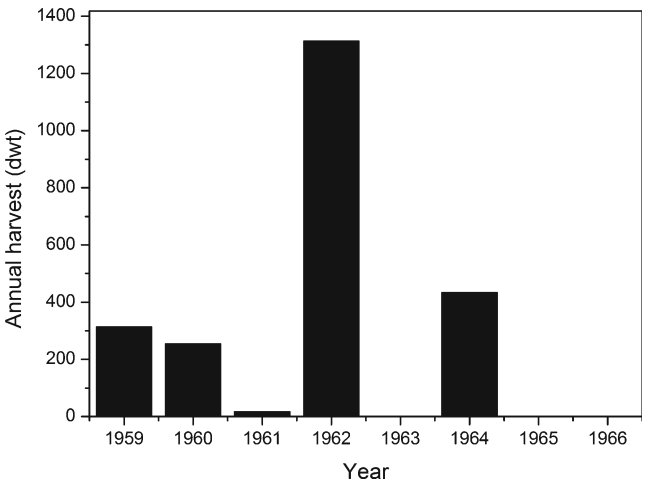

Fig. 3 Annual purchases of kelp fronds (mostly *L. saccharina*) by Arramara Teoranta, Connemara between 1959 and 1966 (*dwt* dry weight tons)

Results

From 1949 to 1997, Arramara purchased through agents dried "sea rods" (*L. hyperborea*) collected from cast in Counties Clare, Galway, and Mayo (Fig. 2). The quantities available varied greatly, from 4,000 dry tons in 1961 to only 500 tons in 1987. It seems that the amounts of rods deposited on these shores depended on the direction of the wind during stormy weather but, after 1970 there was a decline in the numbers of individuals willing to collect such material.

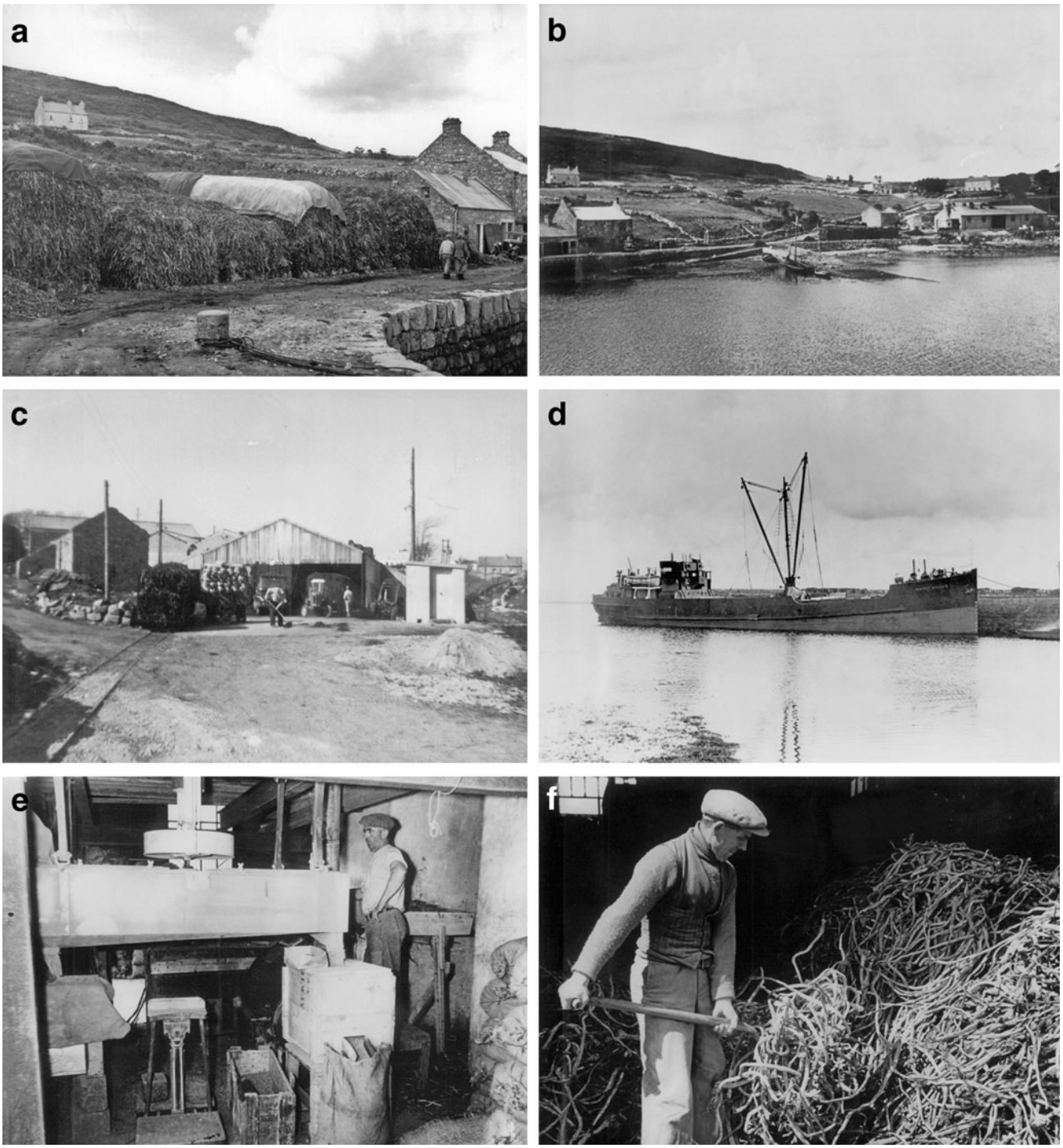

Fig. 4 **a**–**f** Drying and processing seaweed by Arramara Teo in the 1960s. **a** Dry kelp stipes being stored prior to shipping. **b** Arramara Teo factory site at *Cill Chiaráin*. **c** Arramara Teo drying facility. **d** *Saint Angus* coaster at *Cill Chiaráin* pier. This vessel transported 300 tons (dry weight) at a time and came 4–5 times/year. **e** Bagging dried *Ascophyllum* in drying plant. **f** Dried kelp stipes. Photographs © Arramara Teo

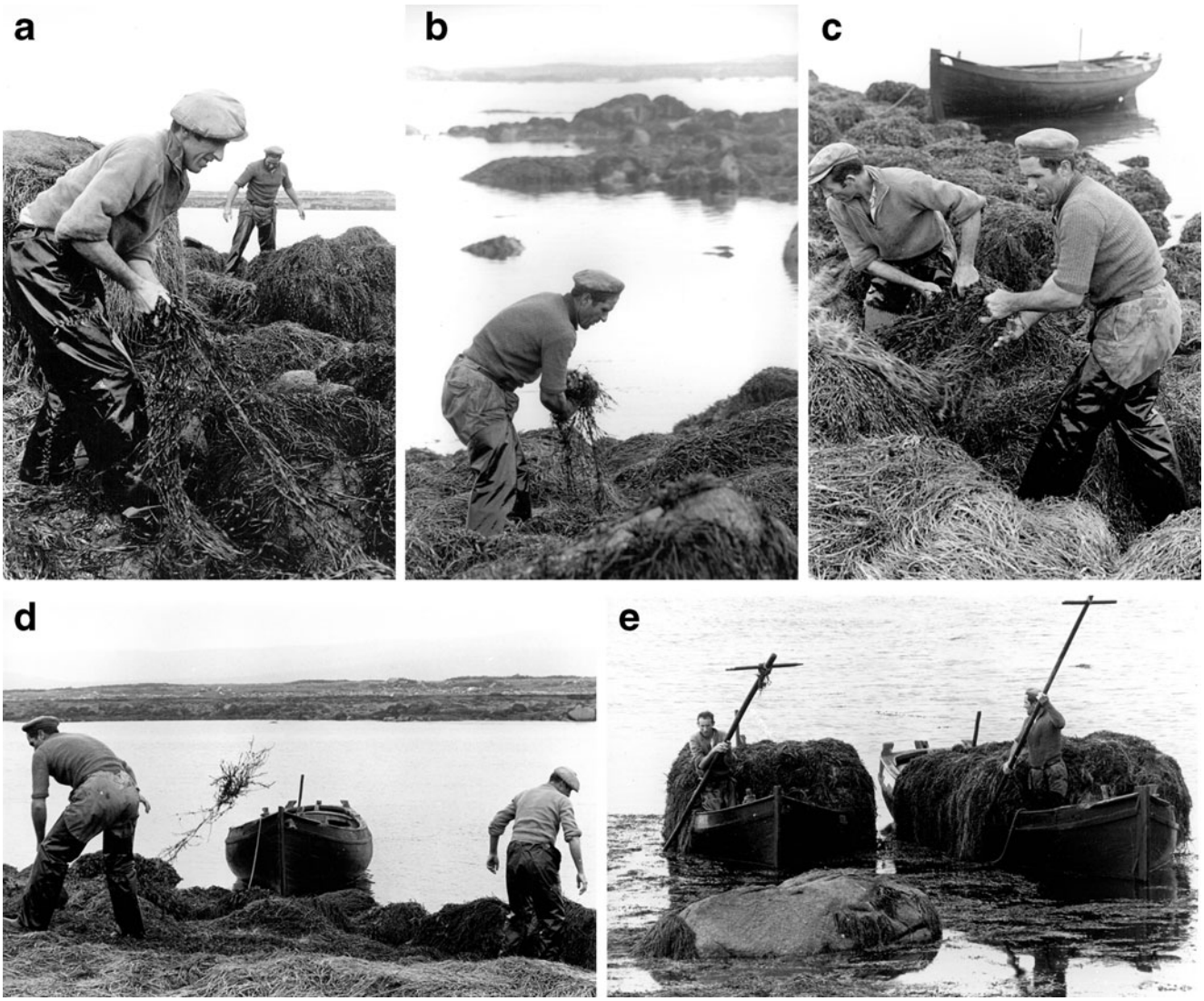

Fig. 5 **a**–**e** *A. nodosum* harvesting in Connemara in the 1960s. **a**–**c** Harvesters cutting weed. **d**, **e** Transporting weed in *báid iomartha.* Photographs © John Reader

Stipes were stored in the factory at *Cill Chiaráin* (Fig. 4a–f) until sufficient material had accumulated for their transportation to Scotland for processing for alginate extraction. It seems that alginate of a particular quality and structure was obtained from these stipes. At no time has *L. hyperborea* been dredged in Ireland as it is in Norway (Jensen 1998).

From 1959 to 1966, *S. latissima* (formerly *Laminaria saccharina*) fronds were collected—mainly in Connemara—dried and exported to Scotland for alginate extraction. Again, the quantities collected varied considerably from 1,300 dry weight tons in 1962 to virtually nothing in 1963, 1965, and 1966 (Fig. 3). Purchase of this material ceased in 1967.

In 1963 and 1968, respectively, factories were built by *Arramara Teoranta* at *Cill Chiaráin* (Kilkerrin) in Connemara and at Meenmore Quay, Dungloe in Co. Donegal, for the storage of kelp stipes and fronds (above) and for the drying of *Ascophyllum*. As part of a restructuring of *Arramara Teoranta*, the Meenmore plant was closed in July 2001, and no further *Ascophyllum* was purchased in Donegal from this time (Fig. 6). Figures 5 and 6 show the plant at *Cill Chiaráin* in the 1960s. Fortuitously situated in a sheltered harbour with extensive berthing facilities (Fig. 4b, d) at the head of *Cuan Cill Chiaráin*, the site has good road and other facilities. Initially, a small coaster, the *Saint Angus* (Fig. 4d) was used to transport dried seaweed to Alginate Industries facilities in Scotland, but subsequently road transport was exclusively used through Larne in Northern Ireland.

Ascophyllum harvesting in Ireland is really a simple process and has not been mechanised. Plants are cut by hand using a small knife by gathering the fronds in one hand and cutting, leaving about 25 cm at the base for regeneration (Fig. 5a–e, taken in the 1960s). The harvesters know from years of experience how much to leave and how often a

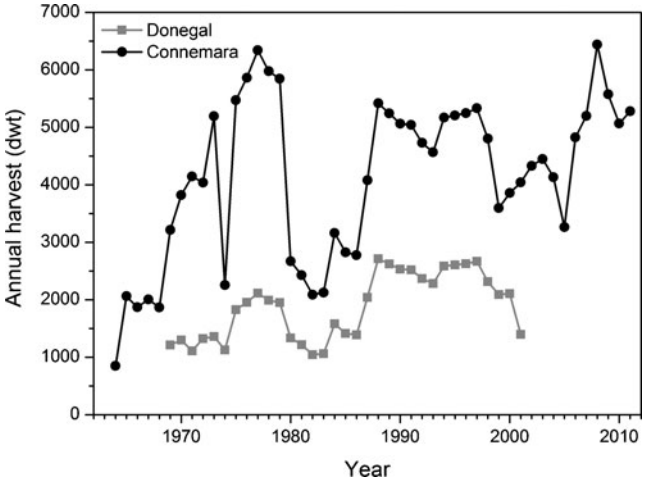

Fig. 6 Annual harvest of *A. nodosum* between 1964 and 2011 (*dwt* dry weight tons). Data for *Arramara Teo* factories in Donegal (Meemore Quay) and Connemara (*Cill Chiaráin*)

particular population can be harvested. In some areas it is possible to harvest on a 3-year cycles, and in others a 5-year cycle is necessary; however, in most a 4-year cycle is used.

Experienced harvesters in Connemara have made an art of making seaweed bundles, locally called *climíní* (literally, bundles), where the bundles are tied off with ropes and allowed to float to the top of the shore. These floating *climíní* are then rowed to small harbours where the weed is collected by lorries and transported by road to the drying plant. In former times, the weed was loaded onto *currachaí* (currachs, timber boats of approximately 6 m in length), and forked onto quaysides or delivered directly to the drying plant.

The annual harvest in dry tons (4 wet tons on average yielded 1 dry ton; a "dry" ton is about 12 % moisture) for the Donegal and Connemara drying plants is shown in Fig. 6. The trends were remarkably similar in both plants. From 1965 to 1980, the harvest at *Cill Chiaráin* increased from 1,000 to over 6,000 tons in 1978 and remained more or less at this level until 1980 when an international economic recession took hold and from 1981 to 1985 annual production was 2,000–3,000 tons. An improving international economy from 1986 saw increases in production to 5,000–6,000 tons annually from 1987–1997. Increasing competition in the international markets from 1997 saw a decrease in demand for the dried weed and Arramara began to sell some of the material as an agricultural and horticultural fertiliser and as an animal feed supplement. From 1999 to 2005, production stabilised at 3,500–4,500 tons/annum. From 2005, mainly as a result of a change in ownership, *Arramara's* requirements for alginate extraction decreased dramatically and the company was entirely reliant on its own sales into its other developing markets, as mentioned above. Production steadily increased from 2005 and in the last 8 years has stabilised at 5,000–6,000 tons annually.

Similar trends are apparent at the Donegal factory, which started processing weed in 1969, but which closed in 2001. The drying plant produced annually 1,000–2,500 tons during this period.

The amounts of *Ascophyllum* harvested in particular localities in Counties Galway and Mayo are shown graphically in Fig. 7 and the localities are shown in Fig. 8. Arramara has historically seen the greatest amount of its raw material come from the *Gaeltacht* (Irish speaking) areas of *An Cheathrú Rua/Leitir Móir* [Carraroe/Lettermore] and *Cill Chiaráin*, *Camus* and *Rosmuc*. This part of Connemara is blessed with a convoluted and sheltered shoreline relatively easy of access and mostly rocky in character, and with numerous small piers, many of which were built by the Congested Districts Board from 1891 to 1912.

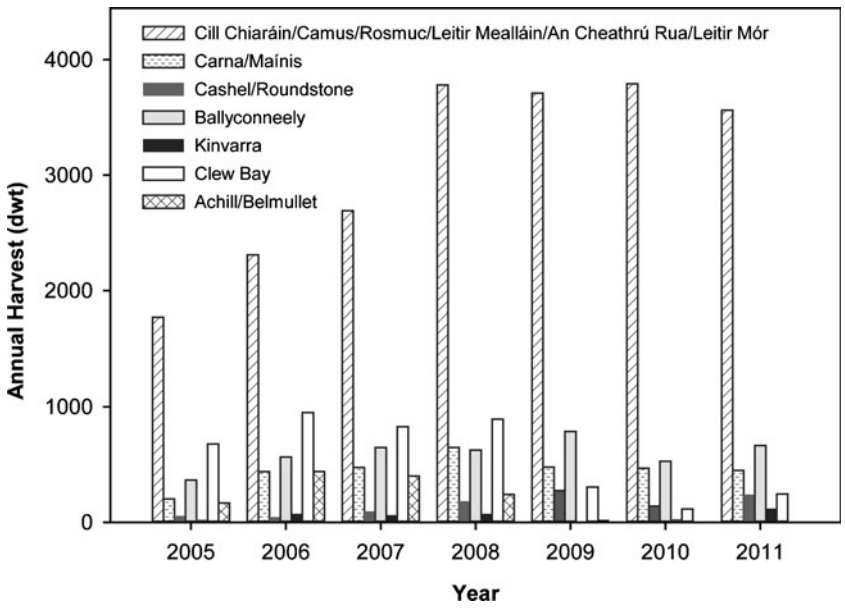

Fig. 7 Annual harvest of *A. nodosum* between 2005 and 2011 (*dwt* dry weight tons) from different regions of the west coast. Localities are shown in the map in Fig. 8

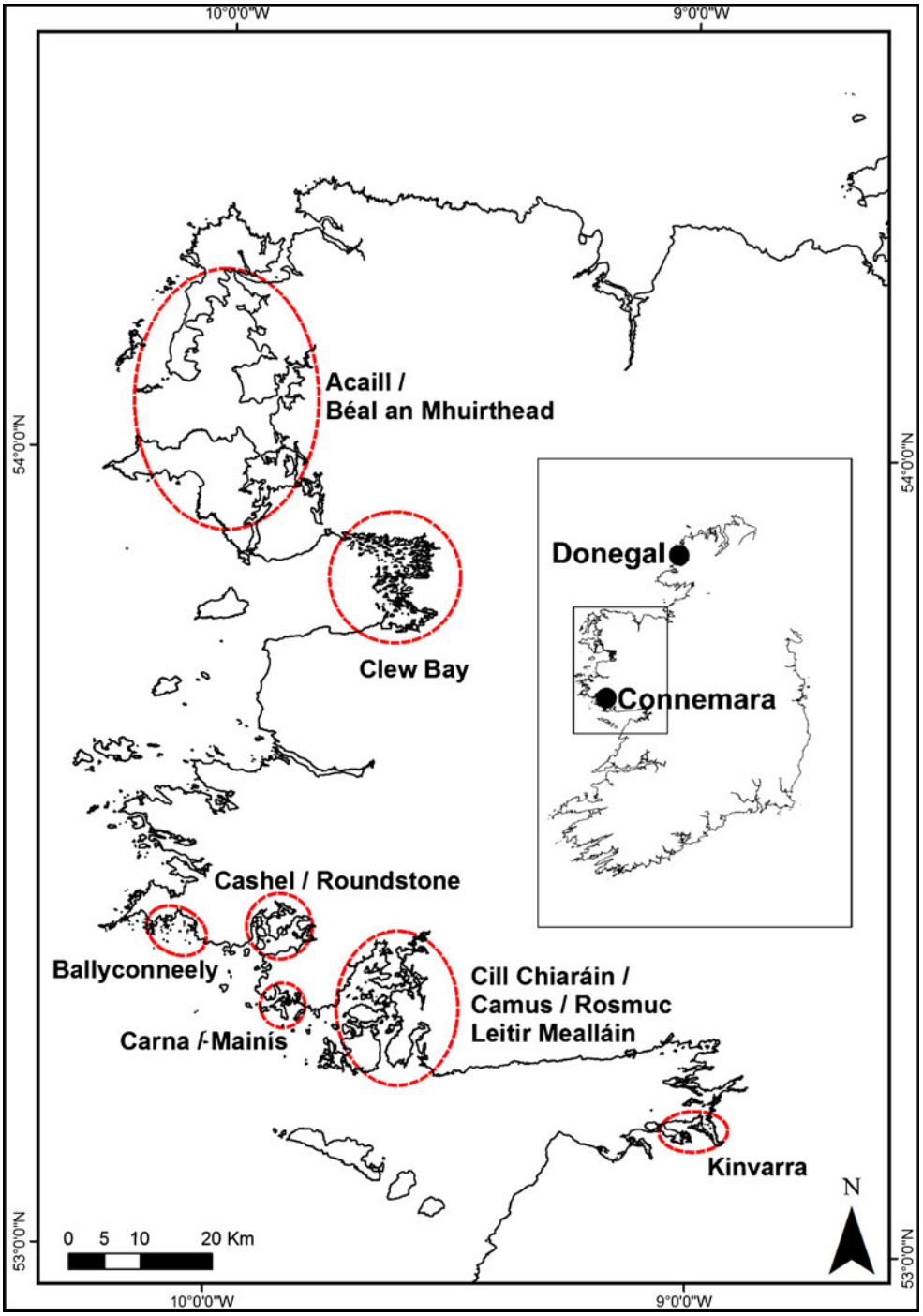

Fig. 8 Sources of *A. nodosum* purchased by *Arramara Teo* in Ireland. No further weed was sourced from the Donegal plants at Meenmore Quay after 2001. The other areas are in Counties Galway and Mayo, and the relative amounts purchased for each are shown in Fig. 7. Most weed comes from the *Cill Chiaráin*, *Camus*, *Rosmuc*, and *Leitir Mealláin* area

Discussion

Arramara Teoranta was one of the earliest companies to be established by the Irish Government and, despite the vicissitudes of the international market for seaweed, has survived for nearly 65 years. During this time it has given employment to many hundreds of seaweed harvesters and factory operatives, particularly in the *Gaeltacht* areas of Connemara. It is no exaggeration to say that Arramara has been pivotal to the economy of the *Gaeltacht*, and is certainly the longest-established company in the Irish-speaking areas.

Not alone does the survival of Arramara show that such a company can thrive in such a remote and disadvantaged area, but its harvesting of *Ascophyllum* for nearly 50 years shows clearly that this seaweed can be sustainably harvested without any diminution of the productivity of the beds. This strongly supports Baardseth's (1949, 1955) conclusions.

Whilst the original area off Grattan Road, Galway studied by Baardseth (1949, 1955) has been extensively transformed by reclamation of land from the sea by Galway City, extensive and luxuriant populations can be found from inside the Mutton Island Causeway (completed in 2004) to Nimmo's Pier, and recently (Spring 2012) there are clear signs that this population has again been harvested thus continuing a tradition that seems to be at least several centuries old, and one that does not seem to have done any discernable damage.

Annual production figures clearly show that 2,000–7,000 dry weight tons (about 8,000–28,000 wet tons) have been harvested sustainably in Ireland each year from 1964 to date. Whilst exports for alginate production in Scotland decreased from 2005, 5,000–6,000 dry weight tons are currently being produced for the animal feed, horticulture, aquaculture and cosmetics markets.

Whilst Boaden and Dring (1980) concluded that [in Strangford Lough in the north–east of Ireland] "… *Ascophyllum* harvesting has a significant and persistent effect on shore ecology. Littoral algae are a valuable commercial asset but it is important that some fairly large intertidal areas should be left unharvested for general conservation purposes". This is generally true for all harvesting practices. A further study of the effects of harvesting in Clew Bay and south Connemara by Kelly et al. (2001) over an 18-month period found no discernable effects on diversity of mechanical or hand harvesting, although *F. vesiculosus* cover increased at both sites.

Cullinane (1984) and Hession *et al* (1998) carried out an assessment of *Ascophyllum* in the area and concluded, respectively, that 159,000 (±45,000) and 75,000 wet tons were available for harvesting. The large difference is due to the methods employed, but it is clear that there are sufficient unharvested areas to satisfy any such requirements for conservation. At present much less than a quarter of the annualised potential yield in County Galway is being harvested.

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