SITE SELECTION AND COMMUNITY PARTICIPATION IN THE DEVELOPMENT OF *Gracilaria gracilis* (STACKHOUSE) STEENTOFT, IRVINE AND FARNHAM MARICULTURE IN THE WESTERN CAPE PROVINCE, SOUTH AFRICA.

by

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DECLARATION

The work described in this thesis was carried out under the supervision of Prof. DW Keats of the Botany Department, University of the Western Cape, and Dr. RJ Anderson, of the Sea Fisheries Research Institute.

I declare that "Site selection and community participation in the development of *Gracilaria gracilis* (Stackhouse) Steentoft, Irvine and Farnham mariculture in the Western Cape Province, South Africa" is my own work and has not been submitted in this or any other form to another university. Where use has been made of the work of others, it has been acknowledged by means of complete references.

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Signature: B. Brown

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Date

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To my friend Edgar

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CHAPTER 1: LITERATURE REVIEW

1.1. PROJECT OVERVIEW:

Seaweeds are utilized for different purposes worldwide, and the industry has grown to such an extent that alternative means of seaweed production are now needed to supply the demand. Different methods, such as sea-bottom planting, ponds, tanks and floating rafts and cages have been developed to farm commercially important seaweeds. The South African seaweed industry is small compared to the worldwide industry, and a few commercial species are collected from the shore or harvested for export, limited local processing, or the feeding of marine animals in culture. Although the feasibility of cultivation of a few species has been investigated, no commercial seaweed farming currently takes place in the country.

Gracilaria gracilis is a red seaweed that is collected from material that drifts onto Saldanha Bay beaches and it is exported for the extraction of agar. The industry is small and subject to fluctuations in the availability of beach-cast material (Anderson *et. al.*, 1989, Anderson *et. al.,* 1992). Because of the value of the seaweed, it is important to find a way to stabilize and increase the supply. Research on the cultivation of this species is done at the Sea Fisheries Research Institute of the Department of Environmental Affairs and Tourism, at the University of the Western Cape, the University of Cape Town, University of the Witwatersrand and the University of Port Elizabeth. The South African Network for Coastal and Oceanographic Research (SANCOR) co-ordinates and facilitates marine science, engineering and technology in South Africa. Its major stakeholders are the Foundation for Research and Development (FRD) and the Department of Environmental Affairs and Tourism (DEAT). This study was initially done with funding from the SANCOR, but became part of the Mariculture Project of the Marine and Coastal Resources Programme of the Foundation for Research Development (FRD). The research undertaken was identified as important for *G. gracilis* mariculture in South Africa, specifically the selection of suitable sites for mariculture, the economic feasibility and the participation of local communities in the seaweed industry.

The selection of suitable sites for suspended raft cultivation of the seaweed is crucial for the success of the farm. Environmental factors, including physical, chemical and biological factors, influence the growth of the seaweed and success of the technology. These factors were identified and the minimum and maximum ranges for seaweed growth and raft survival were obtained from literature. A Geographical Information System was used to analyze data on the most important environmental factors and predict suitable sites for *Gracilaria* mariculture.

The cultivation of *Gracilaria* on suspended rafts has been proven to be feasible in Saldanha Bay and is currently underway in St. Helena Bay. The next step is commercial farming. Cultivation of the seaweed is a potential means of income derivation especially for coastal communities. Before investment can be made, a feasibility study (or pilot farm) must be carried out, and before a feasibility study is carried out, a pre-feasibility study is necessary. In this study an attempt was made to assess the economic, socio-economic and financial aspects as well as the environmental effects associated with suspended raft cultivation, with a view to implement a pilot farm on which a feasibility study could be carried out.

Mariculture is a growing industry in South Africa, especially the culture of high-priced species such as abalone. In this study an attempt was made to introduce *Gracilaria* farming as an alternative or supplementary means of income generation to a community in St.

Helena Bay, and to facilitate their participation in the envisaged expansion of the seaweed industry in South Africa.

1.2. LITERATURE REVIEW

1.2.1. IMPORTANCE OF ALGAE

"Algae" is derived from the Latin word for seaweeds (Harlin and Darley, 1988), which are relatively large photosynthetic organisms usually, found in sea water. Algae range in size from picoplankton (0.2-2.0 micrometer in diameter) to kelps with fronds up to 60 m in length. They are ecologically important because they are primary producers and they provide habitat for a variety of organisms. Some algae are economically important because they are used in food and industrial applications, while others are responsible for toxic algal blooms that can have a negative influence on commercial fisheries and mariculture.

In aquatic ecosystems, algae form the base of food chains because they produce food for secondary users through photosynthesis. Algal productivity is a measure of the rate of synthesis of organic matter from inorganic carbon and solar energy. Total primary productivity is divided into portions to support metabolism, to be excreted as organic carbon, and to contribute to an increase in algal biomass. Primary productivity may be measured in terms of carbon fixed on an area or volume basis, as a specific growth rate or in energy units. Net productivity may also be called yield ($g.m^{-2}$ day^{-1}) in the mass cultivation of algae. The most important environmental factors affecting productivity are irradiance and nutrient supply. Changes in these factors, and in temperature, lead to seasonal variation in productivity (Harlin and Darley, 1988), and thus in yield in mariculture systems.

Algae have potential as fresh food for animals such as abalone in mariculture (Ajisaka and Chiang, 1993; D. Katz, Saldanha Group, pers. comm.), and as an ingredient in the diet of juvenile shrimp (Briggs and Funge-Smith, 1996) or salmon (Sedgwick, 1994). Some algae can also be eaten as vegetables or used in processed form in foods, pharmaceutical preparations or other industries. Perhaps the best known edible seaweed is the red alga *Porphyra* (amanori in Japan), which is used extensively as food in Asian countries (China, Japan, Korea, Philippines), and in North America, Hawai'i, and New Zealand. It is cultivated most extensively in Japan (Mumford and Miura, 1988). The genus *Gracilaria* is used by some peoples as food (the Caribbean, Hawai'i and Fiji), although the importance of plants from this genus lies mainly in their use for the extraction of agarose and agar (Abbott, 1988). The division Phaeophyta also contains many edible seaweeds, the most important ones belonging to the order *Laminariales* (kelp). *Laminaria* and *Undaria* are the most economically important genera of edible kelp. *Laminaria* species are used in Asian cuisine to prepare stock for other dishes, or as a liner to impart its flavour to vegetables or meats. *Undaria pinnitifida* is eaten as fragments in dry, fresh, or salted form. Kelp plants can also be used as fertilizer (Druehl, 1988). Microalgae and cyanobacteria, such as *Spirulina*, are also valued for the pigments they contain. They are sold in tablet, capsule or liquid form (Jassby, 1988). Jensen (1993) estimated the value for nori (*Porphyra* sp.) at US$1800 million per year, wakame (*Undaria* sp.) at US$600 million per year, and kombu (*Laminaria* sp.) at US$600 million per year.

Phycocolloids are extracted from algae and used in industrial and food preparations. Hydrocolloids are thickening or gelling agents used in food products, and can be derived from land plants and seaweeds. Alginates, agar and carrageenans are collectively called phycocolloids, because they are derived from seaweeds. Table 1.1 summarizes the main uses of phycocolloids, and the seaweeds from which they are derived. Agar and carrageenan are derived from red seaweeds. Alginate is derived from brown seaweeds.

Agar is obtained from five genera (*Gelidium*, *Gelidiella*, *Pterocladia*, *Gracilaria* and *Gracilariopsis*) from three orders of red algae (Armisen 1995). Agar is the intercellular matrix of members of Rhodophyta, composed of flexible, differently sulphated galactans. Agars are distinguished from carrageenans by the α 1,4-galactose unit being in the L-form (McLachlan, 1985 and Murano, 1995). The structure of galactose repeating units of agar can be seen in Fig. 1.1 (a). Murano (1995) also reviews the structure and quality of agar from *Gracilaria.* The fraction of agar with the greatest gelling capacity is called agarose, and the other fractions are called agaropectin (Glicksman, 1987). The difference between the two fractions is the replacement of galactopyranose units by 4,6-*O*-(1-carboxyethylidene)-D-galactopyranose in agaropectin. Usually, agar from *Gracilaria* has a high content of methoxyls, which cause high gelling temperatures above 40°C. This means that refrigeration is not necessary for formation of the gels. The agars from the genus *Gracilaria* are more sulphated than those from *Gelidium* and *Pterocladia.* With the method of alkaline hydrolysis (treatment with sodium hydroxide which converts the 'agaroid' from *Gracilaria* into real agar, with a higher gel strength), agar with a gel strength of between 800 and 1000 g cm $^{-2}$ could be extracted from *Gracilaria.* The genus is presently the most important source of food and sugar-reactive grade agars (Murano, 1995). The US Pharmacopoeia and the Food Chemicals Index defines agar as a hydrophilic colloid, insoluble in cold water but soluble in boiling water. A unique feature is that it forms thermoreversible, ion-dependent gels (Murano, 1995). Glicksman (1987) describes the specific properties of agar as formation of very strong brittle gel, resistance to high temperature and ability to hold large amounts of solids. The quality of agar can be measured in terms of the yield, gel strength, melting temperature, gelling temperature, humidity, ash and protein (Table 1.2). The international market requires a gel strength of greater than 750 g cm^{-2} at 1.5 % agar solution (Armisen 1995).

Agar has two main uses: as natural agar (strip or square form) in traditional cooking (mainly Asia) or industrial agar (flake or powder form). Industrial agar can be classified into the following grades: food, bacteriological, pharmacological, clonic plants production, purified (Armisen 1995). Agar is used in microbiological media for cultures, plant nutritional studies (Bornman and Barnard, 1993), and for food preparations. Agarose (a chemical fraction of agar that is neutral) is used for gel electrophoresis. Presently agar is the phycocolloid commanding the highest price on the world market (Kain 1995). In western countries agar was first used as a laxative agent in medicine preparations (Armisen 1995), and also as culture media for bacteria, yeast and molds. Japan is the most important producer of agars, but other countries have started agar production factories, such as Chile, which has influenced *Gracilaria* imports into Japan (Armisen, 1995). In recent years Chile has become a major producer of agarophytes, and it is now regarded as the biggest producer in South America. In 1991 the size and value of the global agar industry (finished product) was estimated at 11 000 tonnes and US$160 million, obtained from 180,000 tonnes fresh weight raw material (Jensen, 1993). In 1995 the global phycocolloid market was estimated at 61 000 tonnes, valued at US$560 million, of which agar contributed 10 161 tonnes finished product, valued at US$203 million (Guiry, 1997).

Carrageenans are derived from *Eucheuma, Kappaphycus, Gigartina, Mazzaella* and *Chondrus* spp. Carrageenan is composed of structurally similar galactans (Glicksman, 1987), and can be classified into kappa-, iota- or lambda-carrageenan, depending on the molecular composition of the phycocolloid (Jensen, 1993). According to McLachlan (1985), the kappa form of carrageenan is soluble at about 70°C and forms a firm, rigid gel. Iota-carrageenan is more elastic. Lambda-carrageenan is devoid of 3,6-anhydrogalactose and does not gel, but produces the highest viscosity in water. He also describes the structure of carrageenans as being composed of D-galactose units only (Fig. 1.1 (b)). The specific properties of carrageenans are its high-quality thermal gel formation, protein reactivity and synergism with locust bean gum (Glicksman, 1987). It is used in dairy products, meat and poultry products, water gels and toothpaste. The main countries producing the seaweed are the Philippines, Indonesia and Chile (Bixler, 1996). The value of the carrageenan industry in 1991 was estimated at US$100 million per year (Jensen, 1993) and at US$214 million in 1993 (Bixler, 1996). The volume demand has grown with about 5% per year for the last 25 years, with carrageenan production of 15,500 tonnes per year and raw material production of 250,000 tonnes (fresh weight) per year in 1991 (Jensen, 1993). The price has increased from less than US$4 per kg in 1970 to more than US$10 per kg in 1993.

Alginate is derived from brown algae, including *Macrocystis pyrifera, Laminaria* spp., *Ecklonia* spp. and *Ascophyllum nodosum.* The processed phycocolloid is composed of alginic acid salts and propylene glycol alginate, and used in food, industrial and pharmaceutical industries (Glicksman, 1987). McLachlan (1985) describes the structure of alginate in the native state as consisting of linked α-L-guluronic and β-D-mannuronic acids. The chemical structures can be seen in Fig. 1.2 (a and b). The properties of alginate are its cold-water solubility, instantaneous calcium reactivity and non-melting chemical gel formation. It may be used to prepare icings, glazes, and paint or paper coatings (Glicksman, 1987), as well as high grade paper with special properties found useful in speaker manufacturing. The value of the alginate industry was estimated at US$230 million, the production of the phycocolloid at 27,000 tonnes per year and production of raw material (fresh weight) at 500,000 tonnes per year in 1991 (Jensen, 1993).

The seaweed industry has continued to grow throughout the twentieth century. Woodward (1966) estimated that the growth of the seaweed industry in the latter part of the century will be greater than that during the first half. Indeed, between 1966 and 1991 the production of phycocolloids have increased from 2,850 to about 10,000 tonnes per year for agar, 1,850 to 15,500 tonnes per year for carrageenan and 7,550 to 27,000 tonnes per year for alginate (Woodward, 1966; Jensen, 1993). The industry has benefited from the support of basic and applied research and development by governments and industry (Magne, 1993), and hopefully this will continue to be the case in future.

1.2.2. SEAWEED COLLECTION, HARVESTING AND CULTIVATION

Traditionally, economically important seaweeds are collected from beach-cast or harvested from natural populations. A worldwide increase in the demand has led to overexploitation of some populations, and the inability of the populations to recover sufficiently for sustainable utilization, as with *Gracilaria* in Chile (Westermeier *et. al.*, 1993).

Different collection and harvesting techniques are used for different seaweeds. Algae that are deposited on beaches by storms and wave action are collected and sold or processed. *Gracilaria gracilis* (previously known as *G. verrucosa*) is collected from beaches in Lüderitz, Namibia (Molloy, 1990; Critchley *et. al.* 1991) and Saldanha Bay, South Africa. Harvesting is the partial or total removal of attached material from intertidal or submersed beds. Plant parts can be cut manually without removing holdfasts, as is done for *Ascophyllum nodosum* in the Northwest Atlantic (Sharp and Pringle, 1990). *Gelidium pristoides* in South Africa is plucked (Carter and Simons, 1987). Whole plants may be removed by dragraking, such as *Laminaria* harvest and *Chondrus crispus* in the Northwest Atlantic (Sharp and Pringle, 1990).

Increasingly the farming of seaweeds such as *Gracilaria, Caulerpa, Enteromorpha, Porphyra, Undari*a and *Laminaria* is used as a method of commercial seaweed production. Cultivation can be done in outdoor tanks or ponds, on suspended ropes in the sea, or on the bottom of shallow lagoons and bays. According to Friedlander and Levy (1995), pond and tank cultivation may be divided into intensive (tank) and non-intensive (pond) cultivation systems. Intensive systems are made of concrete or plastic structures with water agitation systems, and non-intensive systems are usually uncovered earthen constructions without water agitation systems. Florida, China and Taiwan are areas in which non-intensive pond cultivation is practiced. The first countries to practise intensive tank cultivation were the U.S.A. and Canada, although the high cost of production (resulting from the energy needs for seawater pumping, as well as CO_2 enrichment) was a disadvantage. Experimental tank cultivation in Chile was successful (Ugarte and Santelices, 1992), but one limitation proved to be the high expenses associated with such a controlled system. Descriptions of tank and pond culture can also be found in Saito (1984) and Hurtado-Ponce *et. al.* (1992).

Suspended and bottom-planting cultivation are the least capital-intensive forms of cultivation because there is no need for added fertilizer, carbon dioxide or maintenance of structures as in tank and pond cultivation. Methods include suspended raft, line or cage culture (Saito, 1984; Dawes, 1995; Smith, 1997;) and bottom-planting (Santelices and Doty 1989; Buschmann *et. al.* 1995; Smith, 1997). Tufts of seaweed can be used as seeding material, or spores can be settled on ropes or other substrates, as in the culture of *Gracilaria parvispora* in Hawai'i (Glenn *et. al.* 1996).

Some studies on the cultivation of *Gracilaria gracilis* in South Africa have indicated that tank cultivation is suitable in integrated abalone and *Gracilaria* cultivation systems where the seaweed is used to feed the animals (Smit, 1995). Other studies indicated that suspended raft cultivation in sheltered areas may be a more appropriate method for the mass cultivation of the species (Anderson *et. al.,* 1992 and Anderson *et. al.*, 1996).

1.2.3. THE GENUS *Gracilaria* (Rhodophyta: Gracilariaceae)

The taxonomy of *Gracilaria* has been under investigation because of the confusion over the delimitation of some species (Bird, 1995). Precise identification is necessary especially for breeding studies and genetic manipulation. In a study done by Goff *et. al.* (1994), the usefulness of both the nuclear internal transcribed spacer (ITS) region and the plastid ribulose *bis*-phosphate carboxylase (RUBISCO) spacer region for molecular systematic studies of *Gracilaria* and *Gracilariopsis,* were examined. They found that the nuclear internal transcribed spacers can be used to examine species interrelationships among closely related taxa, but it is not useful for examining intergeneric relationships. The RUBISCO spacer region was useful in examining relationships higher than the species level. According to Steentoft *et. al.* (1995), the two species *Gracilaria gracilis* and *Gracilariopsis longissima* have long been confused under the name *Gracilaria verrucosa*. The main differences between the two species were the holdfasts, the origin of 'long-growth' axes and branching patterns of those axes, and the appearance of the terminal segments. The differences between the genera *Gracilaria* and *Gracilariopsis* are summarized by Stegenga *et. al.* (1997). In *Gracilaria*, spermatangia occur in conceptacles and carposporophytes are connected with the roof of the cystocarp via tubular nutritive cells, whereas in *Gracilariopsis*, spermatangia are superficial and tubular nutritive cells are absent. South African and

Namibian *Gracilaria* and *Gracilariopsis* plants have in the past also been assigned to *Gracilaria verrucosa.* The genus in Saldanha Bay and Langebaan Lagoon, based on the description of Isaac, 1956 (cited in Stegenga *et. al.* 1997), is assumed to be *Gracilaria.* The species is described as *G. gracilis* (Stackhouse) Steentoft, Irvine and Farnham (Bird and Kain, 1995). Plant material from False Bay and Swakopmund (Namibia) was recognized as *Gracilariopsis lemaneiformis* (Bory) Dawson, Acleto and Foldvik (Stegenga *et. al.* 1997).

Plants of the genus *Gracilaria* grow attached or free-living from the eulittoral to the sublittoral zone (Oyieke and Kokwaro 1995), such as *G. salicornia* (eulittoral) and *G. corticata* (lower eulittoral to sublittoral). Thalli are bushy and highly branched (Prescott, 1968), with commercial forms being less than 30 cm in length.

1.2.4. ENVIRONMENTAL FACTORS AFFECTING SURVIVAL, GROWTH AND AGAR CHARACTERISTICS IN CULTIVATED *Gracilaria*

The management of cultivated seaweed requires knowledge of the factors that limit algal production. Growth, agar yield and agar quality are the most important aspects influenced by environmental factors. Abiotic factors include temperature, salinity, light, water motion and nutrients, and biotic factors include epiphytism (Ugarte and Santelices, 1992 and Fletcher, 1995), self-shading and grazing (Kautsky, 1990).

1.2.4.1. GROWTH

Important aspects in the cultivation of algae are yield and growth. Yield is calculated as the mass harvested. Growth rate is an indication of the rate at which biomass increases and is used to make predictions about the time of harvesting in the cultivation of certain seaweeds. Growth rate can be estimated as a percentage increase in weight per time measured (Guanzon Jr. and de Castro, 1992), and calculated as follows:

$$RGR = (\ln Nt - \ln No)/t \times week^{-1})$$

where RGR = relative growth rate, Nt = length or fresh weight or number of cells after t days; No = initial length or fresh weight or number of cells; t = experimental time (days) (Orfanidis, 1993).

Temperature, irradiance, nutrients and pH (Levy and Friedlander, 1994), stocking density and salinity affect growth rate. According to K. Laufer (pers. comm.), growth on the floating rafts in the Lüderitz lagoon in Namibia seems to be dependent on the amount of subsurface water movement for circulation of nutrients. Molloy and Bolton (1996) investigated the influence of depth and season on growth of *G. gracilis* in Lüderitz. They found that optimal depth was 0.5 to 2.5 m below surface, and that highest specific growth rate occurred in summer and autumn. Anderson *et. al.* (1996) found that growing *G. gracilis* as close to the surface as possible, usually about 0.2 m deep, (where a lot of water motion occurs), also increased growth. Nitrogen and irradiance is reported by Friedlander *et. al.* (1991), as having an influence on growth rates in *G. conferta*. Engledow and Bolton (1992) found that irradiance and temperature influenced growth rates in *G. gracilis* (as *G. verrucosa*). The plants survived temperatures between 5 -25°C. Maximum specific growth of about 5% day $^{-1}$ took place at 25°C. Smit (1995) reported lower growth rates for *G. gracilis* (as *G. verrucosa*) at high stocking densities. The results of the field study of Anderson *et. al.* (1996) indicated that irradiance influenced growth of *G. gracilis*. They also found that temperatures above 17°C, which occurs in summer (November to February), were usually an indication of oligotrophic conditions in surface water. Temperatures above 17°C, especially after a prolonged period, could lead to die-off of plants. Studies on *G. gracilis* carried out in Japan (Rebello *et. al.* 1996) indicated highest growth rates at temperatures between 21.5-25.5 °C in outdoor culture, and in a closed-recirculating system, the same species had an optimum growth rate at 18 °C. In an outdoor tank cultivation study (Chirapart and Ohno, 1993), maximum growth rates for *G. verrucosa* and *G. salicornia* occurred at 25°C, and for *G. firma* and *G. fisheri* at 26°C. A study by Orfanidis (1993), indicated a tolerance range of 2-34°C for *G. verrucosa* from Greece. Guanzon Jr. and de Castro (1992) found that stocking densities and season influenced mean specific growth rates.

Salinity were also found to have an influence on growth by Koch and Lawrence (1987), where *G. verrucosa* adjusted photosynthetic and respiratory rates after a decrease in salinity from 32‰ to 10‰, and Engledow and Bolton (1992), where *G. verrucosa* tolerated salinities of 9-45‰. Rebello *et. al.* (1996) found that highest growth rates of *G. gracilis* occurred at salinities of between 20.5‰ and 30.5‰ in outdoor culture, and at 30‰ in a closed-recirculating system.

Species of *Gracilaria* have been shown to tolerate shifts in available nutrients by storing nutrients during periods of nutrients deprivation. Dawes and Koch (1990) found that *G. verrucosa* and *G. tikvahiae* could tolerate stress after nutrient deprivation because of their nutrient storage ability. Smit (1995) found that the growth rate of *G. gracilis* (as *G. verrucosa*) decreased with increasing nitrogen limitation, and that the seaweed could continue to grow at non-limiting nitrogen rates (using internally stored nitrogen) for one week before the growth rate decreased.

1.2.4.2. AGAR YIELD AND QUALITY

The value of seaweed used for the extraction of phycocolloids is influenced by the yield and quality of the phycocolloid, which are influenced by environmental factors. Yenigül (1993) found that the highest yield of agar (43%) from *G. verrucosa* in Turkey can be obtained in summer months and the lowest (24%) in winter months. Gel strength seemed to be higher at elevated temperatures. Engledow and Bolton (1992) found that agar content of *G. verrucosa* was 32-34% of the dry weight, and this was not significantly affected by 4 weeks' growth at temperatures of 10, 15 and 20 °C. Rebello *et. al.* (1996) found highest yield and gel strength of *G. gracilis* agar in summer, in an outdoor culture in Japan. The study of Ekman and Pedersén (1990) indicated that the agar composition of *G. sordida* and *G. verrucosa* is highly variable and largely influenced by prevailing culture conditions such as irradiance. Daugherty and Bird (1988) found that salinity of 17‰ caused lower agar yield than salinities of 25 ‰ or 33 ‰ in *G. verrucosa.* Agar yield appeared to increase as both salinity and maximum temperature increased. The reproductive phase influenced biomass and agar yield in the study of Whyte *et. al.* (1981). Variations in yields, gel strengths and gelation characteristics of the agars isolated were shown to be dependent on time of season and life stages of the alga.

1.2.5. SEAWEED UTILIZATION AND MANAGEMENT IN SOUTH AFRICA

Seaweeds were not of economic importance in South Africa until World War II, when agar from Japan became unavailable. A seaweed-collecting industry developed in Saldanha Bay, whereby beach-casts of *G. gracilis* were collected, dried and baled for export (Anderson *et. al.*, 1989). Much research has since been done on the algal resources of South Africa.

Other seaweeds collected for export or processing are *Gelidium pristoides, G. abbottiorum, Ecklonia maxima* and *Laminaria pallida* (Bolton, 1989; Share *et al*, 1996). Anderson *et. al.* (1989) did a review of the utilization of and research on South African seaweeds. The industry earned more than US$2.3 million per annum in 1989, and provided employment for about 2000 people, mostly in economically depressed rural areas. The most important seaweeds utilized in Southern Africa were *Ecklonia maxima, Laminaria pallida, Gracilaria gracilis, Gelidium* spp. and *Porphyra capensis*. The value of the total industry for 1994 was estimated at US$3.2 million (R14,7 million) and *G. gracilis* contributed approximately US$ 0.5 million (R2,5 million) to this figure (Table 1.3). About 400 people are employed in the industry (Table 1.4), of which about 50 are permanently employed by the *G. gracilis* industry. Further research by Levitt *et. al.* (1995) on carrageenophytes, especially on the south-west coast, indicated the presence of harvestable amounts of *Aeodes orbitosa, Gigartina polycarpa* and *Sarcothalia stiriata. Porphyra capensis* is thought to have potential for use in the abalone industry, *Hypnea spicifera* may be a utilized for its carrageenan content and *Suhria vittata* may potentially be cultured for its agar content (Share *et al* 1996).

1.2.6. MARICULTURE IN SOUTH AFRICA

The commercial farming of marine animals has been in existence in South Africa since about 1948, but farming of marine plants is in its infancy. The animals farmed include oysters, mussels, abalone, redbait, trout and clams. Total production was about 2700 tonnes in 1991 (Hecht and Britz, 1992). The most important aspects influencing the growth of the mariculture industry was seen by these authors as aesthetic impact, available space, oceanography, organic pollution, exotic species, parasites and genetic integrity of natural populations. The development of marine plant mariculture, especially for *Gracilaria gracilis*, started when the need for stable resources of certain seaweeds became apparent.

After the construction of an ore-loading jetty in Saldanha Bay in 1974 the *G. gracilis* resource collapsed. It recovered again by 1988, but collapsed again in the same year. Then the Sea Fisheries Research Institute started investigating the biology of *G. gracilis* (Anderson *et. al.*, 1992) as *G. verrucosa*. Diving surveys revealed a decline in biomass of beds in 1989, and the presence of large numbers of herbivores as well as the results of grazing experiments suggested grazing as the cause (Anderson *et. al.* 1993). By the end of 1989 attempts were made to re-plant the seaweed on the sea-bottom and to test growth on sub-surface lines. Although the experimental cultivation indicated that suspended cultivation of the seaweed is feasible in Saldanha Bay (Anderson *et. al.,* 1996), no commercial cultivation is taking place in South Africa. In Lüderitz Bay commercial cultivation experiments have been investigated by Taurus Chemicals Namibia (Rotmann, 1987 and Critchley *et. al.*, 1991).

1.2.7. LEGAL ASPECTS OF SEAWEED UTILIZATION

The acts guiding the exploitation of marine plants and use of the sea and sea-shore until 1997 were the Sea Fisheries Act no 12 of 1988, and the Seashore Act No. 21 of 1935. According to the Sea Fisheries Act, an applicant is granted a concession (a permit to collect and utilize seaweed collected or harvested from the beach) for a stretch of coast. The concession is valid for 5 years, after which the applicant must re-apply. There are 17 concession areas along the South African coastline (map in Anderson *et. al.* 1989). Harvesting from natural beds is prohibited for *Gracilaria*, but other seaweeds are harvested, such as *Gelidium pristoides* (Carter and Simons, 1987). The Act made provision for the collection and removal of aquatic plants and shells from the sea or sea-shore by the holders of approved permits. The letting of the sea-shore or sea water space is administered under the Sea-shore Act of 1935. Neither of the two Acts made provision for the farming of seaweeds in the sea.

A draft National Marine Fisheries Policy was submitted to the Minister of Environmental Affairs and Tourism in June 1996. A White Paper on Marine Living Resources was accepted in June 1997, and in September 1997 a Bill on Marine Living Resources was tabled. This made provision for the administration of mariculture as part of the competency of the Department of Environment Affairs (national government level). Approval for water space for mariculture is still administered under the existing Sea Shore Act of 1935. The management of concessions has not been changed, although it was reviewed and recommendations made.

1.2.8. SOCIO-ECONOMIC ASPECTS OF SEAWEED UTILISATION AND MANAGEMENT

A study to investigate the socio-economic effects of current seaweed management entitled 'The evaluation of South African Seaweed resources and the development of Management Policy options to allow sustainable utilization by coastal communities' was initiated by the Sea Fisheries Research Institute and the Environmental Monitoring Group in 1994. Three studies were completed as part of this project. The study of McQeen (1996) addressed the socio-economic issues around exploitation of *Gelidium* in the Eastern Cape. Some recommendations made regarding wider access to seaweed exploitation rights were:

- to reallocate areas not utilized by current concession-holders;

- to replace the current concession system with another form of resource management;
- to encourage formation of co-operatives for seaweed collection.

A study entitled 'The development of management policy options for seaweed in South Africa: a socio-economic perspective' was completed in 1995 (Freese, 1996). Alternatives suggested to the current system of seaweed management by concessions included:

- maintaining the status quo;
- limiting access with a 'social responsibility clause' worked in;
- increasing entry by restructuring concession zones;
- allowing community access by giving allocation rights to lower governing levels or; formation of co-operatives in communities.

Levin (1996) reported on the socio-economic aspects of seaweed utilization on the West Coast. She did not recommend altered management policies, although the following income-generating projects were suggested:

- fish and abalone feed;
- animal feed;
- human consumption;
- organic agricultural fertilizer;
- irrigation for agriculture and indoor plants;
- cosmetics and vitamins;
- compost and indirect economic uses.

Share *et al* (1996) reported and discussed the results of these studies. In a workshop in 1997 an attempt was made to determine how the knowledge could be used in the development of an appropriate management policy for the exploitation of seaweed (Levin and Share, 1997). The recommendations from the workshop included:

- forming an umbrella body to deal with issues affecting the industry;
- concessions should not be scrapped, although current issues of concern such as security of abalone farmers, permits for different species, length of tenure, sub-letting, levies and management bodies were debated and recommendations made.

The conclusions of the workshop were that research and development in the industry should continue and be encouraged, that access of new entrants be considered, and that the capital provided by the industry to local areas is substantial. Despite the recommendations and conclusions, no clear answer to the issue of access and management of the seaweed resources could be given. This meant that the present system of management remains largely unchanged.

1.2.9. POLITICAL AND SOCIO-ECONOMIC SITUATION IN SOUTH AFRICA

The political history of South Africa is well documented and will not be discussed in detail. The policy of apartheid, introduced in 1948 and officially ended in 1994, created a system of classification of people according to colour. The four major groups classified were “Africans”, “Coloreds”, “Indians” and “Whites”. “Africans”, “Coloreds” and “Indians” were all grouped as “Blacks”. It is estimated that at least 17 million people in South Africa can be termed as poor, and of these at least 11 million live in rural areas (ANC, 1994). Poverty is not merely linked to lack of income, but also to the lack of access to basic resources such as water and sanitation, energy and education.

To improve the socio-economic environment of South Africa, it is important to understand how it was shaped. National physical and economic planning initiatives previously were focused on stimulating new economic growth, and changing distribution of that growth. Attempts to control the perceived growth of metropolitan centres started with the Physical Planning Act in 1968. A 'Decentralisation Policy' was designed to stimulate economic development in Border areas and Homelands (CSIR, 1994).

Following the elections in 1994, the government developed the Reconstruction and Development Programme (RDP), with the aim of eliminating economic imbalances by creating a policy framework for socio-economic instead of physical development (ANC, 1994). The objectives of the five major policy programmes within the RDP were to meet basic needs, develop human resources, build the economy, democratise the state and society, and implement the RDP. The objectives of developing human resources and building the economy were embraced in the present study.

1.2.10. SOCIO-ECONOMIC ASPECTS OF WESTERN CAPE PROVINCE

The Western Cape province is dominated by the Cape Metropolitan area (CMA), which contains over 80% of the population in the province. Its total population increased from 2.2. million in 1970 to 3.6 million in 1990. Of this, 3.1 million lived in the CMA (CSIR, 1994). The total population in the Western Cape in June 1995 was 9% of the total for South Africa. In 1994 the population density in the Western Cape was 28.8 per km^2 , compared to

33.8 per km^2 for South Africa, and 374.7 per km^2 for Gauteng (Central Statistical Services, 1996). In the October Household Survey of 1994, an unemployment rate of 17.3 % was calculated for the Western Cape (Central Statistical Services, 1996). The rate was based on a definition of unemployed persons as persons 15 years or older who were not in paid employment or self-employment, who were available for paid employment during the reference week and had the desire to work and take up employment or self-employment.

In 1993 the Department of Environment Affairs, Department of Welfare and the African National Congress commissioned a study on the fishing communities of the West Coast. Schutte (1993) studied 13 fishing communities from Arniston to Struisbaai. Profiles for each community were drawn up in terms of age, sex, education, occupation, income, family structure, housing standards, migration tendencies and employment practices. Table 1.5 is a summary of his findings for Paternoster, Saldanha Bay, Laaiplek and St. Helena Bay, all of which are located within the area chosen for the present study. The average age was between 43 and 46 years, average size of households between 5 and 6, literacy between 78 and 86.6%, average monthly household income between R760.75 and R1.435.9, and community needs ranged from a library to toilets in the house. The study showed differences amongst communities, and a similar socio-economic need for development and income generation.

Development policies in the past were designed to lessen the dominance of the Cape Metropolitan Area in the province. Regional policies resulted in the establishment of the Cape as a 'Coloured Labour Preference area' in 1968 (CSIR, 1994), and the establishment of an independent 'Coloured Town' at Mamre in 1970. It was argued that the growth of Saldanha can curtail the regional dominance of the CMA. To establish Saldanha and Atlantis (another 'Coloured' town on the West Coast) as deconcentration points, financial incentives were offered to industry to locate in those areas. Development started taking place in Saldanha Bay, especially the establishment of the ore loading jetty in 1975.

Despite all the efforts, the hoped for growth of Saldanha did not occur. Recently the establishment of the West Coast National Park and identification of tourism as a 'leading edge' in the regional economy, signified different developments in the Vredenburg-Saldanha-Langebaan areas (CSIR, 1994). The Department of Trade and Industry initiated a Spatial Development Initiatives Programme for the West Coast in 1997. Development proposals, including a proposal for a seaweed mariculture project, were presented to potential investors at an Investors Conference in February 1998.

1.2.11. THE VREDENBURG-SALDANHA-LANGEBAAN AND ST HELENA BAY AREA

1.2.11.1. MANAGEMENT

Figure 2.18 (Chapter 2) shows the locations of the major towns and roads in the study area. A number of local government bodies and planning instruments have influence over the Vredenburg-Saldanha-Langebaan (VSL) area (CSIR, 1994). The Vredenburg-Saldanha Municipality, the Langebaan Municipality and the St. Helena Bay Municipality provide services, administer zoning of land in urban areas and enforces building regulations. The West Coast Regional Services Council has jurisdiction over Saldanha Bay and surrounds, excluding military areas, the iron ore jetty, oil terminal and oil storage tanks. It owns the regional water distribution network up to the Municipal boundary. Portnet has jurisdiction over the Iscor iron ore jetty, oil terminal and the water area of Saldanha Bay. The West Coast National Park is under the control of the National Parks Board, and it includes the Langebaan Lagoon, Marcus, Malgas, Jutten and Schaapen islands, and 21 000 ha of land between Langebaan and Yzerfontein. The South African Defence Force controls land on the Donkergat Peninsula (excluded from the West Coast National Park) and the Naval Academy in Saldanha (CSIR, 1994).

1.2.11.2. DEVELOPMENT

Saldanha Bay and the adjacent Langebaan Lagoon have over the years become the centre of much planned development, as well as considerable controversy. The area is a popular tourist attraction and economic centre. Saldanha Bay and St. Helena Bay are the seats of several successful fishing companies, and Saldanha Bay has long been used as a harbour and fishing port. The fishing and agricultural industries are the main components of the economy, but they have strongly seasonal characteristics. The main agricultural products are wheat, stock and sheep in drier areas, and potatoes and vegetables where there is available water (CSIR, 1994).

Fishing is the strongest component of many of the coastal towns in the area. Sea Harvest Corporation Limited is the biggest employer in Saldanha Bay. The average wage in the fishing industry is just over R1033 per month for a 47 hour week (CSIR, 1994 and Schutte, 1993). Employment is highly seasonal and unemployment levels in the Saldanha-Vredenburg municipal area are estimated at between 10-30% (CSIR, 1994). Mussel and oyster farming are practised successfully in Saldanha Bay. An oyster nursery was situated in St Helena Bay until 1998.

An example of the sensitive issues around development was the public debate about a proposed steel mill in Saldanha Bay. The Iron and Steel Corporation (ISCOR), together with the Industrial Development Corporation (IDC) proposed the development of a steel plant producing steel coils for export, in Saldanha Bay. The proposed site was the subject of much debate for interested parties, because of the possibility of pollution of ground water at the original proposed site. In 1996 a decision was made to move the site to an area which is less sensitive ecologically, and the mill was built subsequently. It is envisaged that the mill will change the area from a quiet rural environment to a busy industrial area. The possible increase in ship traffic may have negative implications for future mariculture farms in Saldanha Bay.

In 1996 a workshop was held in Saldanha Bay to provide guidelines on activities required for advancement of the planning process in Saldanha Bay (Wentzel *et. al.* 1996). As part of the problem of poor economic growth especially for historically disadvantaged groups, activities were proposed as part of a plan of action. Small enterprise development activities proposed were 'seagrass' (*Gracilaria*), mussel and fish farming.

St. Helena Bay, north of Saldanha Bay, is a fishing village. The study of van Sittert (1992) describes the development of the fishing industry in the bay. He described how the term 'fisherman' on the West Coast came to be a stereotype (as seen by “Whites”) for the “Coloured” people believed to be descendants of the Malay and the original inhabitants. The historical accounts of the post second World War period were written mostly by members of prominent families or companies in the fishing industry, and two themes were perpetuated: that of pioneering “White” industrialists and morally decayed “Coloured” fishermen. These stereotypes were constantly reinforced, and the political policy of the post-war period did much to ensure that the “Coloured” and “African” fishermen remained poor and disempowered while fishing monopolies (controlled by "White" families and companies) developed. Van Sittert argued that the fishing industry developed against the background of the formation of capitalism in the South Western Cape. There was a struggle for control of the marine environment and its products between fishermen, merchants, fishing companies and the state, as is usually the case everywhere. However, in South Africa there was a strong pseudoracial bias in the outcome.

1.2.12. SEAWEED CULTIVATION AS AN ECONOMIC ENTERPRISE FOR ECONOMIC DEVELOPMENT OF COASTAL COMMUNITIES

The section of South African society termed "Black" (also referred to as historically disadvantaged) was subjected to economic discrimination in the past. This is the case with the fishing industry as well, and disadvantaged fishing communities on the west coast need to find alternative employment opportunities. Seaweed exploitation may be such an opportunity, especially as seaweed cultivation has been used or investigated in several other countries as a means of employment creation. Doty (1979) described the successful introduction of seaweed farming to coastal communities in countries such as the Philippines and Taiwan. In Venezuela the cultivation of *Gracilariopsis tenuifrons* on rafts began in 1986. Farming is independent and rafts are owned by farmers once they are paid off (Dawes, 1995). Because of the cultivation of *Gracilaria chilensis* and *Eucheuma* spp. in the Araya Peninsula in Venezuela, poor communities were provided with an opportunity for economic development (R. Rincones, pers. comm.). In Sri Lanka the cultivation of *Gracilaria edulis* proved to be empowering especially for women (C. Amaratunga, pers. comm.). In St. Lucia, in the Caribbean Sea, the cultivation of *Gracilaria* spp. and *Eucheuma* spp. was used for community development (Smith, 1992; Smith, 1997). In Ireland, seaweed is used for food, agrochemicals, alginate raw material, liquid seaweed extracts and body-care products. Ongoing research and development ensured a better understanding and management of the industry in Ireland, which employs nearly 500 people in coastal regions (especially disadvantaged areas) on full-time and part-time bases (Guiry, 1997). As the seaweed *Gracilaria gracilis,* which occurs naturally in sheltered areas on the West Coast, has economic potential and cultivation trials were successful, it seemed logical to introduce the farming of this seaweed to coastal communities. Thus the objectives of this study were:

1. To develop a method for the prediction of suitable and available sites for suspended cultivation of *G. gracilis* in Saldanha Bay, Langebaan Lagoon, and St. Helena Bay.
2. To assess the economic, socio-economic, environmental and legal aspects as part of a feasibility study for community-based cultivation of *G. gracilis* on the West Coast of South Africa.
3. To establish a protocol to facilitate community participation in the development of a seaweed cultivation industry.

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Table 1.1: Summary of the uses of alginates, carrageenan and agar, and the seaweeds from which they are derived

PHYCOCOLLOID	SEAWEED (Genera)	USES	REFERENCES
Alginate	*Ascophyllum, Laminaria, Macrocystis, Ecklonia, Sargassum, Nereocystis, Eisenia*	Preparation of textiles, Liquid fertilizer, Welding rods, pharmaceuticals, specialist paper	Guiry, 1997 Anderson et. al. 1989 Critchley, 1993 Glicksman, 1987
Carrageenan	*Gigartina, Aeodes, Sarcothalia, Iridaea, Chondrus, Mazzaella, Euchema, Furcellaria, Ahnfeltia*	Stabilizer in milk products, gelling agent, confectionery, ice cream, sauces, cosmetics and silk industry	Anderson et. al. 1989 Critchley, 1993 Bixler, 1996 Glicksman, 1987
Agar	*Gracilaria, Gelidium, Pterocladia, Suhria, Gelidiella, Acanthopeltis*	Sweets, pharmaceutical preparations, toothpaste, Bacteriological growth medium	Armisen, 1995 Anderson et. al. 1989 Critchley, 1993 Santelices and Doty, 1989 Murano, 1995 Glicksman, 1987

Table 1.2: Summary of the official USA specifications for agar-agar (US Pharmacopoeia and US Chemicals Codex). From Armisen (1995).

	SPECIFICATIONS	
	Maximum	Minimum
Gelation temperature at 1.5% solution	39°C	32°C
Gel melting temperature at 1.5 % solution		85°C
Moisture	20 %	
Ash	6.5 %	
Ash, acid-insoluble	0.5 %	
Foreign organic matter	1.0 %	
Foreign insoluble matter	1.05 %	
Foreign starch	0	
Gelatin	0	
Water absorption		5 times its weight
Arsenic	3 ppm	
Lead	10 ppm	
Other heavy metals	40 ppm	

Table 1.3: Amount and market value of seaweed harvested and collected in South Africa in 1994 and 1995 (source: Seaweed Research Unit of the Sea Fisheries Research Institute). Weights are of dry material unless otherwise stated.

PROVINCE	SEAWEED TYPE	1994(KG)	1995(KG)	R/TON	TOTAL IN 1995 (RAND)
Western and Northern Cape	1. Kelp (beach-cast); Ecklonia maxima, Laminaria pallida	442,814.9	674,056.4	1,300	876,293
	2. Kelp (wet weight); Ecklonia maxima	364,768	315,695	30,000 (wet)	9,470,850
	3. Gracilaria gracilis	272,467	439,326	6,750	2,965,451
Eastern and Southern Cape	Gelidium pristoides, G. abbottiorum	87,041	73,312	9,000	659,808
Transkei	Gelidium pristoides, G. abbottiorum	80,000	80,000	9,000	720,000
				TOTAL	14,692,408

TABLE 1.4: Estimated number of people employed by exploitation of each seaweed type (Source: Seaweed Research Unit of the Sea Fisheries Research Institute).

ESTIMATED NUMBER OF PEOPLE	SEAWEED TYPE
50 (permanent)	Fresh Kelp (Ecklonia maxima), Western Cape
200 (part-time)	Dried Kelp (E. maxima, Laminaria pallida), Western and Northern Cape
50 (permanent)	Gracilaria gracilis (Western Cape)
50 (permanent)	Gelidium pristoides, G. abbotiorum (Eastern Cape)
>100 (part-time)	Gelidium spp.(Transkei)

Table 1.5: Summary of socio-economic profiles of four West Coast communities (source: Schutte, 1993):

TOWN	Average age	Average size of household	Literacy %	Average monthly household income (Rand)	Priority for community needs
Paternoster	46.8	5	78	760.75	library
Saldanha Bay	44.3	6	86.6	1409.8	work opportunities
St. Helena Bay	43.7	5	81.3	1435.9	toilet in house
Laaiplek	46.6	6	85	1179.43	mobile post office

Figure 1.1: (a) Chemical structure of agar

(b) Chemical structure for carrageenan (from McLachlan, 1985)

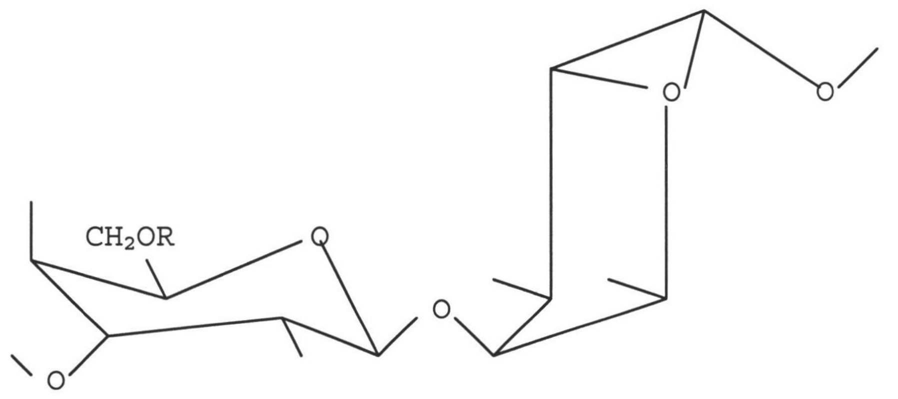
Figure 1.2: Chemical structures of alginate:

(a) α-L-guluronic acid

(b) β-D-mannuronic acid (from McLachlan, 1985)

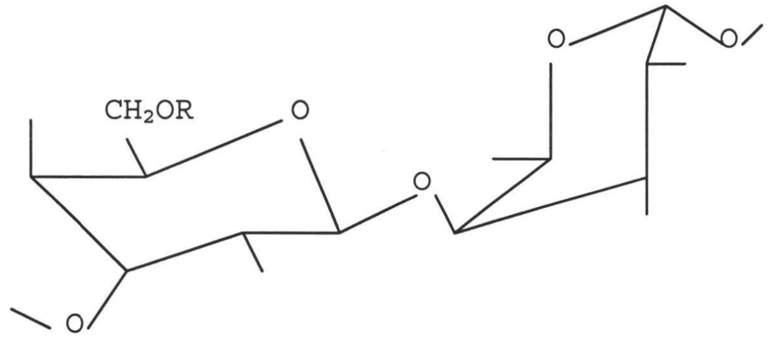
Figure 1.1.

a)



1,3 β-D-Galactose 1,4 α-L-Galactose

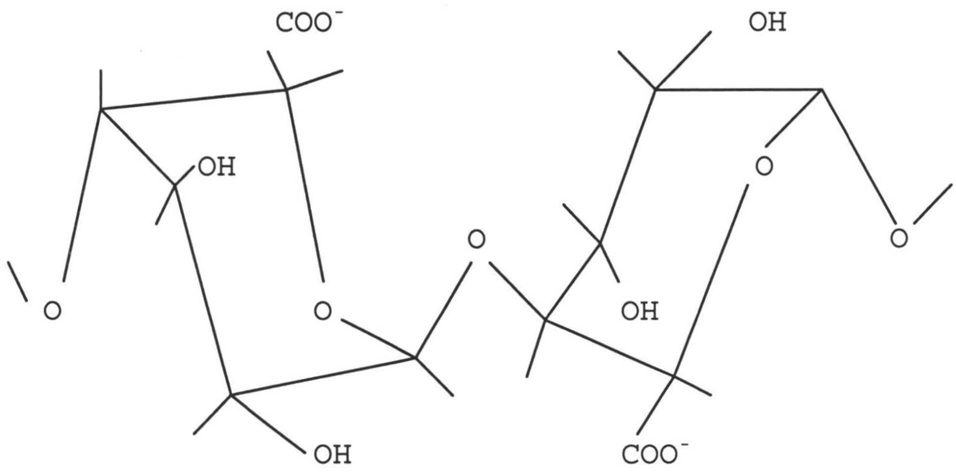
b)



1,3 β-D-Galactose 1,4 α-L-Galactose

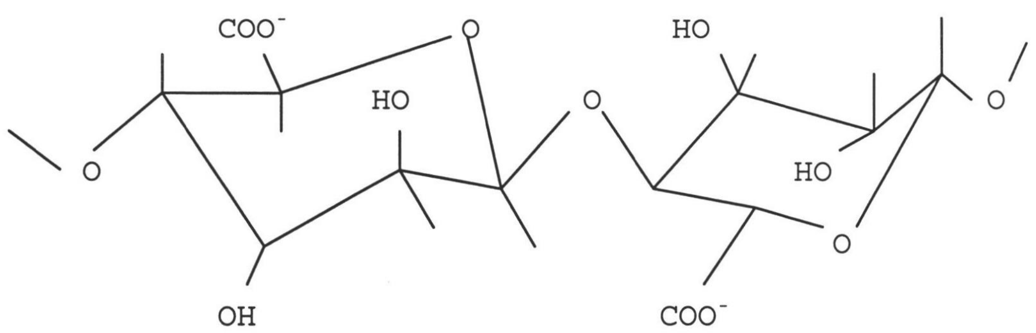
Figure 1.2

a)



1,4 α-L-Guluronic

b)



1,4 β-D-Mannuronic

CHAPTER 2

JOURNAL:

Journal of Applied Phycology

The use of GIS in the determination of suitable sites for suspended cultivation of Gracilaria gracilis (Stackhouse) Steentoft, Irvine *et* Farnham along the West Coast of South Africa.

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ABSTRACT

The seaweed Gracilaria gracilis has been shown in previous studies to have potential for mariculture along the West Coast of South Africa. However, the selection of suitable sites is crucial for the success of a farming enterprise. The variables important in the success or sustainability of suspended raft culture, and the environmental factors influencing these variables, were identified through a literature review. A suitable site was defined as a site with surface water temperature of between 10 and 17 °C, water depth of between 2 and 10 m below surface, and wave heights of less than 4 m. Data and information about these factors were obtained from sources such as the Sea Fisheries Research Institute, the SADCO database, the CSIR and from volunteers in St Helena Bay. The objectives of this study were to convert available data into formats that could be used in a Geographical Information System (GIS), and to predict suitable and available sites for suspended cultivation of Gracilaria gracilis in Saldanha Bay, Langebaan Lagoon and St. Helena Bay. Data were converted to digital format and data layers created. Each data layer represented suitable and unsuitable areas. Areas with existing mariculture, harbours, ship traffic zones and other uses were excluded to determine the real available areas. The Saldanha Bay-Langebaan lagoon system and St Helena Bay, have sites that show potential for suspended cultivation of G. gracilis. The total sizes of the areas selected as suitable are 975.4 ha in Saldanha Bay and 474.8 ha in St. Helena Bay. Some sites predicted as suitable are located in areas known to be subject to conditions not suitable for seaweed mariculture, and led to the conclusion that the accuracy of input data or method of analysis must be improved.

INTRODUCTION

Seaweed cultivation worldwide has the potential to ease the pressure on natural populations which are harvested for the seaweed industry. The seaweed industry in South Africa is small compared to the global industry, but it provides employment for a few hundred people in coastal communities (Sea Fisheries Research Institute, 1995). All commercial seaweeds are harvested or collected as beach-cast material, and the need for a stable means of production became apparent with resources such as Gracilaria gracilis, where beach-cast material fluctuates annually and this fluctuation influences the industry negatively. Cultivation experiments on this seaweed started not only as a result of the collapse of the resource in certain years, but also as a result of its potential as food for cultured abalone in South Africa (Anderson *et. al.*, 1992; Smit, 1995). G. gracilis is the only seaweed in South Africa on which cultivation experiments were done to the extent that commercial cultivation can be based on the same methods. The suspended raft experiments in Saldanha Bay were based on the description of a rope raft system in Dawes (1995).

The results of the suspended cultivation experiments of the Seaweed Research Unit of the Sea Fisheries Research Institute have shown that it is feasible to grow G. gracilis on suspended rafts in Saldanha Bay, South Africa (Anderson *et. al.*, 1996). It also indicated that the success of such a venture is site-specific and depends on environmental conditions (Anderson *et. al.*, 1992, Anderson *et. al.*, 1996). Therefore results obtained at one site cannot always be used to predict cultivation success at sites with different environmental conditions. The experiments showed differences in seaweed performances between three experimental and one commercial pilot rafts in Saldanha Bay, because of factors such as pollution from nearby factories, fouling by mussel spat and temperature (Anderson *et. al.* 1992; Anderson *et.*

al. 1996; V. Pienaar, Sea Harvest Corporation Limited, pers. comm.). In the case of the commercial pilot raft installed by Sea Harvest in the same bay, cultivation was stopped because fouling by mussels made it uneconomical (V. Pienaar, pers. comm.). In outdoor cultivation the environmental factors cannot be manipulated, and the only way to minimize risk is to select sites with minimum risk factors. There was thus a need to find a way to select suitable sites for cultivation of Gracilaria gracilis so that potential farmers could avoid sites where physical or biological factors could make cultivation uneconomical or unsuccessful.

Suspended cultivation of seaweed can only take place in relatively sheltered areas. Rough seas may dislodge rafts and cause financial losses and pollution of nearby beaches with raft material. Because the experiments on suspended cultivation took place in Saldanha Bay, only the areas with potential for seaweed mariculture on the West Coast were investigated. The only areas with large sheltered areas on the West Coast, where G. gracilis occurs naturally, are Saldanha Bay, Langebaan Lagoon and St Helena (Figure 2.1). G gracilis also occurs in the Knysna Lagoon on the south coast (Anderson *et. al.* 1989).

From the literature review and interviews with researchers and seaweed exporters it was clear that the variables important for successful suspended cultivation are growth rate and phycocolloid content of Gracilaria gracilis, ability of rafts to withstand physical stress and the economic sustainability of the rafts. The primary environmental factors having an influence on the growth rate and phycocolloid content are temperature, irradiance, salinity and nutrients (Engledow and Bolton, 1992; Dawes, 1995; Anderson *et. al.* 1996; Molloy and Bolton, 1996; Smit *et. al.* 1997; Wilson and Critchley, 1997). Environmental factors influencing the stability and economic sustainability of suspended rafts are wave action and water depth (R. Anderson, C. Dawes, pers. comm.).

In the context of this study, the growth rate of the seaweed is more important than the agar content or quality. The growth rate is an indication of the rate at which biomass increases. In the culture of seaweeds, the biomass is used to determine the time of harvesting. When the biomass exceeds a certain value, growth is reduced and the risk of crop loss increases (Critchley, 1993; Smit, 1995). The agar yield and quality are indications of the economic value of the seaweed and has been shown in some cases to be optimal at different environmental conditions than for growth rate (Rebello *et. al.*, 1996).

Usually, high temperatures are thought to lead to an increase in the growth of G. gracilis. Several studies indicated high temperature tolerance ranges (between 5°C and 25 °C in Engledow and Bolton, 1992), and high optimum temperatures for the growth of the seaweed (18°C in Critchley *et. al.*1991 and 22°C in Wilson and Critchley, 1997). In the study of Molloy (1992), high temperatures were thought to lead to an increase of growth of the seaweed in Lüderitz, Namibia (also published in Molloy and Bolton, 1995). In contrast, the growth of G. gracilis in Saldanha Bay has been shown by Anderson *et. al.* (1996) to be affected negatively by prolonged temperatures above 17°C. The difference in growth under high temperatures between the above two bays could be attributed to the fact that nitrate content were high (more than 10 μM NO_3 L^{-1}) in Lüderitz Bay (Molloy and Bolton, 1996), and low (almost 0μM N) in Saldanha Bay (Anderson *et. al.*1996).

Salinity tolerance between 9 and 45‰, and an optimum growth at the salinity of seawater, was reported by Engledow and Bolton (1992). Wilson and Critchley (1997) reported maximum growth at salinities of 30‰, 35‰ and 40‰, and a salinity tolerance range from 15‰ to 50‰.

Engledow and Bolton (1992) reported that growth increased with increasing irradiance to a maximum of 80 $\mu mol.m^{-2}.s^{-1}$. In laboratory-based growth studies, Wilson and Critchley (1997) reported a maximum specific growth rate at 22°C, where the irradiance was kept at 100 $\mu mol\ m^{-2}\ s^{-1}$. Molloy and Bolton (1996) found an optimal growth depth for G. gracilis at between 0.5 m and 2.5 m below surface, where light could be at the saturating level. Above and below this depth light was limiting or photoinhibition caused decreased growth.

The water depth (in which rafts are anchored) and wave heights are important for their effects on economic sustainability of rafts. The rafts are anchored in position with chains and concrete weights, which contribute most to the cost of the raft. Thus at a certain water depth, the cost of chains and anchoring weights could make a raft uneconomical. The maximum depth economically sustainable for anchored rafts is generally accepted by scientific and industrial experts to be 10 m (R. Anderson and C. Dawes, pers. comm.). Below 2 m depth anchoring would be difficult, especially as this would usually be near the wave-breaking zone.

Wave heights give an indication of the energy of certain swell conditions, which have an influence on the stability of suspended rafts. A wave height of 4 m or more is an indication of an amount of wave energy that increases the risk of destruction of rafts (C.P. Dawes, pers. comm.).

The actual conditions in Saldanha Bay, Langebaan Lagoon and St. Helena Bay were used to assess which of the environmental factors affecting growth rate, stability and economic sustainability were useful for the prediction of suitable sites. Upwelling usually takes place in summer in Saldanha Bay and St Helena Bay, and causes variations in the temperature and nutrient content of surface water (Bolton and Levitt, 1987). A thermocline may develop after an upwelling event, which divides the water column into a bottom mixed layer, rich in nutrients and with a lower temperature, and a top layer with reduced nutrients and higher temperature (Bailey and Chapman, 1985). Studies on Benguela upwelled water indicates that nitrate is likely to be the limiting nutrient in the top layer of the water column (Brown and Hutchings, 1987). In Saldanha Bay, the nitrogen content can be correlated with temperature. Water temperatures of 9-11°C indicates nitrate levels of 20-30μM, and temperatures of more than 13-15°C indicated nitrate levels of <2μM (Monteiro, pers. comm.). Weeks *et. al.* (1991) reported summer temperatures in Saldanha Bay of more than 17°C. A minimum of 12°C in winter (Fig. 2.2) and maximum of 21°C in summer (Fig. 2.4) was measured during their study. In St. Helena Bay, the upwelling cycle also leads to stratification in the water column (Bailey and Chapman, 1991; Waldron and Probyn, 1991). During the first phase of upwelling, nitrate levels of 8-10μM were measured in the upper layer of water and during the last phase, the nitrate concentration could become <1μM (Bailey and Chapman, 1985; Bailey and Chapman, 1991).

The experimental cultivation study of Anderson *et. al.* (1996) indicated that surface water temperature could be useful as an indication of seaweed performance, because it gave an indication of nutrient content. No published data is yet available about the effect of water temperature and nutrient content on growth of the seaweed in St. Helena Bay. Thus for the purposes of this study, the assumption was made that the growth of G. gracilis in St. Helena Bay would be influenced by temperature in the same way as in Saldanha Bay. This could change when the results of the effect of temperature and nutrients on seaweed growth rate in St. Helena Bay became available in future. For site selection purposes, temperature was chosen as the environmental factor to use instead of nutrients.

A desirable range of 10°C (based on the minimum temperature tolerance of 5°C reported by Engledow and Bolton, 1992, and the minimum of 12°C measured in Saldanha Bay) to 17°C (based on the study by Anderson *et. al.*1996) was specified. As no cultivation studies had at this stage been done in St Helena Bay, the same temperature range was specified as for Saldanha Bay.

Salinity data obtained from the CSIR in Stellenbosch (Table 2.1), indicate that the salinity fluctuates between 32.9‰ and 35.1‰ in winter and summer. Because this range falls within the salinity tolerance range of G. gracilis, salinity was not considered for predictive purposes.

Irradiance levels in suspended cultivation are usually optimal, because the seaweed is grown within 0.5 m of the surface (Dawes, 1995; Anderson, *et. al.*, 1996). Thus irradiance was excluded as a predictive factor.

The water depth exceeds 10 m in Saldanha Bay and St. Helena Bay (as recorded on SAN bathymetry charts), and was included in the definition of a suitable site. The West Coast is known for strong wave action with waves of more than 4 m in Saldanha Bay and St. Helena Bay. This is reflected in data obtained from the SADCO database of the CSIR (Tables 2.2 and 2.3). Wave height was included in the definition, and a desirable range of 0-4 m was specified.

Epiphytes may cause crop losses, as was experienced in the case of the pilot commercial farm of Sea Harvest Corporation Limited, where mussel spat settled on the seaweed (V. Pienaar, pers. comm.). The only way to avoid the problem is to select sites away from existing mariculture farms, or factories where eutrophication may cause the bloom of unwanted algae.

Suitable sites thus were defined as sites where the seaweed would survive, and the raft system would be economically feasible. For the purposes of this study, a suitable site for the successful cultivation of G. gracilis would have the following environmental conditions:

- mean surface water temperature of 10 °C to 17 °C;
- bottom depth 2 m to 10 m below surface;
- mean maximum wave height of smaller and equal to 4 m;

Available sites were defined as sites where environmental factors were suitable, as well as outside areas where mariculture is prohibited such as ship traffic zones, fishing harbors, existing mariculture zones, and legally restricted areas.

A lot of data and information have been accumulated about the study area by private and research organizations in South Africa. There was a need to combine the data and information relevant to site selection, into a database that could be used by researchers and prospective seaweed farmers. Because of the spatial nature of the data, a Geographical Information System (GIS) is the best method of predictive modeling of suitable sites for seaweed cultivation. A GIS is a computerized system consisting of a database in which all data are spatially indexed or geo-referenced (Ricketts, 1992). It allows the use of query functions and modeling of data combinations (similar to the methods used by Jensen *et. al.*, 1992 and Kapetsky, 1994).

Predictive modeling with GIS has been used in many environmental studies. A site selection study was carried out by Ross *et. al.* (1993) for salmonid cage culture, and Hsienshao Tao *et. al.* (1996) identified reintroduction sites for landlocked salmon using GIS. Talbot and Kolm (1996) used GIS to characterize hydrologic systems in Wyoming.

The main objectives of this study were:

1. to obtain and convert spatial and temporal data on the environmental factors identified, into a format that could be used in a GIS;
2. to combine and analyze the data in a GIS to predict suitable and available sites for suspended raft cultivation of G. gracilis in Saldanha Bay, Langebaan Lagoon and St. Helena Bay.

MATERIALS AND METHODS:

The study area boundary was determined as an area extending north from the southern boundary of Langebaan Lagoon, up to Dwarskersbos on the West Coast coastline, and extending eastwards from the coast to the R27 road between Laaiplek and Cape Town (latitudes 32 ° 30' - 33 ° 3' S and longitudes 17 ° 30' - 18 ° 30'E). Areas included were Saldanha Bay, St Helena Bay and Langebaan Lagoon. The LO coordinate-ordinate system was used, because it would allow the measurement of distances and areas in meters. The 19° East longitude was chosen as the central meridian.

Data in a variety of formats and from different sources can be used in specific GIS applications, and visualization of data for decision-making purposes can be enhanced. Several GIS software packages are currently available for data input, management and output. Data types that can be incorporated include remotely sensed data, database tables, ground surveys and existing maps (Chagarlamudi and Plunkett, 1992). Arc/Info software, which was used in this study, has several applications, such as GRID, for specific spatial modeling needs. ArcView can be used for limited spatial analysis, and for data presentation.

Spatial and temporal data on environmental factors were obtained from a variety of sources and used to create base maps. Overlays of areas with suitable environmental conditions were made to determine suitable sites. Additional overlays of ship traffic, infrastructure and town locations were created to determine and assess the real available areas. Data were stored as geo-referenced coverages.

Temperature measurements were obtained from various sources. Four volunteers in St

Helena Bay took daily mean temperature measurements from March 1996 to January 1997 at the shoreline at 17h00. The locations were Laaiplek, Laingville, Steenberg's Cove and Stompneus Bay. The monthly and seasonal average, minimum and maximum temperatures were calculated from the data. The temperature data from 1976 to 1979 for Saldanha Bay, used in the study of Weeks *et. al.*(1991), were obtained from researchers in the Sea Fisheries Research Institute (G. Pitcher and P. Monteiro, pers. comm.). Measurements of surface temperature (0-1 m depth) were obtained at random points during cruises from 1976-1979. The seasonal averages for each year were calculated, and the geographical references (latitude and longitude positions) of the measuring points were used to create a temperature coverage for Saldanha Bay. Overlays were created using the average temperature for each point of measurement for each season. Because of the seasonal fluctuation in temperature in both Saldanha Bay and St Helena Bay, overlays for each season were created.

Information about the swell conditions in the quadrant 32° S - 34° S latitude/17° E - 19° E longitude, for the years 1960-1994 was obtained from the SADCO database of the CSIR in the form of swell roses and occurrence tables. These have been derived from data obtained from Voluntary Ship Observations (VOS). Map overlays for wave heights were generated from extrapolations made from existing points of wave measurements. These extrapolations were made using mathematical formulae obtained from Mr. Hans Moes at the CSIR, Stellenbosch. The significant (H_{mo}) and maximum (H_{max}) wave heights in the study area were calculated in the following manner:

Calculation of significant wave heights for Saldanha Waverider Buoy:

$H_{mo} = BQ + A$, where B = 1.00m and A = 0.407m

$Q = -\ln(-\ln(p))$

$p = 1 - (E/100)$

$E = 100\% / (nx365xN)$

where n = number of events (measurements) per day, and N = return period (years)

Maximum wave height was obtained by using the following formula:

$H_{max} = 2 \times H_{mo}$

The data for the Waverider Buoy was extrapolated to other areas within Saldanha Bay and Langebaan Lagoon by using the following formulae:

$H_{mo} = f_h \times H_{mo}$ (for Saldanha Waverider), where f_h = a factor related to the distance and location form the Saldanha Waverider. The value of the factor for each point was obtained from the CSIR.

For St. Helena Bay, a theoretical value point containing the same value as the Saldanha Waverider Buoy was created on the 20 m depth isoline, opposite Dwarskersbos. Predictions for Laingville and Stompneus Point were made with the above calculations and with f_h values provided by the CSIR. The maximum wave height for a 5-year period for points in Saldanha Bay, Langebaan lagoon and St Helena Bay were used to generate point coverages.

Water depths were digitized from South African Navy (SAN) bathymetry charts of different scales (1: 20 000, 1: 25 000 and 1: 30 000) using the Unix Arc/Info Version 7.0.3. GIS package. The hardware used for this was a Kurta digitizer and Sun (Sparc 20) workstation. The coastline was digitized from 1:10 000 orthophotos. SAN bathymetric charts were used to digitize ship traffic zones, port and fishing harbour limits, existing mariculture areas, and other limited areas. A polygon map was created from this coverage for use in analysis. The infrastructure containing roads, railways, airports and town locations was digitized from 1: 50 000 scale topographic maps.

Latitude and longitude spatial data were projected into real-world coordinates by converting degrees, minutes and seconds (dms) co-ordinates to decimal degrees (dd), (using the formula dd = degree + minutes/60 + seconds/3600) and then the coverages were projected to Transverse Mercator Projection. All projected coverages for each data layer were joined, and common boundaries dissolved to form a final coverage, with measuring units in meters. Data were checked by overlay verification and error edition. Based on the feature class, coverage topology was built as polygons, points or lines.

Because of the seasonal variation in temperature, analyses of conditions were made for each season. The data for each layer were combined using selection formulas specifying for certain conditions. For depth, water temperature and wave heights, Grid images (cell-based or raster images) were created with Arc/Info Grid. A cell size of 50 m was specified. In every Grid image, the pixels corresponding to the specified environmental condition were selected. The resulting grids were combined and the output presented as four maps, one for each season.

The next step was to determine which areas are currently prohibited from use because of existing water users. This would have an impact on the size of the actual areas suitable and available for cultivation. The areas with restricted access were excluded to create 4 maps showing exclusion zones (unavailable) and suitable areas, one for each season. The areas were calculated in hectares to determine how much water space is actually suitable and available. ArcView 3 was used to create map layouts, which were plotted on an HP DesignJet 2500 CP plotter.

RESULTS:

The study area is outlined in figure 2.1. Spatial analyses were done only for the seawater component in the areas indicated.

The maximum, minimum and average temperature for each season for the period 1976 to 1979 in Saldanha Bay are indicated in figures 2.2 to 2.5. The lowest temperature was in winter (12°C) and the highest in summer (21°C). The seasonal maximum, minimum and average temperature for 1996/1997 for four locations (figure 2.9) in St. Helena Bay are indicated in figures 2.6 to 2.8. The highest temperature (21.6°C) was measured in summer and the lowest (13.2°C) in winter.

Table 2.2 is a summary of the monthly fluctuation in swell direction and height derived from swell roses for the area 32 ° - 33 ° S; 17 ° - 19 ° E, which includes the study area. The highest waves recorded were 10 m. Table 2.3 is a summary of the mean and standard deviation of wave heights derived from occurrence tables for the 30' x 30' blocks for the area 32 ° 30' - 33 ° 30' S and 17 ° 30' 18 ° 30' E, for the years 1960 to 1990. This indicates a mean swell height of less than 3 m for the area. Table 2.4 is a summary of the wave height predictions for locations in Saldanha Bay, Langebaan Lagoon and St. Helena Bay, and the highest wave height predicted was 14 m.

Figures 2.11-2.14 are the results of selections for surface water temperature between 10°C and 17°C (classified as suitable), with the rest of the water space classified as unsuitable. The suitable areas for autumn, winter and spring do not differ much, but the overlay for summer indicates that the average surface temperatures in most areas will be unsuitable for seaweed survival. Figure 2.15 indicates areas where the water depth is between 2 and 10 m below surface and thus suitable for raft anchoring. Figure 2.10 indicates the locations for which wave heights were predicted with mathematical formulae, and Figure 2.16 indicates the areas where the maximum wave heights are not expected to exceed 4 m over a 5-year period. The map is only a broad indication of the maximum swell height that could be expected in a certain location in a specified period. Wave period or direction has not been taken into account.

Figure 2.17 indicates those areas that are not available for seaweed mariculture, such as navigation channels, military zones, harbour areas and other mariculture. Figure 2.18 indicates existing infrastructure (roads, railway lines and residential areas).

Figures 2.19-2.22 indicate the areas where the surface water temperature, wave heights and water depth are likely to be suitable for suspended cultivation for each season. Figures 23-24 are the results of a combination of the suitable areas with areas that are not available to seaweed mariculture, in both the Saldanha Bay system and St. Helena Bay. Areas 1 and 2 (Figure 2.23) are the suitable areas in Saldanha Bay, and areas 3 and 4 (Figure 2.24) are the suitable areas in St. Helena Bay. The total areas suitable in terms of annual temperature, wave height and water depth in the study area are given in Table 2.5. In Saldanha Bay 975.4 ha is suitable, and in St. Helena Bay 474.8 ha is suitable.

DISCUSSION

The result of the temperature selection indicates a decrease in suitable areas in summer, as expected. Small Bay, where the first cultivation experiments took place, have high-risk areas in autumn and summer. This corresponds with the results of Anderson *et. al.* (1996), where high temperatures were experienced in late summer and autumn in Small Bay, and the seaweed died or growth rates decreased. The cultivation experiment currently underway in St. Helena Bay, is placed northwest of Sandy Point harbor, in an area which is classified as unsuitable in terms of summer temperature. Although results from this experiment are not available yet, the only major problem leading to die-off of plants was the black tide that occurred in June 1998 (J. Wakibia, pers. comm.). This could mean that the accuracy of temperature predictions in St. Helena Bay is questionable, or that different selection criteria should be used. The temperature data used for Saldanha Bay had a high spatial resolution (hundreds of measuring points over a three-year period), but did not provide enough temporal measurements for each point to obtain a more accurate average. The data for St Helena Bay had a reasonable temporal resolution (daily for almost one year) although not enough measurements were obtained for summer to provide an accurate estimate, especially for Stompneus Bay. The spatial resolution was small, as only 4 locations were used for analysis and predictions. The fact that the measurements in St Helena Bay were taken on the beach, where the surface temperature might be slightly higher due to the shallowness of the water, could also decrease the accuracy of the predictions. However, the database can be updated in future as more reliable and accurate data becomes available. One way to obtain more accurate predictions may be to classify areas where the temperature remains above 17°C for one week or more, as unsuitable.

The spatial resolution of the data for wave heights obtained from the SADCO database was too big (30' x 30' blocks) to be useful for the prediction of sites, but it provided an idea of the average swell conditions and direction that may be expected over the area. The dominant swell direction in winter is south-west, and south in all other seasons. Langebaan Lagoon and St. Helena Bay are protected against the prevailing swells from the Atlantic Ocean. The mouth of Saldanha Bay opens to the west, and the bay is thus affected by southerly, westerly and south-westerly swell. Some of the areas selected as suitable in terms of wave heights, did not correspond to the available information. Area 1, to the south of the breakwater and west of Donkergat Peninsula, is exposed to westerly and south westerly waves, yet is selected as suitable. Area 2, outside the mouth of Saldanha Bay and west of Milnavair, is protected from incoming waves by the outcrop of land, but may be affected by refracted waves. The only real wave measurements used in the predictions of wave heights were taken from the two waverider buoys inside and outside the mouth of Saldanha Bay, and this could have led to inaccurate predictions of wave heights in other areas. Results from a simulation study by Mocke *et. al.* (1996) indicated that wave fronts from a SW direction (the direction the bay is most exposed to) entering Saldanha Bay are diffracted around the head of the breakwater into Small Bay. Most of the wave energy reaches the beaches opposite the entrance, and a small amount of wave energy enters Small Bay. The typical wave heights predicted for Small Bay in their study (0.1m to 0.4 m) corresponds to the results of this study.

St. Helena Bay is open to the north, and is exposed to storms from a north-westerly to northerly direction in winter. The areas shown as suitable in St. Helena Bay, do not all correspond with the general expectations. Area 4, west of Shellbay Point, is expected to be exposed to westerly swell, but has been classified as suitable. Thus the accuracy of the predictions or the method of analysis may be questionable. It could also be that the area of analysis was too small. Additional wave predictions for the exposed areas between Cape Columbine and Saldanha Bay may have been useful to provide a more accurate classification of wave conditions. Ross *et. al.* (1993), in a site selection study for salmonid cage culture, also found that the accuracy of input data could be a potential problem. Residents in St Helena Bay confirmed the increased presence of west-northwest to northerly swell from May to September, with heights of 3-10 m (C. Solomons, pers. comm.). Although these conditions do not occur all the time during winter, the possibility of storms from a northwesterly direction in a bay that is exposed to the north, increases the risk of dislodging of rafts.

The water depth in the study area may change because of siltation and dredging. The water depths were digitized from bathymetry charts that may already be outdated, thus it will be useful to update the data on water depth in future. The road infrastructure is generally good, and a freeway runs from Cape Town to Saldanha Bay and Laaiplek. This will ensure that transport of dried seaweed to the point of export will not be a major problem.

The total areas shown as suitable for seaweed mariculture do not imply that all those areas will be utilized for this purpose. The carrying capacity of the Saldanha Bay system and St. Helena Bay is not known and needs to be determined. Factors such as user conflicts and demand for cultivated Gracilaria gracilis will influence the amount of space being used for seaweed cultivation.

Although no quantification of tides and currents were attempted, these factors, together with wave action, influences the amount of water motion around the rafts which is important for the exchange of nutrients (R.J. Anderson, pers. comm.). Currents are also important for the movement of nutrient-rich water into the bays. A generalized description of current movements in St Helena Bay (Holden, 1985; Chapman and Bailey, 1987) in summer, indicates that cold and nutrient-rich water is likely to be transported into the inshore regions of St Helena Bay by the west-flowing current. The Saldanha Bay experiments have taken place in Small Bay, which is protected against large swells by the breakwater erected between the mainland and Marcus Island in 1976 (Anderson *et. al.,* 1989). Weeks *et. al* (1991) estimated that residence time of water in Saldanha Bay is approximately 20 days. A study by Bilski (1993) confirmed that there is a clockwise circulation in Small Bay, but indicated a residence time of about 6 days for water in Saldanha Bay. The effects of currents on the replacement of water and replenishment of nutrients in relation to the seaweed survival and growth rate should be investigated in future studies. No commercial cultivation is taking place in South Africa yet, but when it becomes a reality, sites which are best for optimal growth rate, agar yield and quality, may be selected.

The study showed that the usefulness of a geographical information system is dependent on the accuracy of input data. The accuracy of the data used in this study or the definition of a suitable site is questionable, especially as some suitable sites predicted in Saldanha Bay and St. Helena Bay are known to be subject to constraining environmental factors. Experimental cultivation has taken place only in three sites in Small Bay, in Saldanha Bay (Anderson *et. al.,*1992; Anderson *et. al.*, 1996), and is currently underway at one site in St. Helena Bay. The locations of these rafts have been used to assess the accuracy of predictions at those sites. The accuracy of the predicted suitable sites in other areas can only be verified once cultivation experiments in those sites have been conducted, and additional criteria for successful cultivation or different ranges for these criteria are identified. In contrast, Kapetsky (1994) concluded that GIS-predicted locations can not be verified by using actual aquaculture locations. Hamman and Butcher (1997) created a suitability map for mussel mariculture in Saldanha Bay, and concluded that a GIS is useful for participatory resource allocation, and coastal zone research and management. The GIS used in the present study can be considered as a decision making tool and will provide more accurate predictions when environmental data with better spatial and temporal resolution become available. A method of testing the accuracy of predictions should be determined, as in Suwabe and Gomi (1995), who calculated the percentage difference between actual and predicted dam volume and area.

The capabilities of a GIS have not been used to their full potential during this study. Data that could be added to improve the assessment of suitable sites, are the locations of fish factories and other sources of possible pollution. Qualitative data that could be added include the legal implications of suitable sites, especially where they fall within the boundaries of nature conservation areas and military zones, and visual impact scores (a method for visual impact assessment is described in Miller and Xiang, 1992). The distance from residential areas to sites, from sites to drying areas, and from drying areas to point of export could be calculated (as in the method of Kohli *et. al.*, 1995) to improve economic forecasting. Socio-economic data, such as the number of people in each residential area, could be added to estimate the availability of possible farmers. The availability and value of land or buildings for drying purposes can be added to estimate costs.

This study may be considered as a first step towards the identification of suitable sites for Gracilaria mariculture on the West Coast of South Africa. As more information about seaweed mariculture becomes available, and more complete data sets can be obtained, the accuracy of predictions can be improved.

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Table 2.1: Salinity measurements for the 30' x 30' blocks in area 32° 30' - 33° 30' S; 17° 30' - 18° 30' E, for the years 1920-1984. Mean (M), Standard deviation (Std) and number of occurrence (N) obtained from the SADCO database, CSIR, Stellenbosch.

32°30'S; 17°30'E		18°30'E	32°30'S; 17°30'E		18°30'E
AUTUMN	34.9 (M)	34.7	WINTER	35	32.9
	0.18 (Std)	0.13		0.23	7.22
33°	383 (N)	337	33°	393	357
	34.9	34.9		35	34.9
	0.23	0.35		0.22	0.27
	610	115	33°30'	709	108
33°30'					
SPRING	35	34.6	SUMMER	34.8	34.8
	0.21	1.7		0.15	0.12
	398	339	33°	351	326
	35.1	35		34.9	35
	0.2	0.69		0.17	0.35
	670	108	33°30'	668	102
33°30'					

Table 2.2: Monthly fluctuation in wave height and direction for the area 32° S - 33° S; 17° E - 19° E, for the years 1960-1994 (source: SADCO database, CSIR, Stellenbosch)

SEASON	MONTH	DOMINANT DIRECTION	HIGHEST % FREQUENCY (m)	HIGHEST SWELL (m)
Summer	January	S	2 & 3	10
Summer	February	S	2 & 3	7
Autumn	March	S	2 & 3	10
Autumn	April	S	2 & 3	7
Autumn	May	S	2 & 3	7
Winter	June	SW	2 & 3	10
Winter	July	SW	2 & 3	10
Winter	August	SW	2 & 3	10
Spring	September	S	2 & 3	7
Spring	October	S	2 & 3	7
Spring	November	S	2 & 3	10
Summer	December	S	2 & 3	10

Table 2.3: Wave heights calculated for the 30' x 30' blocks in area 32° 30' - 33° 30' S; 17° 30' - 18° 30' E for the years 1960-1990. Mean (M), Standard deviation (Std) and number of occurrence (N) obtained from the SADCO database, CSIR, Stellenbosch.

32°30'S; 17°30'E		18°30'E	32°30'S; 17°30'E		18°30'E
AUTUMN	2.4 (M)	2.2	WINTER	2.6	1.9
	1.4 (Std)	1.3		1.4	1.0
	227 (N)	8	33°	252	10
33°					
	2.3	2.0		2.7	2.7
	1.2	0.9		1.5	1.7
33°30'S	900	22	33°30'S	896	24
SPRING	2.3	2.0	SUMMER	2.2	1.6
	1.2	0.9		1.3	1.0
33°S	839	22	33°S	225	7
	2.6	2.3		2.2	2.0
	1.4	1.1		1.1	1.1
33°30'S	839	20	33°30'S	885	41

Table 2.4: Wave height predictions for 1 and 5 year periods for all locations

WAVE CALCULATIONS FOR WAVERIDER BUOYS

	N	E	p	Q	H(mo)	H(max)
SALDANHA WAVERIDER	1	0.069	1.0	7.3	4.0	7.9
	5	0.014	1.0	8.9	4.6	9.2
OLD WAVERIDER	1	0.069	1.0	7.3	7.0	14.0
	5	0.014	1.0	8.9	8.2	16.3

WAVE PREDICTIONS FOR ALL OTHER LOCATIONS

	N (years)	H(mo)	H(max)
CLUB MYKONOS	1	1.2	2.4
	5	1.4	2.8
LANGEBAAN	1	0.8	1.6
	5	1.0	1.9
SALDANHA JETTY	1	1.0	2.0
	5	1.2	2.3
BLOUWATERBAAI	1	0.6	1.2
	5	0.7	1.4
HOEDJIESBAAI	1	0.5	1.0
	5	0.5	1.0
CHURCHAVEN	1	0.5	1.0
	5	0.5	0.9
GEELBEK	1	0.5	1.0
	5	0.5	0.9
KRAALBAAI	1	0.5	1.0
	5	0.5	0.9
RIETBAAI	1	0.5	1.0
	5	0.5	0.9
BOTTELARY	1	0.5	1.0
	5	0.5	0.9
DWARSKERSBOS	1	4.0	8.0
	5	4.6	9.2
BLINDER	1	4.0	8.0
	5	4.6	9.2
LAINGVILLE	1	0.2	0.3
	5	0.2	0.4
STOMPNEUS BAY	1	0.2	0.3
	5	0.2	0.4

H(mo) = significant wave height (m)
H(max) = maximum exceedance wave height (m)
E = exceedance percentage
N = number of years
p = probability of exceedance
Q = -ln(ln(p))

Table 2.5. Total areas suitable for suspended raft cultivation in terms of temperature, wave height and water depth.

AREA	TOTAL SUITABLE AREA (Ha)
Saldanha Bay system	975.4
St. Helena Bay	474.8
TOTAL	1450.2

FIGURE CAPTIONS

Langebaan Lagoon

Figure 2.24. Areas suitable and available for seaweed mariculture in St. Helena Bay

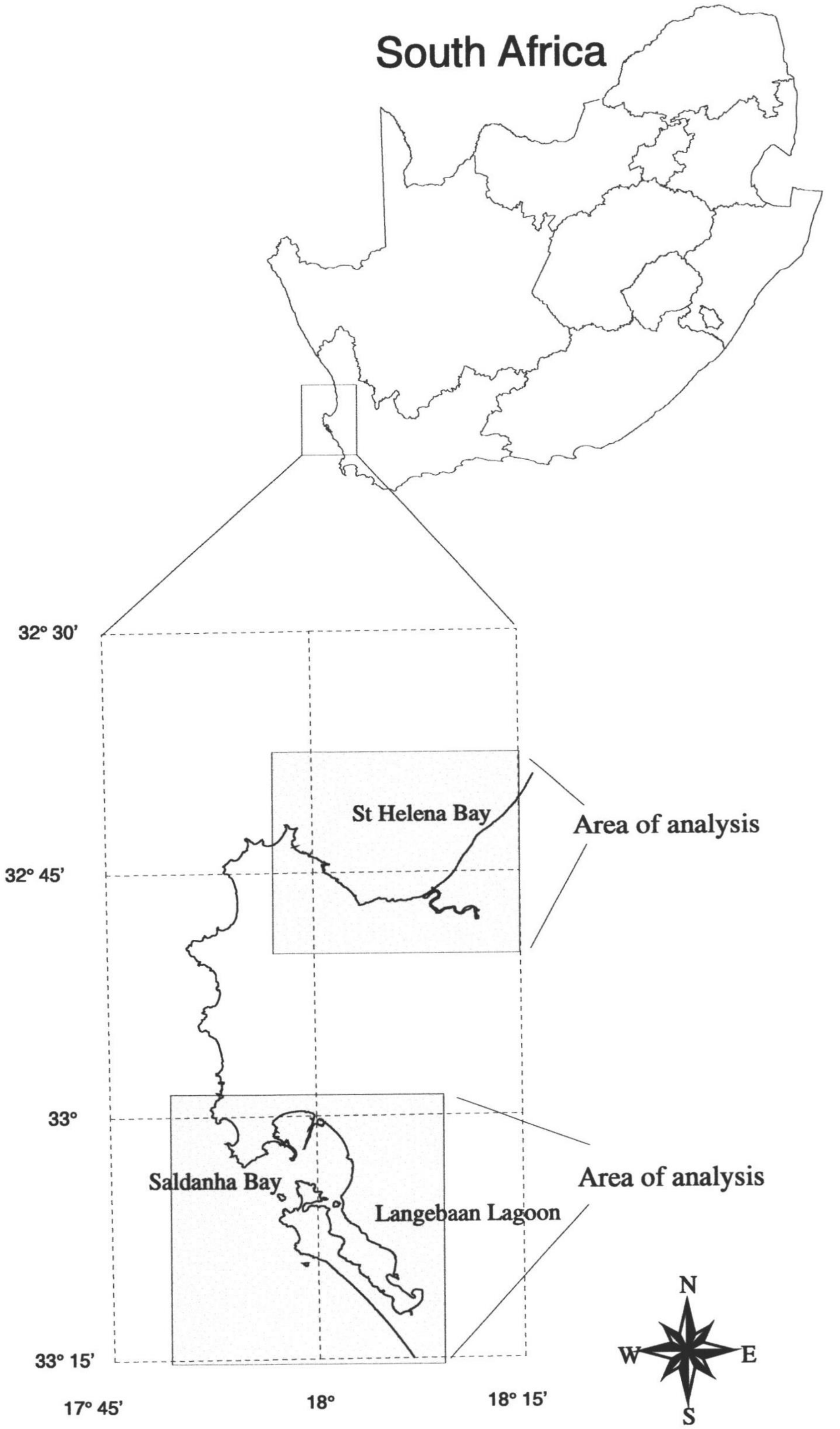

South Africa
32° 30'
32° 45'
33°
33° 15'
17° 45'
18°
18° 15'
St Helena Bay
Area of analysis
Saldanha Bay
Langebaan Lagoon
Area of analysis
N
W
E
S

Figure 2.1

Figure 2.2

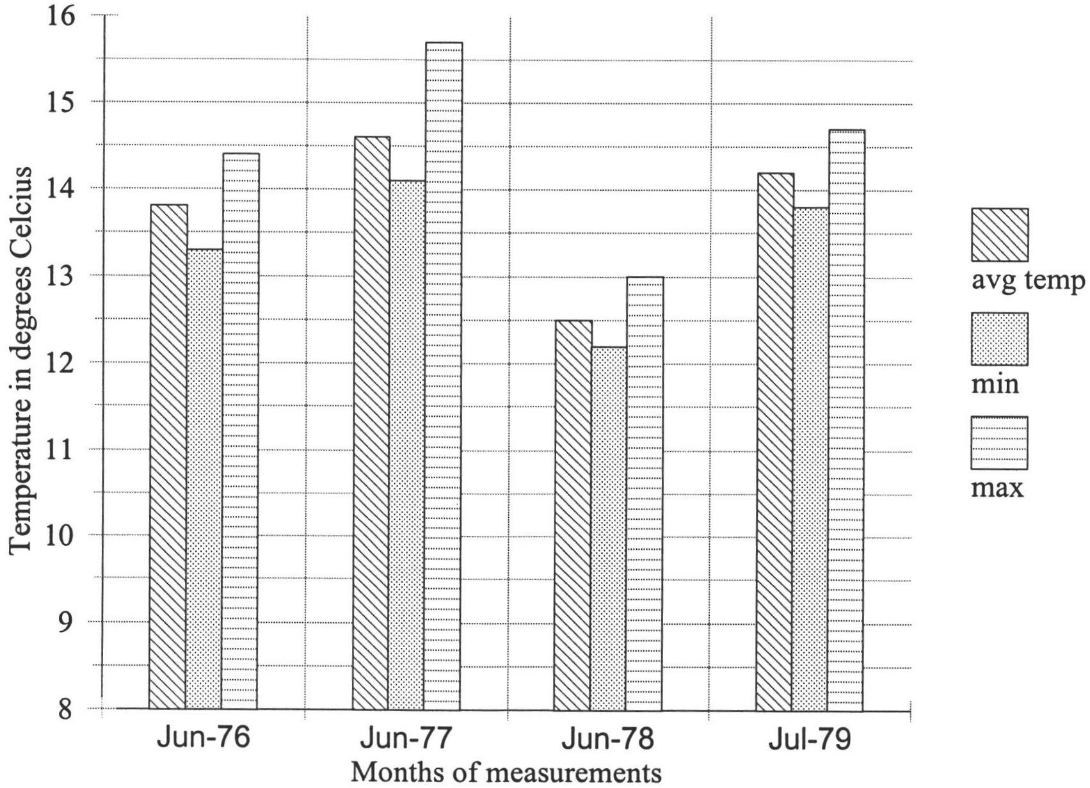
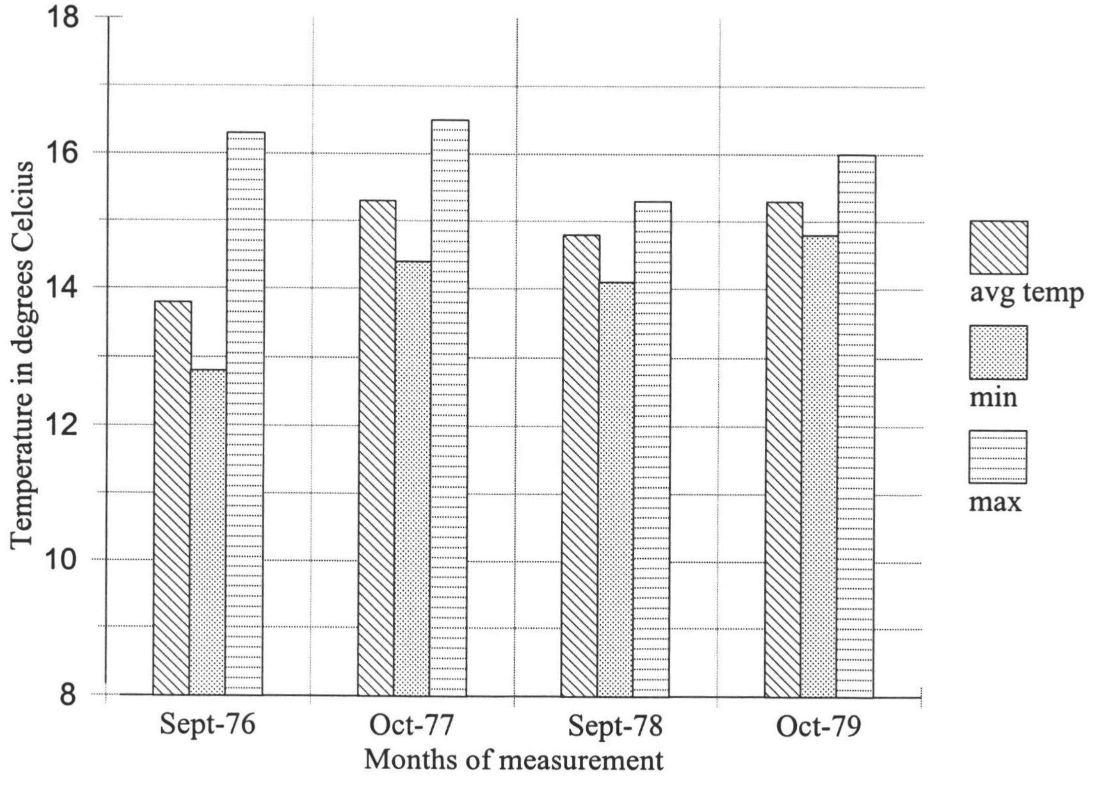
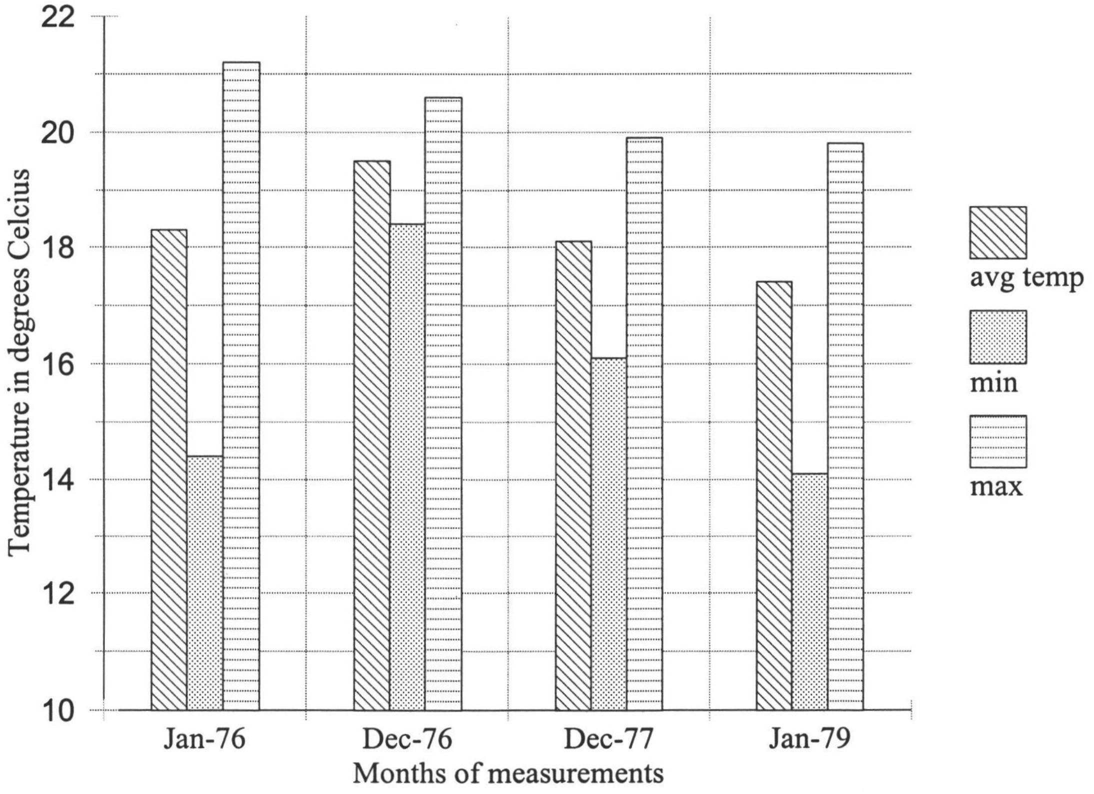

16
15
14
13
12
11
10
9
8
Temperature in degrees Celcius
Jun-76
Jun-77
Jun-78
Jul-79
Months of measurements
avg temp
min
max

Figure 2.3



18
16
14
12
10
8
Temperature in degrees Celcius
Sept-76
Oct-77
Sept-78
Oct-79
Months of measurement
avg temp
min
max

Figure 2.4



22
20
18
16
14
12
10
Temperature in degrees Celcius
Jan-76
Dec-76
Dec-77
Jan-79
Months of measurements
avg temp
min
max

Figure 2.5

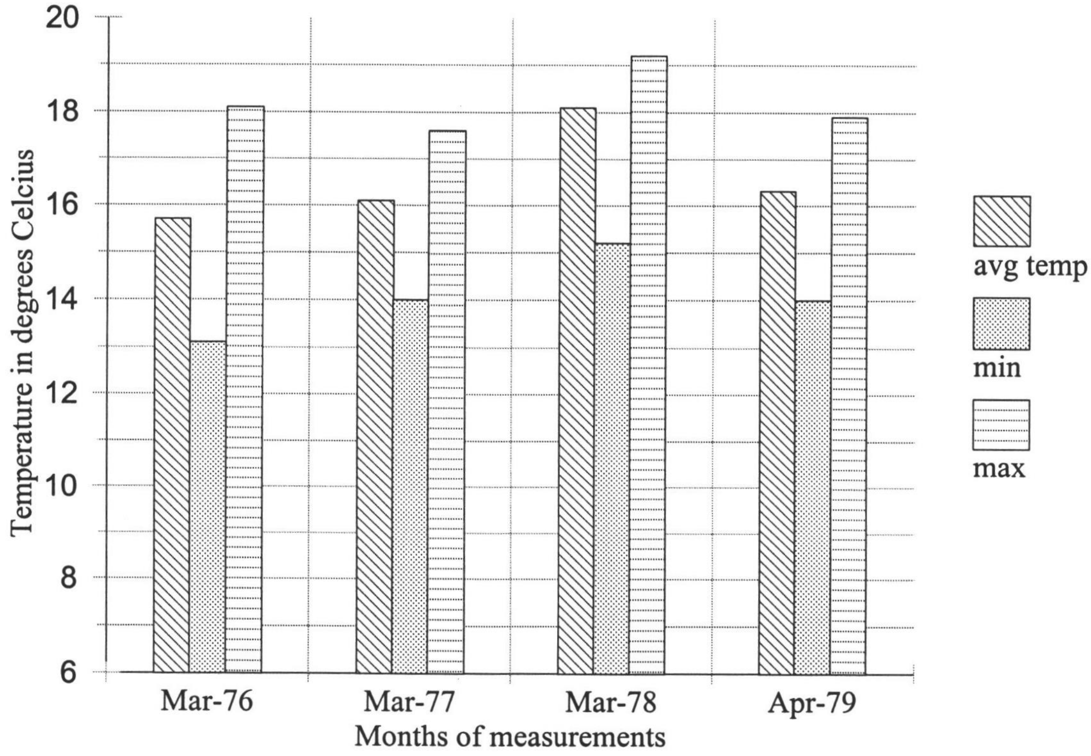
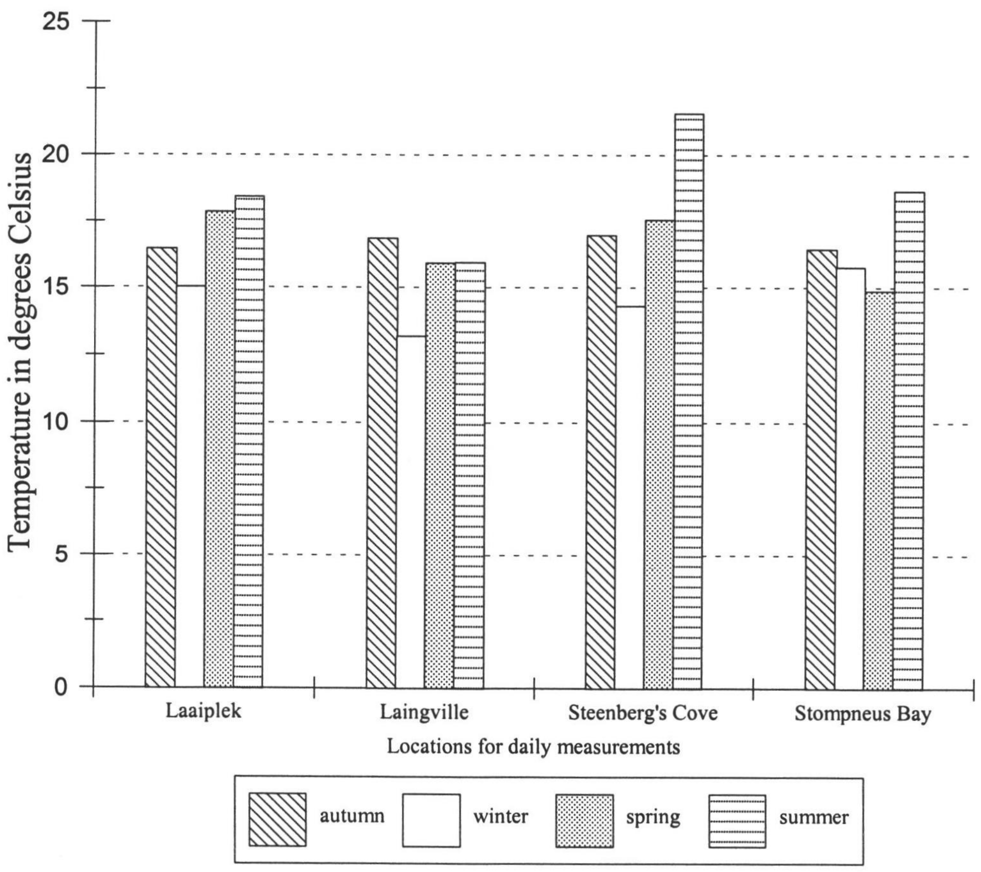
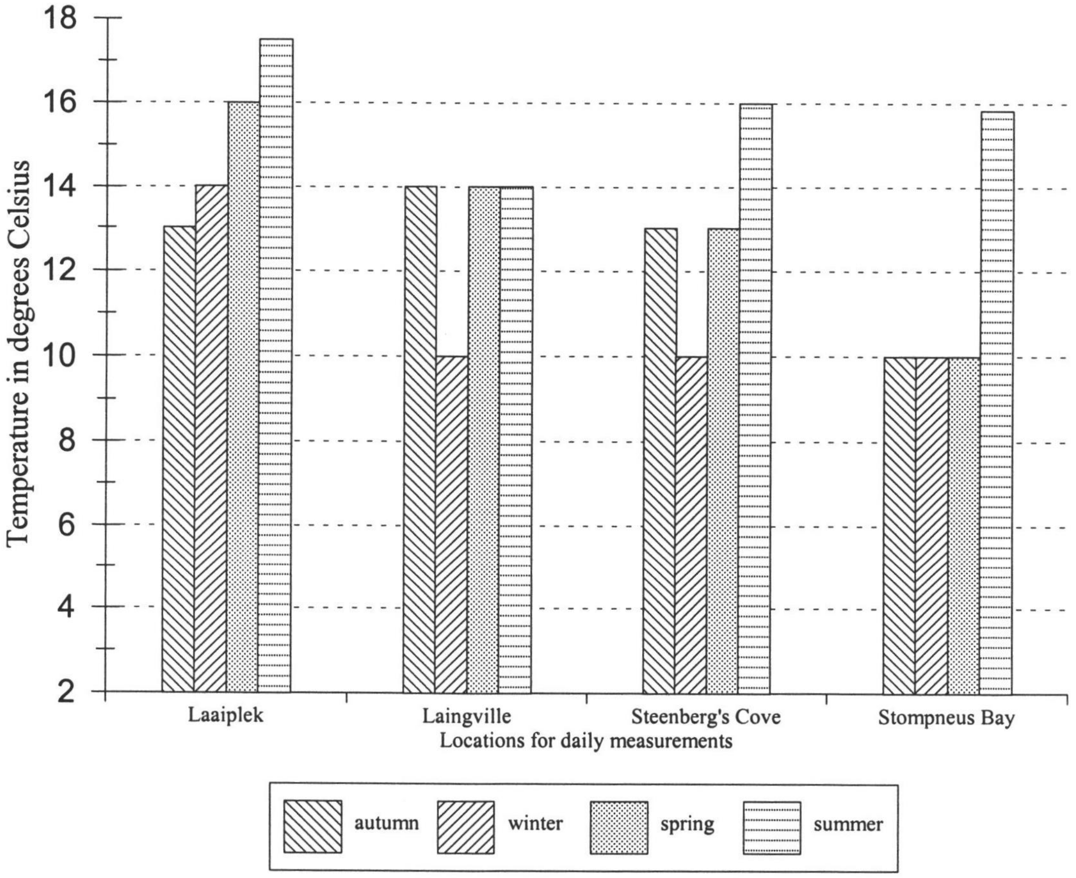

20
18
16
14
12
10
8
6
Temperature in degrees Celcius
Mar-76
Mar-77
Mar-78
Apr-79
Months of measurements
avg temp
min
max

Figure 2.6



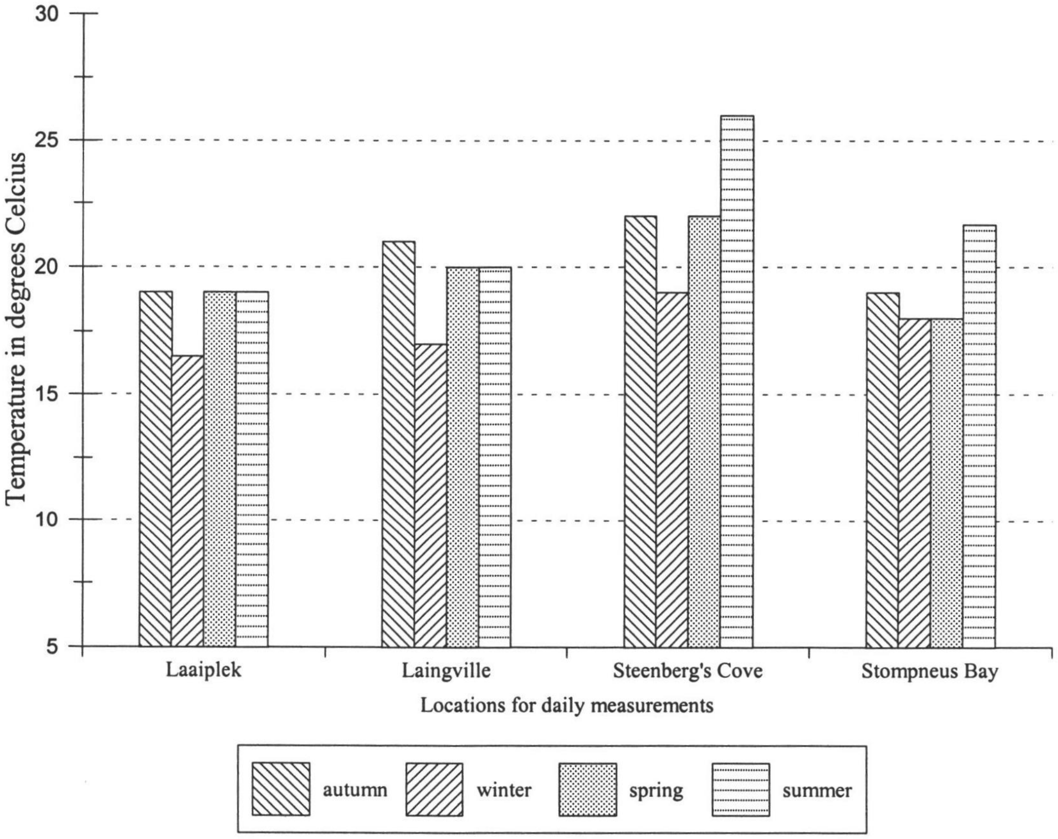
25
20
15
10
5
0
Temperature in degrees Celsius
Laaiplek
Laingville
Steenberg's Cove
Stompneus Bay
Locations for daily measurements
autumn
winter
spring
summer

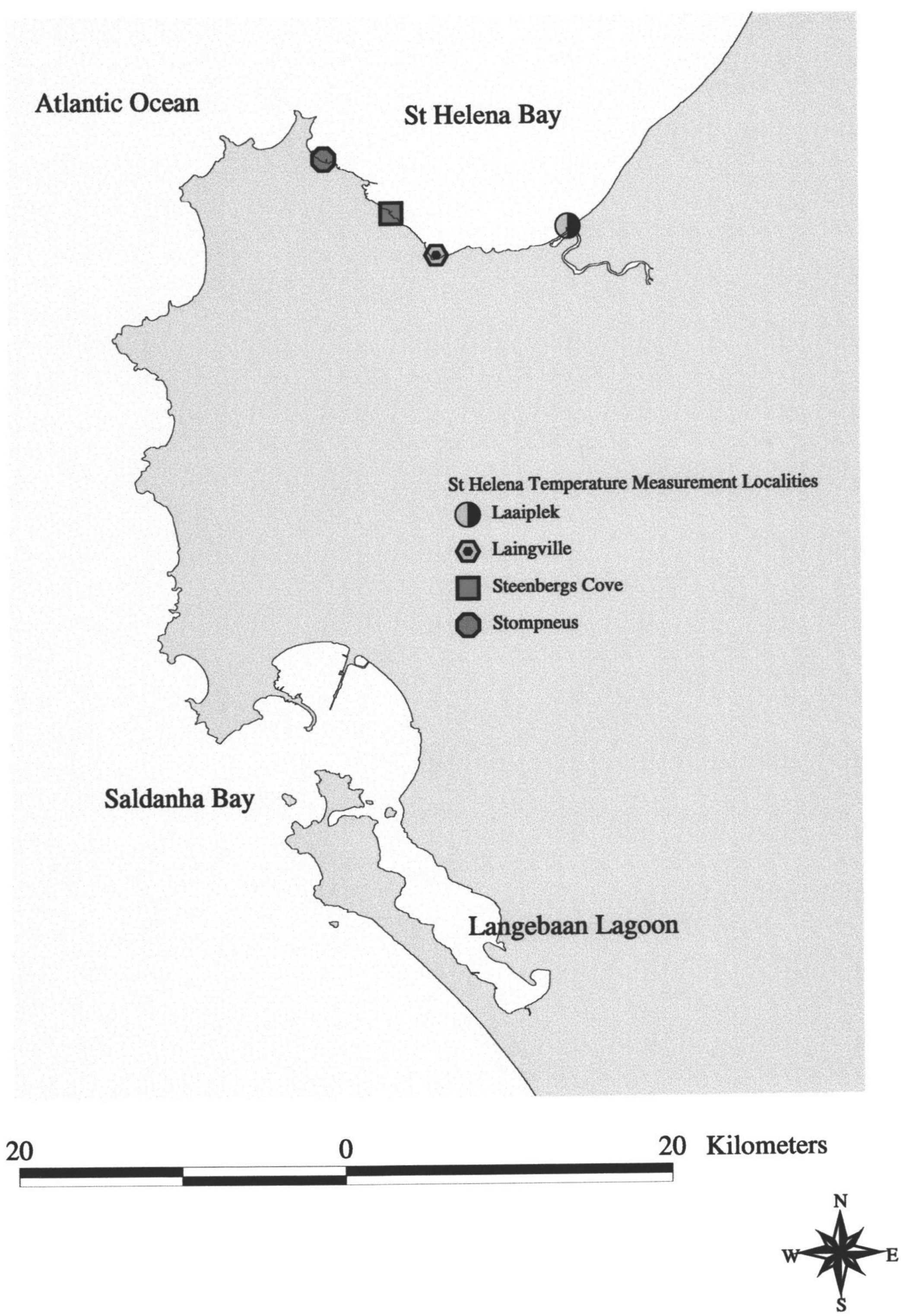
Figure 2.7



18
16
14
12
10
8
6
4
2
Temperature in degrees Celsius
Laaiplek
Laingville
Steenberg's Cove
Stompneus Bay
Locations for daily measurements
autumn
winter
spring
summer

Figure 2.8


30
25
20
15
10
5
Temperature in degrees Celcius
Laaiplek
Laingville
Steenberg's Cove
Stompneus Bay
Locations for daily measurements
autumn
winter
spring
summer



Atlantic Ocean
St Helena Bay
St Helena Temperature Measurement Localities
Laaiplek
Laingville
Steenbergs Cove
Stompneus
Saldanha Bay
Langebaan Lagoon
20
0
20 Kilometers
N
W
E
S

Figure 2.9

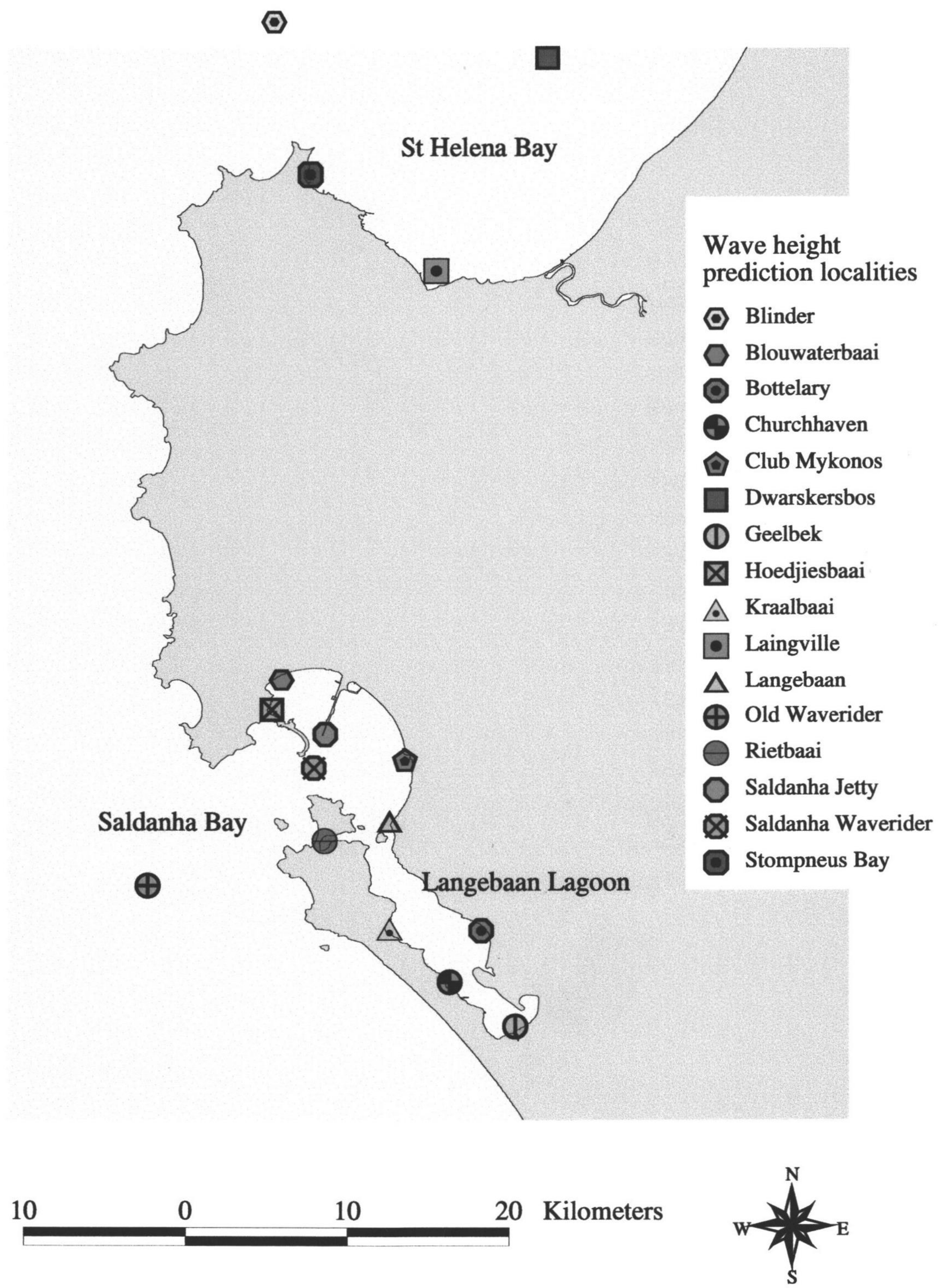

St Helena Bay
Saldanha Bay
Langebaan Lagoon
Wave height prediction localities
Blinder
Blouwaterbaai
Bottelary
Churchhaven
Club Mykonos
Dwarskersbos
Geelbek
Hoedjiesbaai
Kraalbaai
Laingville
Langebaan
Old Waverider
Rietbaai
Saldanha Jetty
Saldanha Waverider
Stompneus Bay
10 0 10 20 Kilometers
N
W
E
S

Figure 2.10

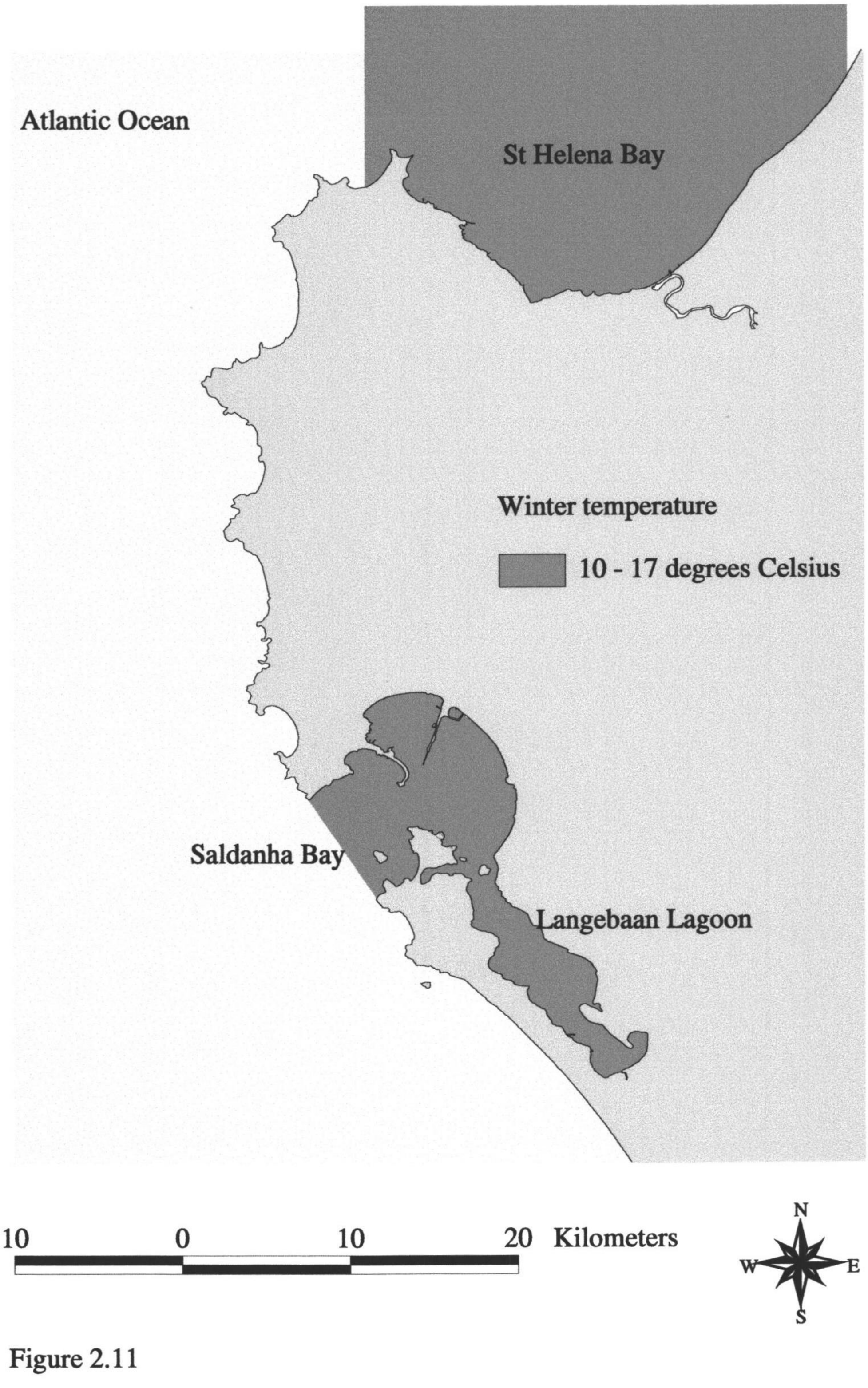

Atlantic Ocean
St Helena Bay
Winter temperature
10 - 17 degrees Celsius
Saldanha Bay
Langebaan Lagoon
10 0 10 20 Kilometers
N
W
E
S

Figure 2.11

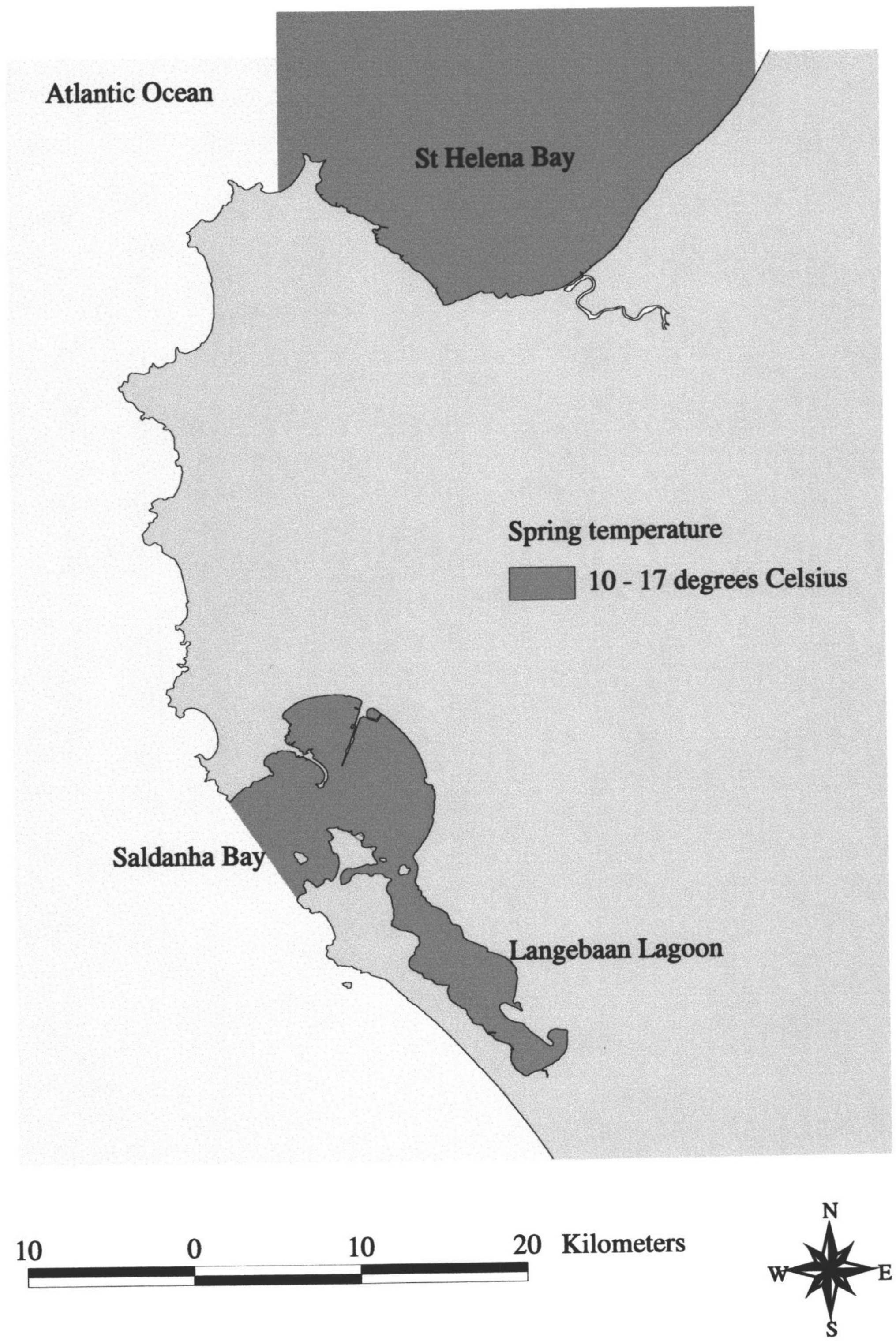

Atlantic Ocean
St Helena Bay
Spring temperature
10 - 17 degrees Celsius
Saldanha Bay
Langebaan Lagoon
10
0
10
20
Kilometers
N
W
E
S

Figure 2.12

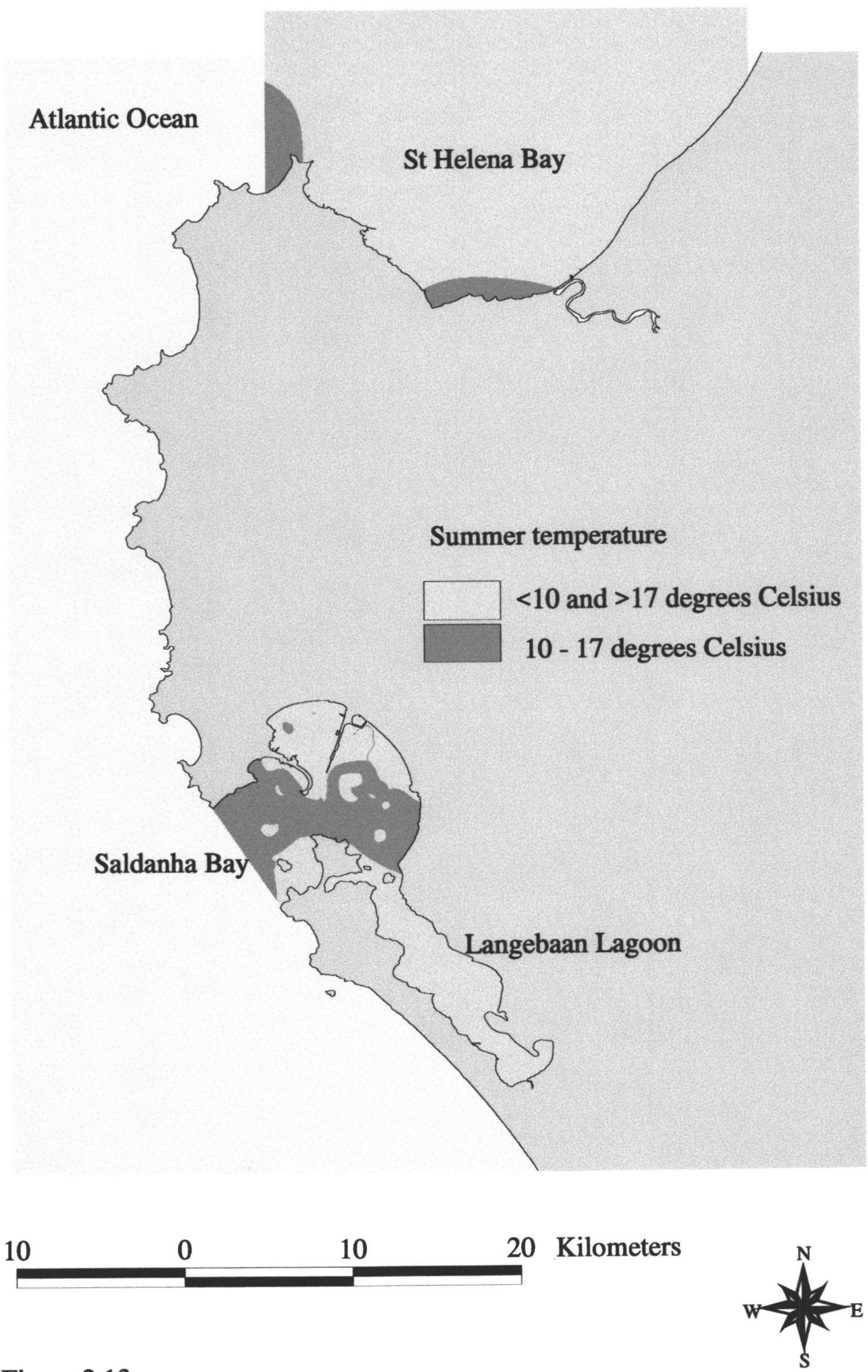

Atlantic Ocean
St Helena Bay
Summer temperature
<10 and >17 degrees Celsius
10 - 17 degrees Celsius
Saldanha Bay
Langebaan Lagoon
10
0
10
20 Kilometers
N
W
E
S

Figure 2.13

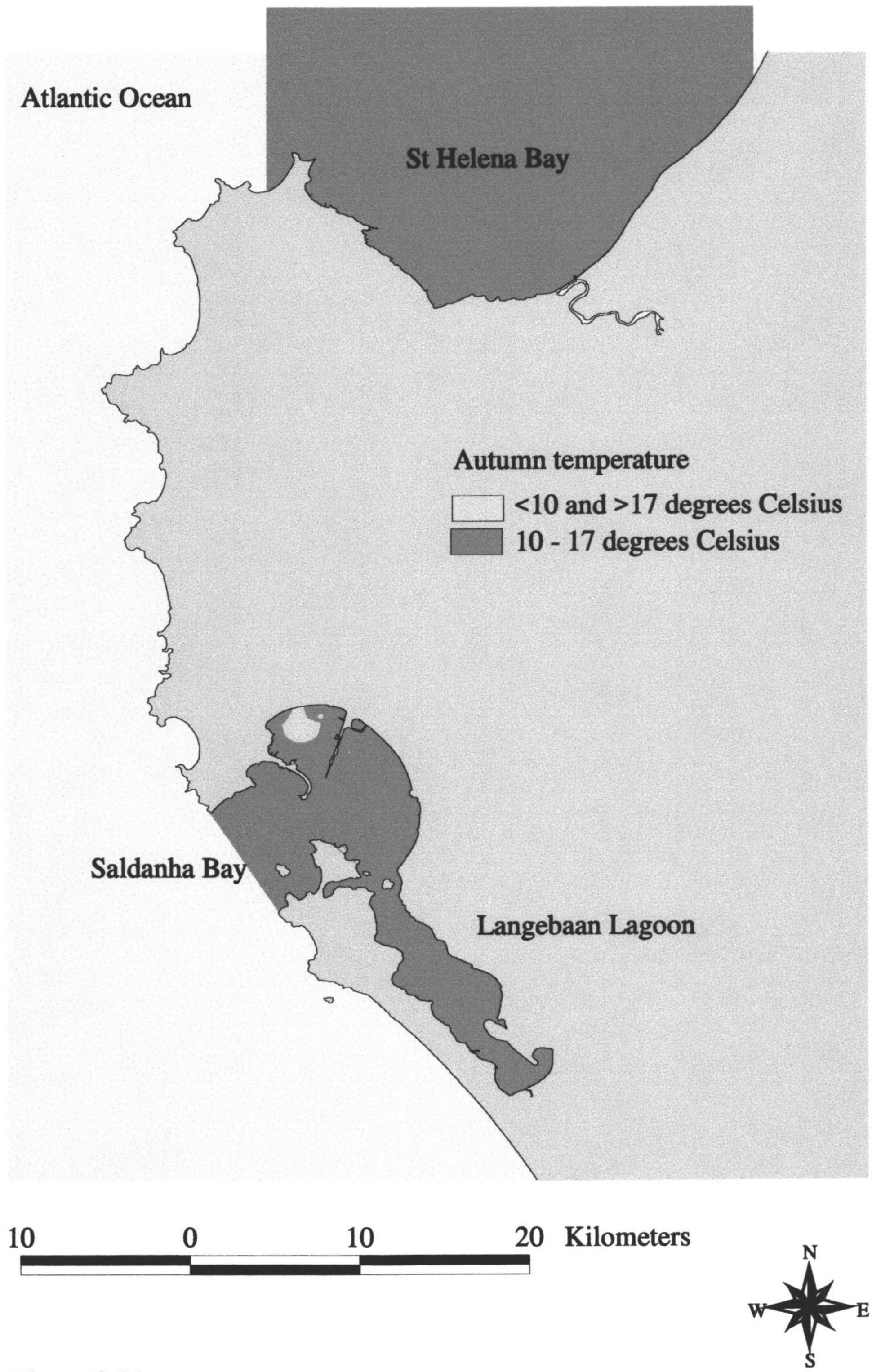

Atlantic Ocean
St Helena Bay
Autumn temperature
<10 and >17 degrees Celsius
10 - 17 degrees Celsius
Saldanha Bay
Langebaan Lagoon
10 0 10 20 Kilometers
N
W
E
S

Figure 2.14

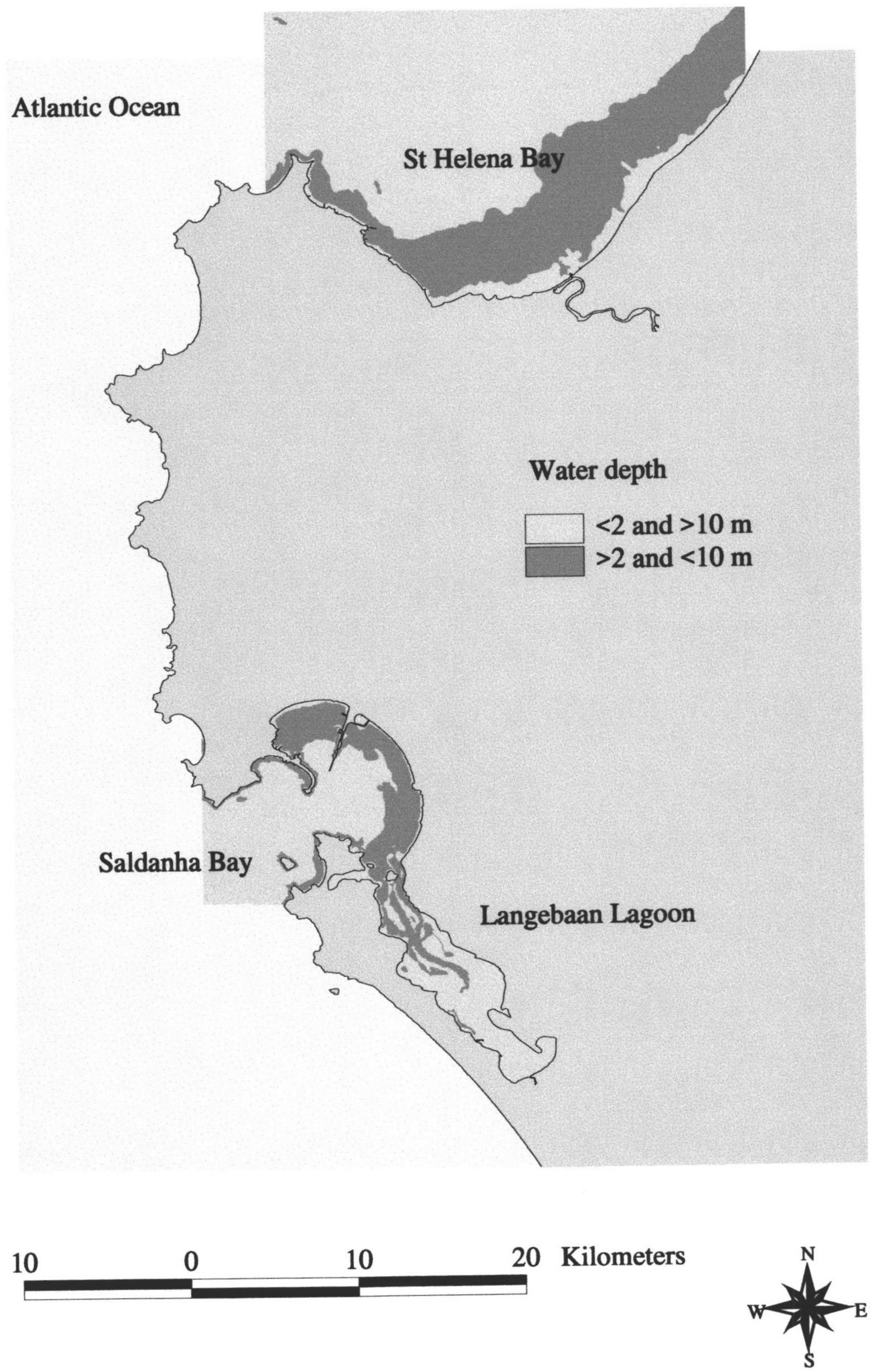

Atlantic Ocean
St Helena Bay
Water depth
<2 and >10 m
>2 and <10 m
Saldanha Bay
Langebaan Lagoon
10
0
10
20
Kilometers
N
W
E
S

Figure 2.15

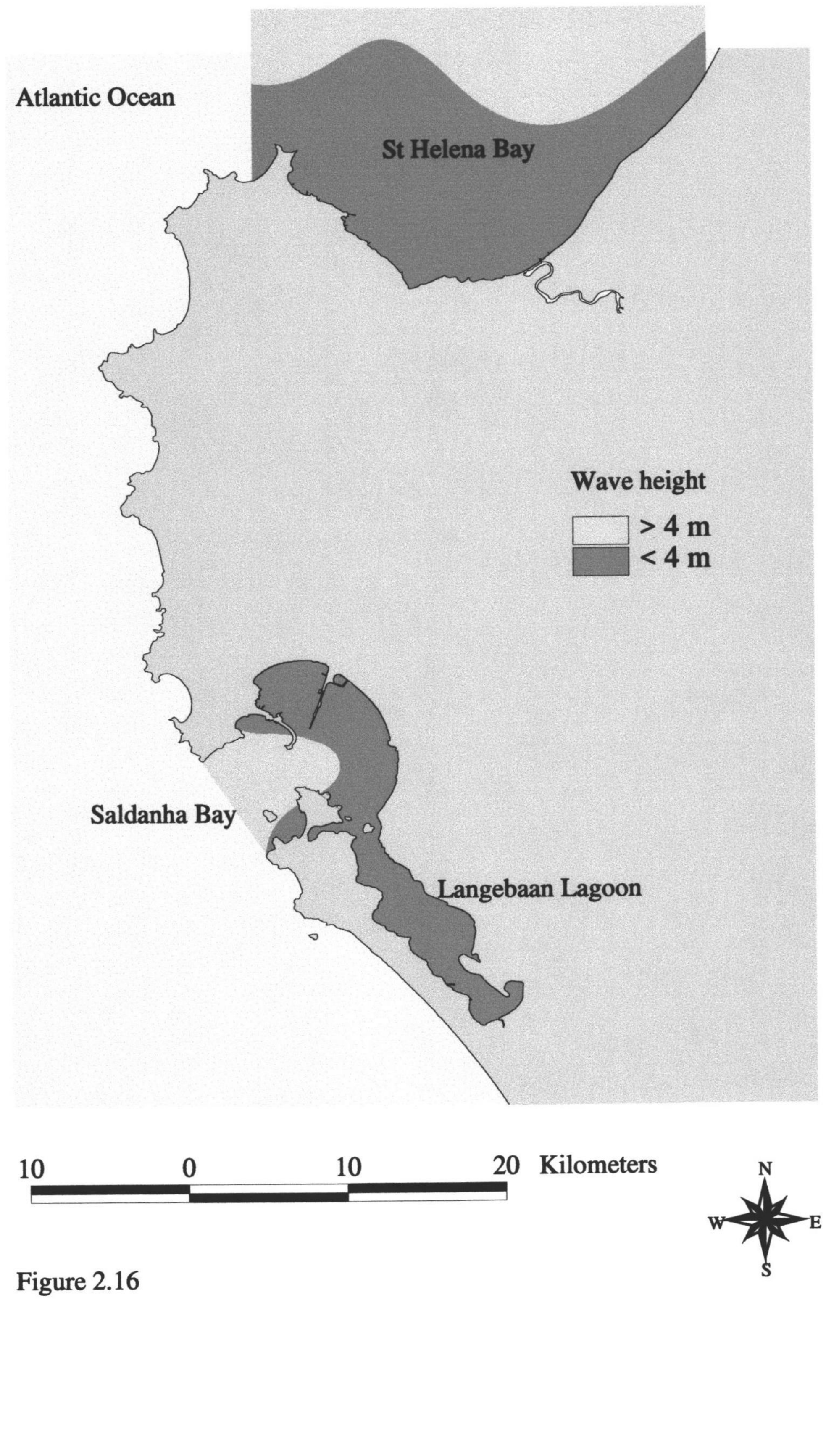

Atlantic Ocean
St Helena Bay
Wave height
> 4 m
< 4 m
Saldanha Bay
Langebaan Lagoon
10
0
10
20
Kilometers
N
W
E
S

Figure 2.16

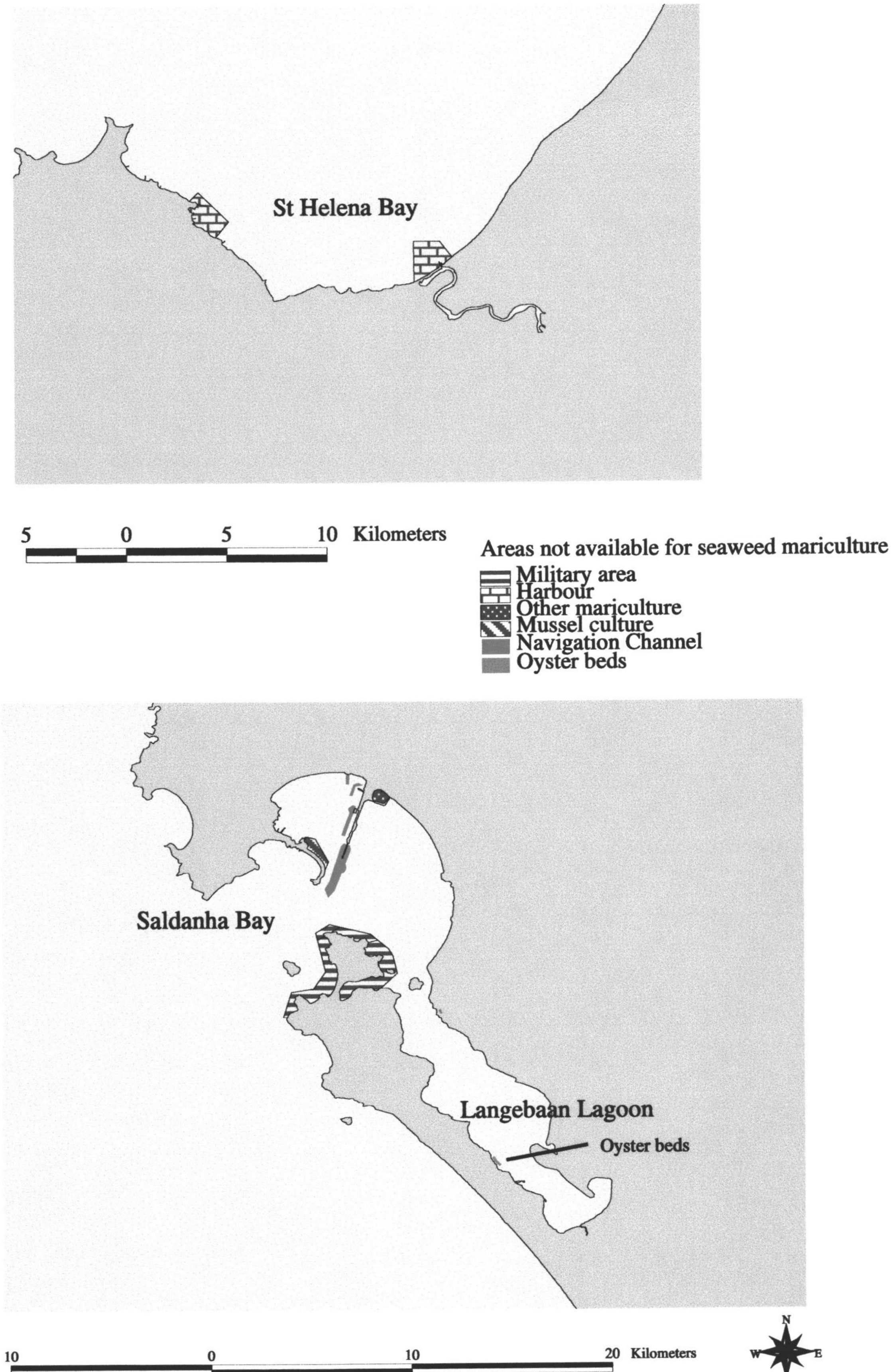

St Helena Bay
5 0 5 10 Kilometers
Areas not available for seaweed mariculture
Military area
Harbour
Other mariculture
Mussel culture
Navigation Channel
Oyster beds
Saldanha Bay
Langebaan Lagoon
Oyster beds
10 0 10 20 Kilometers
N
W
E
S

Figure 2.17

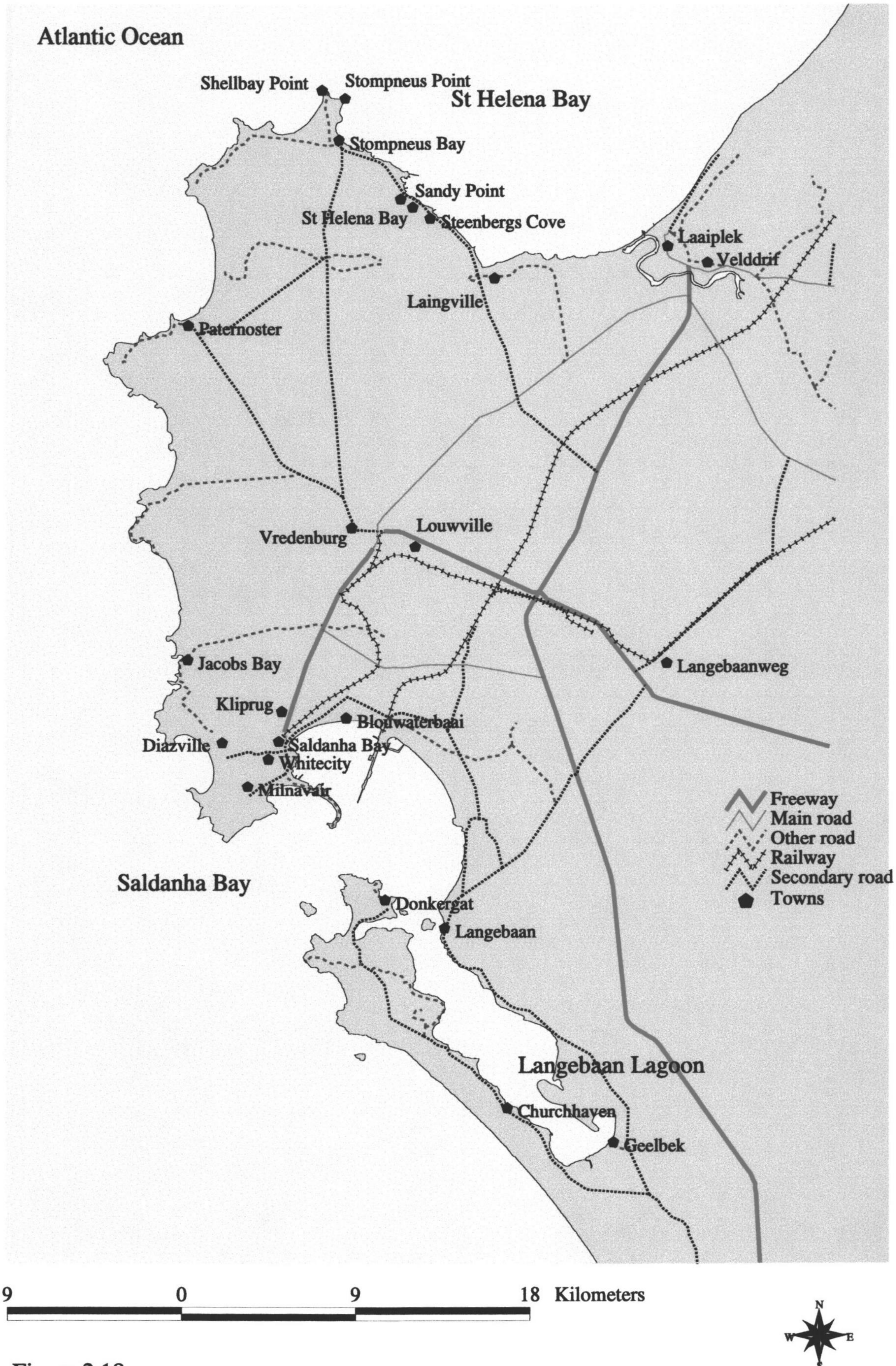

Atlantic Ocean
Shellbay Point
Stompneus Point
St Helena Bay
Stompneus Bay
Sandy Point
St Helena Bay
Steenbergs Cove
Laaiplek
Velddrif
Laingville
Paternoster
Vredenburg
Louwville
Jacobs Bay
Langebaanweg
Kliprug
Blouwaterbaai
Diazville
Saldanha Bay
Whitecity
Milnavair
Saldanha Bay
Donkergat
Langebaan
Langebaan Lagoon
Churchhaven
Geelbek
Freeway
Main road
Other road
Railway
Secondary road
Towns
9 0 9 18 Kilometers
N
W
E
S

Figure 2.18

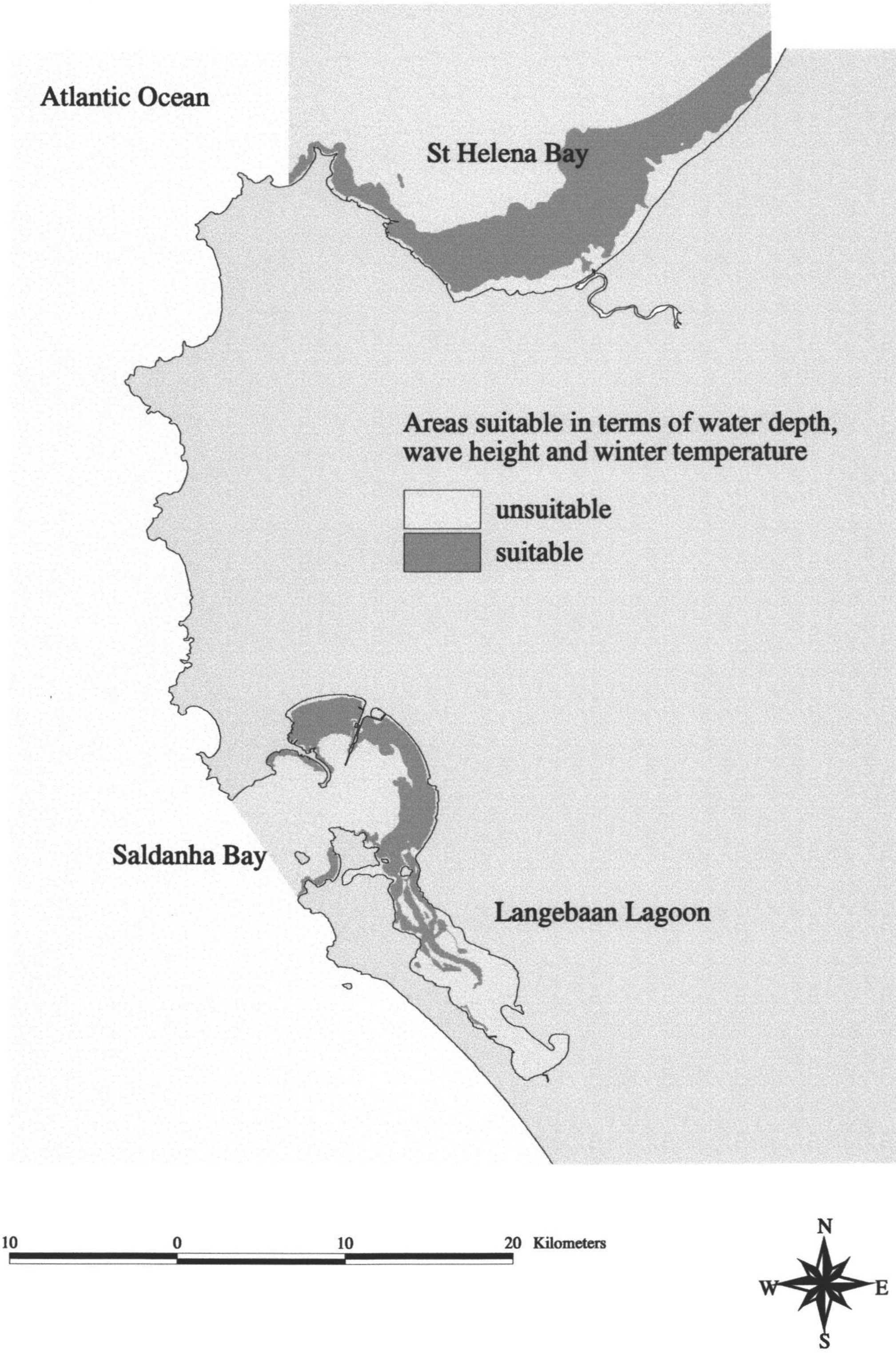

Atlantic Ocean
St Helena Bay
Areas suitable in terms of water depth, wave height and winter temperature
unsuitable
suitable
Saldanha Bay
Langebaan Lagoon
10
0
10
20 Kilometers
N
W
E
S

Figure 2.19

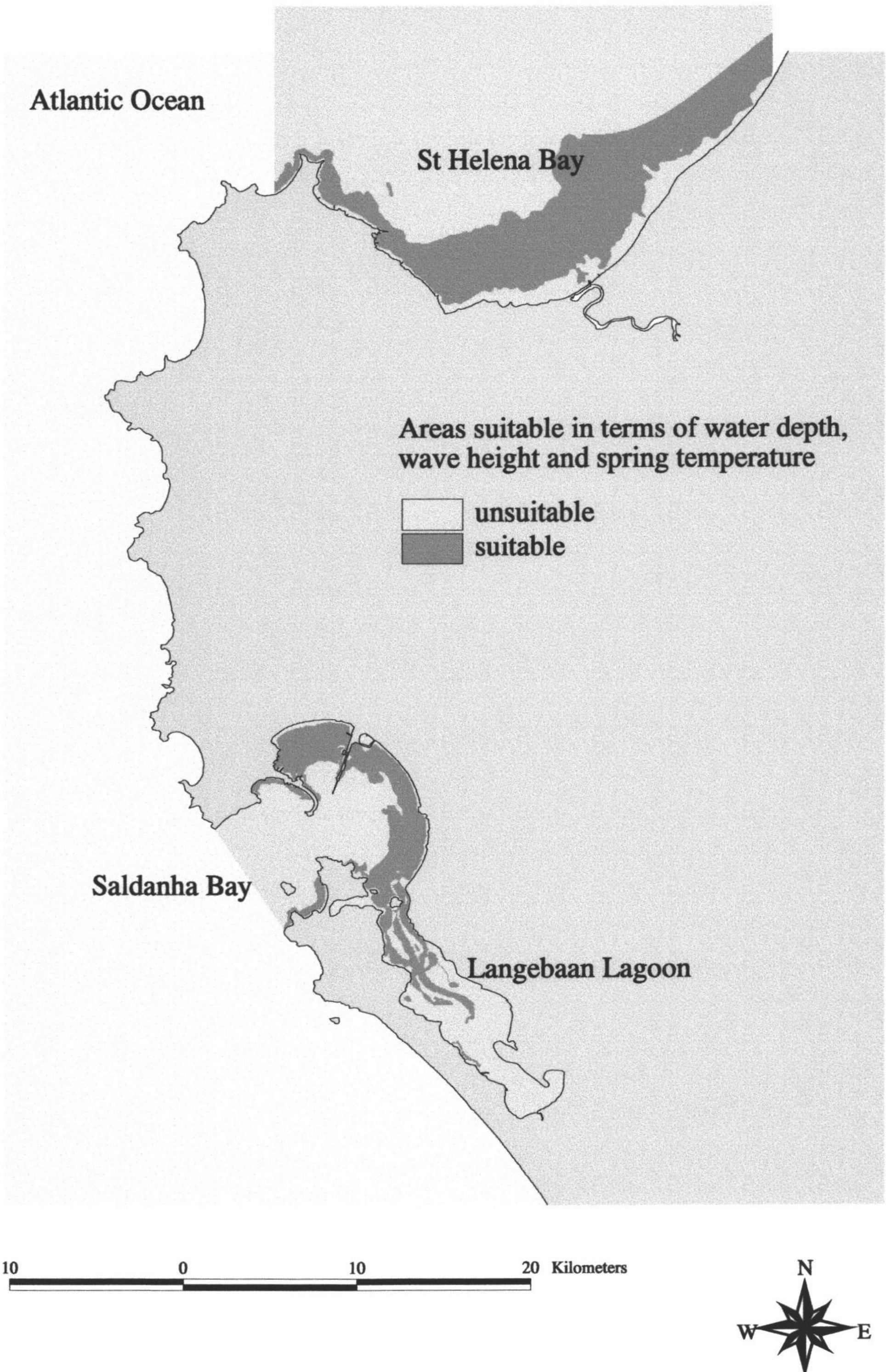

Atlantic Ocean
St Helena Bay
Areas suitable in terms of water depth, wave height and spring temperature
unsuitable
suitable
Saldanha Bay
Langebaan Lagoon
10 0 10 20 Kilometers
N
W
E
S

Figure 2.20

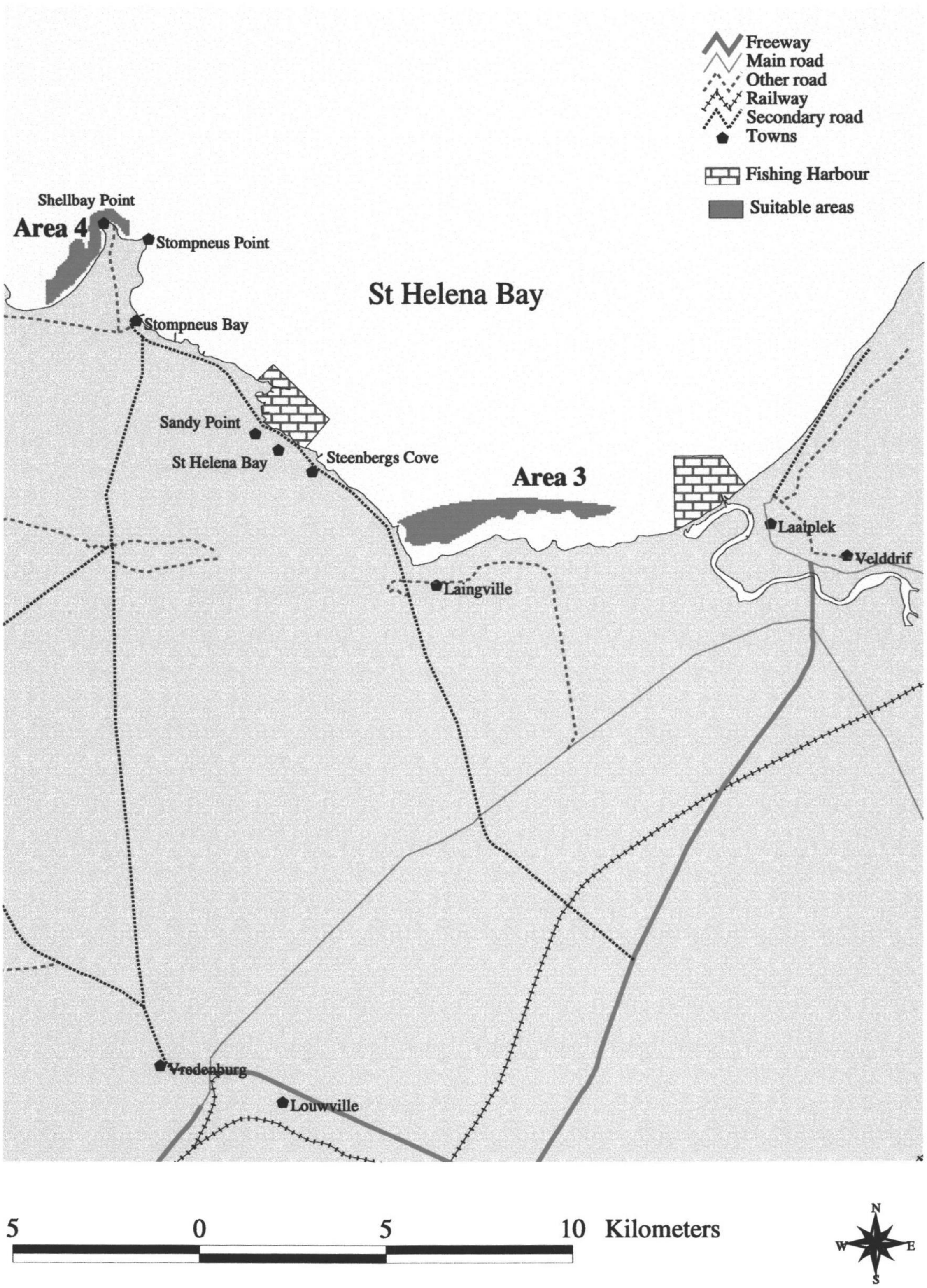

Freeway
Main road
Other road
Railway
Secondary road
Towns
Fishing Harbour
Suitable areas
Shellbay Point
Area 4
Stompneus Point
St Helena Bay
Stompneus Bay
Sandy Point
St Helena Bay
Steenbergs Cove
Area 3
Laaiplek
Velddrif
Laingville
Vredenburg
Louwville
5 0 5 10 Kilometers
N
W
E
S

Figure 2.24

CHAPTER 3

JOURNAL:

Journal of Applied Phycology

A feasibility study for community-based commercial cultivation of Gracilaria gracilis along the west coast of South Africa.

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ABSTRACT:

Many coastal communities along the West Coast of South Africa lack sufficient sustainable income to meet basic needs. The cultivation of seaweeds has been proven in other countries to contribute to the economic survival of coastal communities. Gracilaria gracilis, an economically important seaweed growing naturally in sheltered bays along the West Coast of South Africa and Namibia, has potential for community-based enterprises. Before investment in a potential industry can take place, the feasibility of the enterprise must be ascertained. In this study, results from experimental and commercial cultivation of the seaweed in Southern Africa (Lüderitz Bay, Namibia and Saldanha Bay, South Africa) were used to do a feasibility study for community-based seaweed cultivation at selected sites on the West Coast. Results indicated that suspended cultivation of G. gracilis has a good chance of succeeding as an economic enterprise in the study area, although flooding of the market for dried Gracilaria may occur. There is potential to create two to three permanent jobs per hectare. A financial assessment indicated that seaweed cultivation could be successful as a business enterprise, but that changes in income or expenditure could influence the internal rate of return and net present value considerably. Potential markets in South Africa are local seaweed export companies and abalone farmers. Economic predictions have to be verified in a pilot commercial farm.

INTRODUCTION

Coastal and marine resources in South Africa are exploited for subsistence and commercial purposes. Economic opportunities include capture fisheries, seaweed exploitation, mariculture, tourism, and agriculture. The fishing industry is based on the harvesting of natural fish populations, which can decline if overexploitation takes place. Mariculture of fish is a possible method of increasing production in the fishing industry. Mariculture of marine animals in South Africa is in a more advanced state of development than for seaweeds and includes farming of abalone, oysters, shrimp and fishes (Hecht and Britz, 1992; Hecht and Britz, 1993). The seaweed industry in South Africa is much smaller than the fishing industry, but mariculture is also considered as a method to increase seaweed production. The exploitation of seaweeds will be discussed here, as this is the industry with which the present study is concerned.

Seaweeds collected or harvested for local processing or export include Gracilaria gracilis, Ecklonia maxima, Laminaria pallida and Gelidium spp. (Anderson *et. al.*, 1989, Share *et. al.*, 1996). These seaweeds are used for the extraction of phycocolloids, growth stimulants, or for the manufacture of fertiliser. The value of the seaweed industry in 1995 was estimated at R14.5 million. Production in the same year was estimated at a total of 316 wet tonnes (kelp used for plant hormone extraction) and 1,267 dry tonnes of seaweed used for other purposes (data from Seaweed Research Unit of the Sea Fisheries Research Institute). These estimates do not include the value of the kelp used in mariculture as abalone feed. Gelidium spp. and Gracilaria gracilis are exported for the agar extraction market. Although

Gelidium is regarded as the better source or agar, the G. gracilis industry will be considered, as this species has the greatest potential for cultivation.

The South African Gracilaria industry is based on the collection of beach-cast material in Saldanha Bay. Beach cast fluctuates annually according to the size of underwater populations and wave action. This has had a negative influence on the number of people employed by the industry (estimated at 50 permanent workers in 1995). The species exploited is G. gracilis (Stackhouse) Steentoft, Irvine and Farnham. Production was estimated at 439.3 dry tonnes in 1995, with a value of R2.97 million (data from Seaweed Research Unit of the Sea Fisheries Research Institute). Expansion of the local industry was not possible to date because of its dependence on beach-cast material and the prohibition of harvesting from natural populations. Because of the world-wide demand for Gracilaria species for agar extraction, the cultivation of the seaweed as an alternate means of production has been successfully introduced in other parts of the world. This, as well as the annual fluctuation in available wild stocks locally, led to the investigation of the possibility of cultivation of the local species by South African scientists in Saldanha Bay since 1991 (Anderson *et. al.*, 1992; Anderson *et. al.*, 1996).

The technological information necessary for large-scale cultivation is available from laboratory and field cultivation experiments. The technology best suited for South African conditions is open-water cultivation on suspended rope rafts (Anderson *et. al.* 1996). A commercial raft consists of ropes, netlon 'Superope' (a netting tube forming a rope when pulled tight), anchors and floats (Anderson *et. al.*, 1992; Anderson et.al, 1996; Dawes, 1995). A simple rope system design measuring 20 x 5 m (a "cell") can be expanded to form bigger units measuring 75 m x 75 m (5625 m^2). The netlon, on which the seaweed is grown, is tied to the rope frame. Rafts are kept in place with anchors. In a commercial farm, rafts can be set up next to each other to make up blocks. The rafts are suspended at about 0.5 m below water surface by means of anchors and floats (2 litre plastic bottles and 25 litre plastic drums). This ensures maximal exposure to light. Gracilaria grows very well vegetatively, and the plants get nutrients from the sea water. The potential yield calculated from experimental rafts was 36 dry tonnes ha^{-1} $year^{-1}$ (Anderson *et. al.*, 1996). A commercial scale pilot trial, installed in Saldanha Bay by Sea Harvest Corporation Ltd. in 1995, was abandoned after two years because of the seasonal settling of mussel spat on the seaweed (Vossie Pienaar, pers. comm.). Another experimental suspended raft was installed in St. Helena Bay in 1997. The studies so far concentrated on testing the technical feasibility of cultivating the seaweed and determining growth rates and seaweed quality. The question arose as to whether this technology could be used to promote Gracilaria cultivation as a small-scale commercial enterprise to communities on the West Coast.

Seaweed cultivation could potentially be practised as a small or medium sized enterprise by coastal communities, as is the case in St Lucia (Smith, 1997), where Eucheuma farming is practised, and Sri Lanka, where Gracilaria edulis is cultivated (Dr. Carol Amaratunga, pers. comm.). Coastal communities in the Philippines are farming Kappaphycus and Eucheuma spp. (Samonte *et. al.*, 1993; Hurtado-Ponce *et. al.*, 1996). Most authors reported an increase in income and socio-economic benefits associated with seaweed farming. Eucheuma spp. are also farmed successfully in Tanzania by coastal community farmers (Msigeni, 1994).

Before Gracilaria farming can contribute to community development in South Africa, the economic feasibility of its cultivation must be assessed. As experimental cultivation has been successful, the next step would be to set up a pilot farm to test the concept of community-based seaweed farming. However, to obtain funding for such a farm, a feasibility study is necessary. The word 'feasibility' is derived from 'feasible', described as 'capable of being done', according to the Penguin Pocket English Dictionary (1985). This would include assessment of the economic, socio-economic, and environmental feasibility of community-based Gracilaria farming in South Africa.

The results from the feasibility study will give an indication of whether it would be useful to install a pilot community-based cultivation farm to test the assumptions. The objective of the study was to do a feasibility study of community-based G. gracilis farming on suspended rafts in selected areas on the West Coast.

MATERIALS AND METHODS

i. Socio-economic feasibility:

Information about the suitable technology for the West Coast was obtained from literature, researchers, consultants and business people involved in Gracilaria cultivation. The farming methodology, production potential of the seaweed, and labour and material needs for a farm were investigated and used to calculate the job-creation potential, and to estimate the labour and material costs associated with suspended raft farming.

ii. Economic feasibility: Market study

The supply, demand and marketing conditions for Gracilaria gracilis was assessed from literature reviews and interviews with selected knowledge experts. On the supply side, the world production, production in Southern Africa, processed goods and major companies were investigated. On the demand side, the major buyers, major commodities and price trends over time were investigated. The marketing conditions were assessed by investigating the product quality, processing, level of competition, contracts and quantities.

iii. Economic feasibility: Financial investment analysis

The financial model was based on the projected implementation costs, running costs, and income of one raft (based on the assumption that a one-hectare raft is the smallest economically sustainable unit). If bigger farms are applied for, the results for a one hectare farm could be up-scaled. The discounted cash flow at constant prices (excluding inflation) and at nominal values (including inflation of 10%) were calculated. The discount rate used for calculating the net present value (NPV), was 5 % and 15% for constant and nominal values respectively. The internal rate of return, and the net present value of the business were calculated from this analysis. A real cost of capital or required rate of return of 5% was assumed. The income and outflows were changed in different scenarios to perform a sensitivity analysis.

iv. Environmental aspects

The environmental assessment included the potential impact of the industry on the environment, or the impact of the environment on the industry in terms of pollution and ecological impact. The assessment was based on literature surveys and a comparison of the impacts of aquaculture in other areas.

vi. Legal aspects

The existing laws and policies affecting seaweed exploitation and mariculture were investigated through literature reviews and interviews with government officials and industry representatives.

RESULTS:

i. Socio-economic feasibility:

The job-creation potential of Gracilaria was assessed by looking at the cultivation technology in detail and assessing labour needs for each stage. The assumption used was that one raft would be an economic unit, and would be owned and managed by the people working on it. Water-based activities include maintenance, harvesting and restocking of seeding lines. Other farming activities include drying, cleaning, baling, administration and management. Labour requirements for one raft of 75 m x 75 m (Figure 3.2), which is made up of 'cells' (Figure 3.1) has been calculated as in Table 3.1, based on estimates obtained from the Seaweed Research Unit in the Sea Fisheries Research Institute. The rafts are designed to be maintained from the surface once installed, so that no permanent divers are required. Once installed, one ha could be seeded, harvested and maintained by two to three people. Divers are needed to maintain chains and anchors, and could be contracted in as needed. Alternatively, if farms belong to a co-operative, divers could be hired through this facility. Two divers could service a 20 ha farm. Instead of hiring commercial divers, people working on or owning the rafts could be trained. If the same people are used for making the raft, harvesting and restocking, a minimum of 2-3 workers will be needed.

Restocking of the ropes or netlon takes place on land, usually in a factory or warehouse. A wooden board with metal hooks is used, whereby the netlon is slipped over the hooks, the seaweed tufts are put on the hooks, and the netlon slipped over the tufts and out of the hooks. This automatically secures the tufts in the netlon. All restocked netlon lines are taken back to the raft by boats, and tied to the rope frame (Dawes, 1995). Maintenance of the ropes and seeding lines and harvesting takes place from within boats.

Subsequent processing (drying, cleaning and baling) may be more labour-intensive, but depends on the yield per raft. The seaweed is spread in the open air, either on vacant land, as in Saldanha Bay and Lüderitz (Rotmann, 1987; Critchley *et. al.*, 1991), or on elevated wooden or bamboo structures, which reduces impurities and improve drying. Depending on the size of the farm, either the same people can do the work on a rotational basis, or additional people can be employed. Another option is to centralise the post-harvest preparation for different farms to increase efficiency. At least one person would be responsible for administration and farm management. For the purpose of conservative cost estimation, it is assumed that three people can be permanently employed to do the harvesting, maintenance, restocking, drying and baling for a one ha raft on a monthly rotational basis, and administration and management on a daily basis.

Thus it is assumed that a minimum of three permanent jobs can be sustained per ha. For a 40 ha farming site containing one raft ha^{-1}, the total area under cultivation could support a minimum of 80 persons on a permanent basis. None of the farming activities are gender-biased. Literacy will be required of those persons involved in the administrative aspect of the business. The potential seaweed farmers will presumably already possess sea-faring skills and experience, which are desirable skills for those involved in maintenance, implementation and harvesting.

ii. Economic feasibility: Market study

The supply included world production, production in Southern Africa, processed goods and major companies. Gracilaria is used to produce the hydrocolloid agar, but the market investigated in this study, is for the raw product (dried Gracilaria). Jensen (1993) estimated the world production of agar-producing seaweeds in 1991 at 180,000 tonnes per year (fresh weight), from which 11,000 tonnes agar with a value of US$160 million was produced. In 1995 the global phycocolloid market was estimated at 61 000 tonnes, valued at US$560 million, of which agar contributed 10 161 tonnes finished product, valued at US$203 million (Guiry, 1997). Porse (in press) estimated the production of Gracilaria in 1997 as 300 dry tonnes from Europe, 450 dry tonnes from Africa, 22,350 dry tonnes from the Americas and 10,900 dry tonnes from the Asia-Pacific region. The total raw material (from Gracilaria, Gelidium and Pterocladia spp.) available for agar extraction estimated in 1997 was 54,350 dry tonnes, of which most were used. Total sales of agar were 7,500 tonnes with a value of US$132 million (Porse, in press), which are less than the figures by Guiry (1997) for agar production and value.

Production from beach-cast material in Lüderitz, Namibia, was estimated at 835 dry tonnes in 1995, and 1 ha is presently under cultivation (Molloy, 1998). The production of Gracilaria in South Africa was about 439.3 dry tonnes in 1995, but this figure fluctuates annually. An increase in the production from beach-cast is not expected, but the potential for increased production through cultivation has been estimated at 36 dry tonne ha^{-1} $year^{-1}$ (Anderson *et. al.*, 1996). This was set at 30 dry tonnes ha^{-1} $year^{-1}$ for the purpose of conservative calculation of production. The areas estimated to be suitable for Gracilaria cultivation are 975.4 ha in Saldanha Bay and 474.8 ha in St. Helena Bay (Table 2.5). A study on the carrying capacity of the two bays is needed to determine the real area that could be used for cultivation. However, until more information becomes available from pilot and commercial farms, these estimates are used to calculate a total possible production in Saldanha Bay at 29,262 dry tonnes and in St. Helena Bay at 14,244 dry tonnes. This means that production in South Africa theoretically has the capacity to expand to 43,506 dry tonnes annually. However, this figure remains a rough estimate subject to the results of a carrying capacity study.

Although no extraction of agar takes place in Southern Africa at present, the agar yield and quality of G. gracilis has been determined in studies by researchers. Rebello *et. al.* (1996) reported variable agar yield and strength in different seasons in Japan, with the highest yield of 17.08% and gel strength of 859 g cm^{-2} at 1.5% agar solution in June (summer). Gelling temperatures ranged from 45 to 50°C. The agar was considered to be of commercial quality. No processing other than drying and cleaning of seaweed takes place in South Africa. The exported product is dried, cleaned and baled Gracilaria gracilis.

Taurus Products Ltd. is at present the only company in Southern Africa exporting the dried seaweed. The company is the concession holder for the exploitation of the seaweed in the Saldanha Bay area and in Lüderitz, Namibia. The supply (obtained from beach-cast) is not stable enough for large investment (Anderson *et. al.* 1989).

The demand included major buyers (local and international), major commodities and price trends over time. Phycocolloids are seaweed-derived hydrocolloids (substances used in food and industrial preparations as thickeners or gelling agents), most of which are of plant origin (Bixler, 1993). Agar is one of three seaweed-derived hydrocolloids. The major buyers of seaweed for the production of phycocolloids are food hydrocolloid companies. Sanofi, Hercules, Kelco, FMC, Rhone Poulenc and Grindsted have been listed as the major international hydrocolloid companies by Bixler (1993). The major agar manufacturers are found mainly in Japan, Chile, Spain (Porse, in press), the USA, Denmark, and France (Jensen, 1993). Porse (in press) reported the first three countries as producers of 60% of the agar output. Gracilaria-derived agar extraction capacity was utilised from 80-90% in 1997, and 100 % for Gelidium-derived agar. Potential raw material sources of 5,000 to 10,000 tonnes from Chile and Indonesia were identified in 1998. The agar market for the medium term future is described as mature and with low (1-2% p.a.) growth prospects. Requirements for the industry were better raw material management, and more investment in technologies, products and new market development (Porse, in press).

Agar is used in several applications such as pharmaceutical preparations, food or bacteriological studies (Armisen, 1995; Lewis *et. al.,* 1988). Gracilaria is the most important source of food grade agar, Gelidium being the superior source for agar used in bacteriology and other industrial applications. The market for agar in food and feedstuffs were seen as relatively constant in 1993 (Jensen, 1993). The product to be produced by farms in South Africa will be dried, cleaned and baled Gracilaria for the agar extraction industry, and possibly fresh seaweed to be used as a food supplement for cultured abalone. The international market requires a gel strength of greater than 750 g cm^{-2} at 1.5 % agar solution (Armisen 1995). If seaweed is sold to abalone farmers, it will be sold fresh.

According to Bixler (1993), the total revenues growth (volume and price) of the hydrocolloid industry has been slightly over 9% per year from 1978 to 1993. The value of the agar market has been estimated at US$44 million in 1978, with a 12% market share and at US$144 million in 1993, with a 10% market share (Bixler, 1993). The value of the market for agar in 1995 was estimated at US$ 203 million, and the value of the international seaweed gums market US$560 million in the same year (Guiry, 1997). Porse (in press) estimated the growth of the agar market from 1998 to 2002 as 1-2% per annum. The price for agar in 1998 is US$9 lb^{-1}, translating to US$19.80 kg^{-1} (D. Seisun, Industrial Market Research (IMR) International, pers. comm.). The price for the dried seaweed is about US$1,000 dry $tonne^{-1}$ (K.Rotmann, Taurus Chemicals and C.P. Dawes, Seaweed Supplies Ltd). This price fluctuated between US$1250 and US$800 from 1996 to 1998.

Four local parties have been identified as possible seaweed buyers. Taurus Chemicals Ltd. is already established in Southern Africa as an exporter of Gracilaria (K. Rotmann, pers. comm.). Sea Harvest Corporation Limited is regarded as another possible exporter of the seaweed, because of their interest which resulted in a pilot farm operated in Saldanha Bay from 1995 to 1996 (V. Pienaar, pers. comm.). Agartek CC is private company planning to farm the seaweed in St. Helena Bay, and is regarded as a third possible seaweed exporter (F. Basson, pers. comm.). A fourth market identified was the abalone farmers in South Africa, who are interested to buy fresh seaweed as abalone food (D. Katz, Saldanha Group, pers. comm.). Preliminary negotiations indicated a positive response to the possibility of buying cultivated seaweed from farmers. The price for dried seaweed would differ from that obtained on the international market, as a handling fee of at least 7.5 % would be standard (K. Rotmann, pers. comm.). No price for fresh seaweed could be determined at this stage. No international company was approached, because the seaweed cultivation industry in South Africa does not produce seaweed yet, and it will take time to build up a good reputation (for consistency in delivery and quality) amongst international buyers.

The price for the seaweed would be influenced by the quality of the product and negotiations between farmers and buyers, as well as the difference between demand for seaweed and supply. The market requirements for dried seaweed are: a maximum of 15 % moisture, maximum 3 % impurities, dried, cleaned and baled into 100 kg bags, and delivery in Cape Town (K. Rotmann, pers. comm.). The quality and yield of agar would determine the ultimate purpose for which the agar is used. The international market requires a gel strength of greater than 750 g cm $^{-2}$ at 1.5 % agar solution (Armisen 1995). The agar must be derived from the seaweeds as listed by the U.S. Food and Drug Administration, which includes Gelidium, Gracilaria and Pterocladia spp.(Glicksman, 1987).

Processing in South Africa consist of post-harvest preparation. After collecting or harvesting, the seaweed is dried in the open air, and cleaned of sand and other seaweeds by rotating drums or manual removal of mussels and other seaweed. It is then baled for export (Dawes, 1995). Depending on buyer requirements, the seaweed may be dried for a few days without losing its maroon colour, or for a few weeks to provide a bleached product (Critchley *et. al.*, 1991). In Lüderitz, Namibia, an agar-processing plant producing alkali-treated Gracilaria, has been in operation for a few years (Critchley *et. al.* 1991). It closed down in 1995 (Molloy, 1998) and only post-harvest cleaning and baling is taking place currently.

Competition with G. gracilis would be other seaweeds used for the same application, or substitutes for agar. Gelidium pristoides, which is also harvested in South Africa, yields superior grade agar. In the food industry agar is used in bakery products such as glazes and icings, in canned meats, in confectionery such as jellied candy and other products such as clear pasta noodles and silkworm food. In jellied candy, agar can be substituted by less expensive products such as starches, pectin and gelatin (Glicksman, 1987). Jensen (1993) listed alginate as a possible competitor for agar in the use of gels for micropropagation of terrestrial plants.

iii. Economic feasibility: Financial investment analysis

The cost of Gracilaria cultivation includes capital and operational costs. Capital costs include building and installation of a raft and infrastructure for farming operations. Operational costs include labour and maintenance, cost of the water lease and application for water space, lease of land-based buildings and drying areas, materials, fuel and equipment. Capital cost estimations were obtained from two local companies. An estimate from Vossie Pienaar, Sea Harvest Corporation Limited, was given as about R10/m $^{-2}$, including raft manufacture, installation cost, materials such as ropes, netlon, chains, anchors and floats, and excluding labour. An estimate of R16/m^{-2}, obtained from Agartek CC, included manufacture, installation, materials and labour. The estimate from Agartek CC was used to calculate the cost of constructing and installing one raft (75 m x 75 m), in the financial model used in this study. Operational costs include application, labour, fuel, maintenance, lease and equipment. Equipment required for maintenance, stocking and harvesting are ropes, netlon, rowing boats (preferably with an outboard motor), protective clothing, and a wooden board with hooks for re-stocking of the netlon lines. If divers from within the local communities are recruited and trained, they will need diving equipment. If a minimum wage of R1,500 per month, based on the average monthly wages of R1,410 for Saldanha Bay and R1,436 for St. Helena Bay reported by Schutte (1993), is assumed per person permanently employed, labour cost for a maximum of 3 people per raft will be R54 000 raft^{-1} year^{-1}. The wage specified may be changed when a community-based project is started, as the cost of living does not remain stable.

Maintenance and equipment cost has been estimated at R15 000 raft^{-1} year^{-1}. This includes replacement of floats, ropes and netlon, and equipment such as outboard motors. Chains have been estimated to last for about five years, which is also calculated as the life span of a raft (Robert Anderson, pers. comm.). The lease of the water space (based on information from the Department of Environment Affairs and Tourism in 1996) will cost R200 ha^{-1} year^{-1}, and an initial amount of R600 for advertisement of intentions. If application is made for more than 21 ha, the cost of the lease and application increases as follows:

1st 5 years: 15 c /m^2/ year^{-1}

6th year: 15 c/m^2/ year^{-1}

7th year onwards: 15% escalation

Table 3.2 gives an indication of the minimum cost per hectare that could be expected, based on the capital cost, advertisement, lease, equipment, labour and maintenance. A start-up cost of R159,800 ha^{-1} is calculated. Tables 3.3 (nominal cash flow) and 3.4 (discounted cash flow) are part of a financial analysis based on the following assumptions:

- The analysis is based on the cost and benefit expected for one raft (5,625 m^2), which is assumed to be the smallest economic unit.

- The cost of the raft is calculated at R16m² for a 75m x 75 m raft, which amounts to R90000.
- A maximum of 3 people will be employed permanently on the raft with a monthly salary of R1500 each.
- Additional operational expenditure amounts to R15 000 per annum.
- The lease is R200 ha^{-1} $year^{-1}$, plus an initial advertisement fee of R600.
- Seaweed will be sold to local seaweed export companies or directly to the international hydrocolloid companies.
- The average international price is US$ 1000 per dry tonnes. Taking freight, wharfage and railage costs (referred to as transport cost in the present study) estimated at 30% into consideration, an income of 70% of the above value per dry tonne is assumed.
- A possible yield of 30 tonnes dry weight ha^{-1} $year^{-1}$ is assumed.
- The cash flow analyses are conducted over a 5 year period, which constitutes the life of a raft.
- A Rand/US Dollar exchange rate of 4.5:1 (October 1996 exchange rate) is assumed, because that was the time that the first cash flow analysis was made. Subsequent changes in the exchange rate will have an influence on the potential profits, but also on costs as the unit price of commodities such as fuel and rope will increase accordingly.
- Naturally occurring seaweed can be used as first seeding material, but the permission of the concessionaire must be obtained. 10 kg seaweed per day can be collected for personal use by persons other than the concessionaire, but it may not be for commercial use (Regulations in terms of the Sea Fishery Act No. 12 of 1988, Government Notice No. 18357). Subsequent harvests can be used for seeding material. However, if a farm is bigger than one hectare, it may be more practical to buy seaweed from the concessionaire at the

price set by the concessionaire.

Assuming sales to an international company, the price assumed for the dried seaweed is US$1,000 per dry tonne, and an income of R135 000 ha^{-1} $year^{-1}$ before transport is calculated. The discounted cashflow at constant prices does not include inflation, depreciation and tax. An annual income of R 94,500 is expected after deductions of transport cost of 30% (transport estimate obtained from rural economist L. Hobson). The Net Present Value (NPV) is R23,250 and the Internal Rate of Return (IRR) is 20% (Table 3.3). The discounted cash flow at nominal values is adjusted to include the effect of inflation, and indicates an NPV of R22,059 and IRR of 32% (Table 3.4).

When assuming sales to a local export company at US$925 per tonne (the international price minus 7.5% export and handling charges, as quoted by Klaus Rotmann, pers. comm.), and an income of R124 875 ha^{-1} $year^{-1}$ before transport and export cost is then calculated. The IRR at constant values becomes 0% and the NPV changes to -R7,435 (Table 3.5). The IRR at nominal values change to 10% and NPV to -R6,189 (Table 3.6).

The sensitivity analysis (Table 3.7) shows high sensitivity of IRR and NPV to changes in income and expenditure. The variables used to assess the sensitivity are the percentage of transport costs, production, raw seaweed price, labour cost and exchange rate. Even small increases or decreases in the bruto income or net income before finance may cause the IRR or NPV to be unacceptable. If labour cost is dropped, the IRR and NPV increases dramatically.

iv. Environmental aspects

The possible environmental impacts of Gracilaria cultivation include visual impact, obstruction to other users, pollution from farming practices, possible alteration of species composition in the farming area and danger to other marine life.

Visual "pollution" is perceived as an important consideration in the tourism industry, and opposition from this sector must be considered. The floats used in suspended seaweed cultivation, consisting usually of plastic 2 litre soft drink bottles and 25 litre plastic drums, will be visible above water. However, the further the raft is from the shore, the less visible it will be. Figure 3.3 provides an idea of what a raft in the field will look like.

Rafts may obstruct the passage of smaller boats, and alter access to areas previously used for fishing or recreation. Suitable space for cultivation is available in Saldanha Bay, Langebaan Lagoon and St Helena Bay, although some areas are already used for other purposes (as discussed in Chapter 2). Other users of water space are fishing vessels, recreational boats and other ship traffic.

The proposed cultivation technology takes place in an outdoor system, making use of nutrients in the sea water. Upwelling occurs regularly in summer, ensuring nutrient replenishment. This will eliminate the need for added fertiliser, which could alter the nutrient content in indoor systems and contribute to running costs. Beach pollution may result from dislodged rafts in rough weather, or an increase in the amount of beach-cast seaweed may be experienced. G. gracilis occurs naturally in the areas under investigation. This will exclude the cost and environmental risk of introducing another species to the ecosystem. However, permission to collect naturally occurring seaweed for stocking must be obtained from the existing concessionaire. Only beach-cast can be collected, and harvesting from natural beds is prohibited.

Marine mammals such as whales, which are frequently seen in St. Helena Bay (personal observation) and are a popular tourist attraction, may be endangered by the rafts (F. Basson, pers. comm.). If they become entangled in the ropes, environmentalists and the public may oppose the enterprise. If this becomes a problem, it will increase costs, and solutions to prevent entanglement will have to be found.

The possible impacts of the environment on the industry include industrial pollution, epiphytes and grazers, natural disasters such as storms or diseases, and damage by ship traffic or other marine life. Oil pollution from ships is a risk, especially in Saldanha Bay, where industrial activities are increasing and the oil jetty extended in preparation of increased ship traffic. Anderson *et. al.* (1992) reported problems with epiphytes and grazers, which could usually be controlled. They also reported the growth of mussels on the seaweed and recommended that farms be situated as far from mussel rafts as possible. In Lüderitz, strong currents may cause problems with destruction of rafts (Rotmann, pers.comm.).

The raft system is designed to withstand normal water motion and wave strength, but it is not known yet if they will survive the winter storms in Saldanha Bay and St. Helena Bay, if farms are located in areas exposed to prevailing wave direction. Thus there is a risk of farm destruction, in which case the remains may be deposited on beaches. Marine mammals such as whales pose a risk to farms, as already mentioned. Boats may run over the rafts and cause damage, as happened with the experimental raft in Saldanha Bay (Anderson *et. al.*, 1992).

v. Legal aspects

At the start of the study, marine activities were administered by two Acts: the Sea Fisheries Act of 1988 and the Sea Shore Act of 1935. The Sea Fishery Act (No. 12 of 1988) provides for the conservation of the marine ecosystem and the orderly exploitation, utilisation and protection of marine resources. Provision is made for the exploitation of naturally occurring marine animals and plants on the shore or in the sea through a system of quotas and concessions (Anderson *et. al.*, 1989). The South African seashore and the sea within territorial waters are administered in terms of the Sea-Shore Act of 1935.

An application for a mariculture project previously had to be approved by the Sea Fisheries Research Institute (operating under the Department of Environmental Affairs) as well as by the authority governing the sea space applied for. In the case of Saldanha Bay Portnet is the governing authority. In the case of St Helena Bay, the Cape Provincial Administration represented provincial government. However, no specific mention of mariculture was made under the Sea-Shore Act of 1935, and this was interpreted as meaning that the Cape Provincial Administration did not have the authority to make a decision about mariculture activities. In terms of the Marine Resources Act (number 18 of 1998), mariculture applications have to be submitted to the Minister of Environment Affairs and Tourism. The use of sea water space is still administered under the Sea Shore Act of 1935.

DISCUSSION:

i. Socio-economic feasibility

Cultivation of seaweeds could provide income by creating full-time jobs, or by providing fishers and other community members with the opportunity to supplement their income while still continuing with fishing activities. Other effects of cultivation could be an improvement in the living standard of farmers. The estimate implies that an entire household may be able to operate one raft, as is the case in farms in the Philippines (Hurtado-Ponce *et. al.,* 1996). The same author reported an improvement in the living standard of Kappaphycus and Eucheuma farmers in Panagatan Cays (Philippines), because of higher incomes. The income of farmers in Chile increased with 110% or more after management plans for harvesting and farming practices were introduced (Santelices, 1996). The same author also suggested that socio-economic models arising from farming in one country should not be applied directly when considering the introduction of farming in another country, due to socio-economic differences between countries.

The employment creation potential may be bigger or smaller than estimated, depending on the actual yield of seaweed on a commercial farm or raft and the size of a farm. It cannot be concluded in this study that G. gracilis farming will make a contribution towards alleviating unemployment. However, it does suggest that there is sufficient potential, and it is recommended that a pilot farm is installed to test the assumptions made in this study. If the cultivation of the seaweed proves successful, an agar processing facility may eventually be established, which will also increase job creation potential. Apart from that, implementation of a raft will facilitate technology transfer and skills learning for those involved.

ii. Economic feasibility: Market study

The world production of Gracilaria has increased in the past decades, following a growing demand for agar. Most of the supply came from the Americas and the Asia-Pacific region. The aquaculture industry (including freshwater and marine plants and animals) is regarded as a fast growing industry, with an annual growth rate of about 12% for the past decade (FAO, 1995, cited in Shang and Tisdell, 1997). It seems likely that farmed seaweed will increasingly supplement harvest from natural populations. The contribution of aquaculture to total seaweed production was estimated at 27.7% in 1993 (Shang and Tisdell, 1997).

The production of dried Gracilaria is an established, although small, industry in South Africa. Cultivation of the seaweed on suspended rafts is technologically feasible and there is a real possibility that production of the seaweed will enable the industry in South Africa to grow. The estimated total production through seaweed cultivation is 43,506 dry tonnes, which, if compared with the total world production for 1997 (54,500,000 dry tonnes), is relatively small. If projected production can be realised, it may be feasible to start an agar extraction factory in Southern Africa, but this possibility will be explored only when production starts. The expected increase in supply from Chile and Indonesia may have an effect on demand in 1998.

The processing of the seaweed involves sophisticated technology, which is cost-effective only when a steady supply and consistent quality can be guaranteed. Thus the dried product to be produced in from South Africa is not expected to change to processed agar in the near future. The agar yield and quality is expected to fluctuate seasonally, but is not expected to drop below commercially acceptable standards. Four possible seaweed buyers are available in South Africa, and established links with the international market already exist through Taurus Chemicals Ltd. Thus a local market for farmed Gracilaria already exists.

There is no evidence to suggest that the demand for Gracilaria world-wide will decrease in the foreseeable future. The potential increase in supply from South Africa is not big when compared to the world production. If the price, as defined by classical economical theory, is influenced by supply and demand, the assumption can be made that the price will be higher when demand is high and supply low, and lower when the reverse is true. Overproduction can influence the international price, as happened early in 1998 when Chile, which is the biggest producer of Gracilaria in South America, produced too much seaweed (K. Rotmann, pers. comm.). In a discussion of farmed catfish production in the USA, Waldrop (1986) explained that cycles of over- and under-supply, with resultant price changes, could be attributed to the fact that markets developed slower than production. These cycles could usually be expected when a product is new. Agar is not a new product, and such cycles should not have a severe impact on the price. According to Jensen (1993), the growth in consumption of agar should not change radically in future, because of general growth in human population and some improvement in the standard of living. The fact that the world-wide agar processing capacity was almost fully utilised in 1998, suggests that drastic increases in supply may flood the market, unless processing capacity is increased.

The major economic value of the seaweed lies in the phycocolloid agar, but Gracilaria may increase in value as an ingredient in feed for farmed marine animals. In this case the seaweed will be sold wet, with no value-adding process. This may lead to a decrease in the price obtained for the seaweed, as reported by Ajisaka and Chiang (1993), where farmed Gracilaria in Taiwan was sold as abalone feed. Briggs and Funge-Smith (1996) anticipated the decrease in Gracilaria price with increased cultivation in their study on the suitability of the seaweed as feed for juvenile shrimp. Research about end-user products must continue to expand the market for agar, and for the raw material. Markets will have to be evaluated constantly and market development must take place within South Africa. The only product considered in this study was dried Gracilaria for the agar extraction industry. Pilot farming should include the development of other products from the seaweed, which would require close co-operation with research institutions. The market for agar in South Africa, which was not considered, should be researched with a view to establishing an agar processing facility in future. Becker and Rotmann (1990) proposed a marketing strategy for processing and selling of agar in South Africa. This included a consumer awareness campaign, use of marketing instruments and a marketing plan. The development of the agar market and an agar-processing facility (also advised by Critchley *et. al.*, 1998) in South Africa may ensure a local market for farmed seaweed.

Only a general overview of demand was given in this study. Based on the growth rate, world-wide production and value of the agar industry, the conclusion is that there is a demand for dried Gracilaria. However, as the growth rate is low and supply from other producers may increase in the near future, there is a possibility of overproduction and price decreases. A more detailed method of demand analysis is needed before the investment stage is reached. Detailed methods of demand analysis include the market trend, demand function, direct market experiment and consumer survey (Shang, 1990).

The dried seaweed product should meet the market requirements specified. The quality of the raw material may differ between farms, if farm owners take responsibility for drying and cleaning their own harvests. The gel strength of G. gracilis tested in laboratory conditions met the requirements for agar extraction, although the strength and yield fluctuated seasonally. Agar quality from G. gracilis cultivated in outdoor conditions may differ. If the quality of the agar is consistent, good prices should be obtained for farmed seaweed. The important points for consideration of suitable species for Gracilaria culture is described by Trono (1994) as selecting a species which is fast growing and propagated by vegetative propagules or spores, have large and robust thalli, and have high agar yield of good quality. G. gracilis is fast growing, reproduce vegetatively, have robust thalli and is reported to have a high agar yield of good quality.

The market share for agar has not changed much between 1978 and 1993, suggesting that it should not be substituted to a large extent. However, competition from other phycocolloids may be experienced in areas where its uses overlap. Products that could be used in the place of agar in current applications (as in the microalgae market analysis described by Borowitzka, 1994), need to be investigated to provide a better market assessment.

One aspect about the market which was not considered, is marketing infrastructures and systems, which is specified by Shang (1990) as an important part of market survey. Marketing infrastructures refer to facilities and services such as wholesale, retail, transportation and storage. The establishment of these facilities and services are usually beyond the ability of the small-scale farmer, and would require government and industry support. The marketing system refers to the mechanism of co-ordinating production, distribution and consumption activities, and can be evaluated in terms of market structure, conduct and performance. Although Taurus Products is already exporting seaweed and have established a marketing system, this aspect needs to be evaluated in terms of community involvement in a pilot farm.

In summary, the market evaluation suggests that the demand for Gracilaria for the agar market may not be as big as anticipated, and that oversupply is a real possibility which might decrease prices. A local market for farmed seaweed exists, but expansion of cultivation must be controlled to prevent overproduction. Gracilaria gracilis is expected to meet market requirements. It is suggested that the cultivation of other economically important species together with Gracilaria is considered, or that farming is combined with existing fishing activities so that risk is spread.

iii. Economic feasibility: Financial Investment analysis

In the case of exported seaweed, the projected cash flow before funding reflects the inherent viability of one raft as a potential business. The net present value (NPV) is the present value of inflows less the required outlay. If this value is negative, the project is earning less than the required rate of return and investors will not approve of the project (Shang, 1990; GIMT, 1995). Thus the NPV of R23250 is acceptable. The internal rate of return is that rate of required return which makes the present value of the inflows exactly equal to the present value of the outflows. The required rate of return on investment is the rate required by investors (Shang, 1990; GIMT, 1995). If one assumes a real cost of capital or required rate of return of 5%, then the internal rate of return (IRR), based on the net position before financing, of 20% is acceptable. Thus the IRR at nominal values (32%) is also acceptable. If seaweed is sold to a local company which exports the seaweed, the IRR of 0% is not acceptable, and neither is the net present value (NPV) of -R 7435. The IRR at nominal values of 10% is acceptable, but not the NPV of -R6189.

The sensitivity analysis (Table 3.5) indicates that the IRR and NPV are highly susceptible to changes in income and expenditure. The Rand: US Dollar exchange rate is still changing, and fluctuated between 6.36:1 and 5.5:1 in 1998. For this reason the exchange rate of 4.5:1 initially used in the analyses, was not changed. The change in exchange rate will influence the value of income from exports, but may also lead to general price increases (for materials, taxes or interest rates) which will lead to increased expenses. It is assumed that labour cost has to be included for a financial assessment, but if a raft is owned and operated by a family unit, this cost might be reduced. If the IRR is used for evaluation of the project, the required rate of return of the investors may be higher than 5%, which could lead to difficulty in obtaining capital. In a pilot study, the cost of capital used in the pilot farm must be used to rate the IRR. The cash flow analyses reflect the values before finance. If a loan is taken to cover capital cost, payment and interest must also be taken into consideration.

Doty (1986) described a method of estimating returns from Gracilaria and Eucheuma farming, where factors affecting the returns were given unique values. These values were based on real and estimated data and were assumed to become more accurate as farming developed and real data could be substituted in the model. It would be useful in a South African cultivation industry to use such a model, together with estimates from this study and data obtained from pilot farms, to predict returns from farms more accurately.

According to Shang (1990), project analysis is used to decide if a project will make a contribution towards reaching the objectives of an individual or a country, to decide which is the best amongst several projects, and to secure financial support. The four major sub-feasibilities considered are bio-technical, economic, institutional and social. The economic feasibility consist of financial analysis, mostly used for private investment, and economic analysis, mostly used for public investment. The methods of economic feasibility analysis include the pay-back period, average rate of return on investment (ROI), and the discounting method (also described in Firdausy, 1991). The ROI in canal and pond farming in Western Visayas, Philippines were calculated as 39% and 908% respectively (Hurtado-Ponce *et. al.*, 1992). The pay-back period was 2 months for canal farming and 1.8 years for pond farming of Gracilaria. In the same area, the ROI and pay-back period for Kappaphycus farming was 243% and four months for bottom line culture, and 93% and 9 months for raft monoline culture (Samonte *et. al.*, 1993). Firdausy (1991) used estimates on IRR (35.8 to 200%), ROI (45.5-269%) and pay-back period (4.1 to 13.5 months) to compare different size Eucheuma farms in Bali. She concluded that Eucheuma farming is an attractive economic investment for coastal rural dwellers. In an economic assessment of Gracilaria field cultivation in Chile (Martinez *et. al.*, 1990), profitability indicators used were the net present value, internal rate of return, pay-back period and break-even point. One hectare was used as the minimal area planted for commercial exploitation by fishing communities, which is the same as the assumption used in this study. An NPV of US$57,219, an IRR of 81% and a pay-back period of 1.8 years were calculated for a one-hectare bed. The discounting method was used in the present study, using the net present value and internal rate of return. The benefit-cost ratio method may also be useful in determining the economic feasibility. The cost of producing a kilogram of seaweed will have to be compared to the price per kilogram, to make an assessment of profitability (as in the discussion on catfish production by Waldrop, 1986). If the IRR and NPV values of the above examples are compared with those estimated for Gracilaria cultivation in South Africa, the assumption can be made that Gracilaria cultivation will be less profitable than anticipated. If sold to a local seaweed export company, it will not be profitable at all.

However, the cash flow analyses were based on estimates and can only be verified in a pilot study. The capital cost is very high, and efforts will have to be made to decrease this cost. Production may also be higher or lower than estimated. Labour requirements may also be higher or lower. Rotmann (1987) estimated freight, wharfage and railage at 13.8% of the price for Gracilaria from pond farming in Namibia, which is lower than the estimate used in the present study. The cost of seeding material was excluded in this model, but in the study of Gracilaria culture in Taiwan, Shang (1976) included seed stock as a cost item. It is clear that effective farm management will be needed to keep costs as low as possible, and production and seaweed quality as high as possible.

The financial model used in this study does not differ much from the model used for large-scale algal production by Borowitzka (1992). In his model, four major components for algal production (culture, harvest, process and market) were used as the basis for cost estimation. This correspond largely with the components used in this study for cost estimation. However, the cost estimation was very conservative and did not account for costs such as tax, depreciation or interest on capital. It also did not cover in sufficient detail the prices of commodities such as netlon, rope and fuel. The use of naturally occurring Gracilaria (beach-cast material) as seeding material may be sufficient for one raft, but in an expanded farming industry seeding material will have to be purchased at market price from the concessionaire. The labour estimate can only be used for one raft. If a farm consist of more than one raft, the labour needs will change. More sophisticated management skills will be needed, and a market-related salary for a farm manager will have to be included. It may not be possible to use harvesters, seeders and processors interchangeably is this case, as the farm and the yield will be bigger. Insurance against crop losses and raft damage has not been built into the financial model, but will have to be considered once the industry is established. As was discussed by Secretan (1986), losses in aquaculture farms (the examples used were fish and mollusc farms) could result from unexpected events such as very high spring tides combined with wind, which deposited debris on salmon cages and destroyed them. The best way to deal with losses is to identify the major risks in a farm, such as diseases and try to minimise their effects.

In the assessment of the profitability of an aquaculture farm, the sustainability of the venture must also be taken into account. If short-term profitability is obtained at the expense of the environment, the farm is not sustainable. Shang and Tisdell (1997) viewed sustainability as important on a micro (farm) level and on a macro (societal) level. On the micro level, there is a need for the selection of the correct species, constant evaluation on what to produce (based on future market trends), input and output prices, and improvements in culture technology. On the macro level, sustainability depends on the objectives of the development, species for culture, culture systems and techniques, and environmental policy measures. Based on previous research on the technology and the results of the present study, it is expected that farming of Gracilaria gracilis will be sustainable on a micro level. The sustainability on a macro level will be determined in the pilot study.

The financial investment analysis of the economic feasibility of seaweed culture was based on the assumption that farming at the investment stage will constitute private investment by individual farmers. If the project is developed further as a public investment project, an economic analysis (as described in Shang, 1990) will be needed. The methods include assessment of the social benefits and social costs.

The financial investment analysis in the study cannot be used to predict the economic or financial viability of a raft or a bigger commercial farm, as the estimates used for cost and benefit estimation are not complete or detailed enough. A specific site may have unforeseen environmental factors influencing production cost. Production may also differ considerably in a pilot farm. The analysis can only provide a model on which to base an analysis with real data in a pilot farm, and a broad indication of the economic potential of Gracilaria cultivation.

iv. Environmental feasibility:

Suspended raft farming does have visual impact, but it may be far less than the impact of animal mariculture. However, the further the raft is from the shore, the less visible it will be. Fridley (1992) also reported resistance of coastal property owners to visual pollution as a constraint to mariculture development in the United States. Hecht and Britz (1992) considered the visual impact as a possible problem in the mariculture of species which requires building of infrastructure. Continuing research indicated that the plastic bottles used as floats in Gracilaria culture may not be necessary, thus decreasing the visibility of rafts (R.J. Anderson, Sea Fisheries Research Institute).

Upwelling occurs regularly in summer along the West Coast, ensuring nutrient replenishment. Thus nutrient enrichment is not considered as an impact from farming. Gracilaria gracilis occurs naturally in the areas under investigation. This will exclude the cost and environmental risk of introducing another species to the ecosystem.

The risk of raft dislodgement will be minimised as far as possible by careful site selection and proper installation and maintenance. Harbour authorities and fisheries control officers are usually entitled to check for pollution from any private industry. Apart from this, any environmental monitoring group may be asked to assess the environmental impact of the rafts once or twice a year and make recommendations based on their findings. However, the responsibility of reducing environmental risk will be the main responsibility of the seaweed farmers. Practical solutions to beach pollution, such as employing people to clean beaches daily, or using beach-cast seaweed as harvest, may be implemented.

Space for cultivation is potentially available in Saldanha Bay, Langebaan Lagoon and St Helena Bay (Chapter 2), although there are many other users to be considered. Fridley

(1992) reported space conflicts between mariculture farmers and fishermen in the United States. In Kenya, suitable space for cultivation of Eucheuma and Gracilaria is used for other purposes such as recreation (Coppejans, 1989). On a Gracilaria farm, clean lanes between the rafts, big enough for small boats or rowing boats, are essential for unhindered passage of subsistence fishers and maintenance and harvesting by boats. Careful site selection will ensure that the rafts are placed outside shipping lanes used by commercial fishing boats and recreational boats. Where a farm is situated in an area used by small-scale fishers, clean lanes between the rafts, big enough for unhindered passage of the boats of subsistence fishers, are essential.

In the case of the mariculture of animals, much of the same problems as for seaweed culture are experienced, as well as others. Stickney (1997) and Bardach (1997), listed the possible impacts of fish mariculture in inshore waters as visual pollution, potential impact on non-target bacteria from antibiotics in fish feed, infection of wild fish with diseases from cultured fish, noise and odour pollution, pollution from waste feed and faecal decomposition, interference with navigation, and removal of access to traditional fishing and recreational areas. However, the production of seaweeds is seen as more environmentally friendly than production of animals because algae consume dissolved nitrogen and produce oxygen (Shang and Tisdell, 1997). This ability can in fact be used to good effect, as suggested in the study of Tam and Shan (1994), where Chlorella pyrenoidosa was efficient in the removal of nitrogen and phosphorus from sewage.

With the development of aquaculture, certain environmental effects must be expected. Rosenthal (1994) proposed strategies to avoid or mitigate the environmental impacts of aquaculture such as determination of carrying capacity, establishment of site selection criteria and improvement of aquaculture practices.

Some of the effects of the environment on Gracilaria culture can be avoided by careful site selection. However, risks can not be totally eliminated or foreseen. Black tides and storms have to be expected in Saldanha Bay and St. Helena Bay, and the risk of raft dislodgement can not be ignored. Damage by boats and marine mammals, as well as oil pollution, can not always be controlled or anticipated by the farmer. Trono (1994) also mentioned the problems of grazing and epiphytes on cultured seaweeds as problems affecting the productivity of farms, and suggested increased efforts in solving these problems.

Bardach (1997), in a discussion on aquaculture and pollution, listed some of the sources of pollution influencing aquaculture as nutrient enrichment from external sources (especially nitrogen and phosphorus), toxic algal blooms and toxic industrial effluents. Rosenthal (1994) discussed natural and human impacts of the environment on aquaculture. Natural impacts include phenomena such as earthquakes and human impacts include industrial activity and multiple users of the water space..

Any aquaculture venture will have an effect on the environment, or be affected by it. From the literature it is clear that seaweed farming does not have such a big impact as animal culture (as described in Thia-Eng *et. al.*, 1989). Nevertheless, the coast is a shared resource and proper planning must take place before any farm becomes a reality, to ensure maximal sustainability and minimal conflict. The environmental effects of aquaculture refers also to socio-economic impacts. The long-term sustainability of a project must be weighed against its environmental effects. Short-term gains favouring the aquaculture farmer, but causing long-term environmental decline, have an unacceptable cost to other resource users and will lead to conflicts. Shang and Tisdell (1997) concluded that a sustainable aquaculture system must be biotechnically feasible, environmentally sound and socio-economically viable. Seaweed mariculture is not expected to cause environmental damage, but issues such as formation of seaweed monopolies, availability of sea water space, finance to the less affluent sectors of communities, and labour issues must be carefully considered before and during establishment of a seaweed farming industry.

v. Legal aspects

The issue of property rights is very important in mariculture, because investment cannot be made if security of tenure cannot be guaranteed for a long enough time to justify the investment. In the Kingdom of Tonga, ownership of reefs and lagoons, as well as all territorial waters, is vested in the Crown, and all Tongans have free access to territorial waters. The only exceptions are the prohibition of fishing in declared marine parks, and the recognition of ownership in the case of reefs surrounded by fish fences (Fairbairn, 1992a). The situation in Fiji is more complex, where marine property rights are characterised by state ownership of offshore waters and Fijian tribal ownership of fishing rights on customary fishing grounds (Fairbairn, 1992b). In these countries local customary laws and community-based management of coral reef ecosystems are nationally recognised (Hviding E, 1994), and the implications for activities such as seaweed mariculture is that permission for culture must be obtained from the local users of a particular area.

The situation in South Africa differs from the above examples in that the sea and sea-shore is considered as belonging to the state. The coastline is about 3000 km long, but there are very few sheltered areas suitable for mariculture. The result is that the few sheltered areas have to be shared by many users.

Much can be learned from the way in which other countries have developed their seaweed potential. Chile has become the largest producer of agarophytes in South America, by developing research capacity, and increasing scientific and economic activity around seaweed. The value of semi-processed and processed algal products was estimated at US$34 million per year in 1993 (Santelices, 1996). The seaweed farming industry in Tanzania developed from basic research about suitable species for cultivation, to pilot farms testing assumptions about technological and economic aspects, to commercial production which led to socio-economic benefits (Mshigeni, 1994). South (1994) suggested that planning of seaweed farming should take account of the specific conditions in a country, and that assumptions must be tested in a pilot farm. He also suggested that the factors to be taken into account in a feasibility study should include the following:

- the minimum income that a seaweed farmer will accept;
- local costs of establishing a seaweed farm;
- domestic costs such as transport;
- costs for the exporter;
- world prices and currency exchange fluctuations.

The projected economic feasibility of suspended cultivation remains speculation until a pilot farm can be operated. The real cost of production, rate of return and net present value may then be calculated. Factors such as diseases, oil spills and grazers occurring in a chosen site, may have more important effects on the viability of a farm than hitherto considered. What must also be carefully considered, is the carrying capacity of the area for mariculture activities and the effect of uncontrolled expansion. One example of the effect of overproduction is the salmon industry in Norway, which was reported by Holm and Jentoft (1996) as a very profitable industry until 1990, when gradually decreased prices and overproduction combined to cause serious losses to salmon farmers. However, the markets, both local and international, must be explored in more detail before investment is made. In a project in Sri Lanka, farmers had difficulty finding a market for G. edulis even after community-based farming became a reality (C. Amaratunga, pers. comm.). It is clear that any aquaculture project cannot be properly planned or expected to be sustainable if the economic, socio-economic, environmental issues are not addressed simultaneously.

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TABLE 3.1: Number of people required for different tasks associated with seaweed farming on one raft (5,625 m^2). (Seaweed Research Unit, Sea Fisheries Research Institute).

NUMBER OF PEOPLE	TASK
4	making the raft
2	divers for installation and maintenance
2-3	checking and harvesting
2-3	restocking of the lines
2-3	drying, cleaning and baling
1	management and administration

Table 3.2: Cost per hectare based on information obtained from Agartek CC, Sea Harvest Corporation Limited, the Sea Fisheries Research Institute and the Department for Environment Affairs and Tourism.

ITEM	TERMS	COST PER HA (RAND)
Advertisement of intentions in provincial and national newspapers	30 days period for public to file objections	600
Lease	For less than 21 ha: R200/ ha^{-1} /$year^{-1}$	200
Equipment and materials	rope, netlon, restocking boards, fuel, outboard motor, small fishing boat	15,000
Capital cost	raft manufacture and installation	90,000
Labour and maintenance	3 permanent workers for farming activities	54,000
	TOTAL:	159,800

Table 3.3: Discounted cash flows (constant values, direct export)

	Year 1	Year 2	Year 3	Year 4	Year 5
INFLOWS					
Sales	94,500	94,500	94,500	94,500	94,500
Total	**94,500**	**94,500**	**94,500**	**94,500**	**94,500**
OUTFLOWS					
Labour	54,000	54,000	54,000	54,000	54,000
Lease	800	200	200	200	200
Other	15,000	15,000	15,000	15,000	15,000
Total	**69,800**	**69,200**	**69,200**	**69,200**	**69,200**
Capital					
Raft	90,000				
Total	**90,000**				
Net before finance	**(65,300)**	**25,300**	**25,300**	**25,300**	**25,300**
Cumulative	(65,300)	(40,000)	(14,700)	10,600	35,900
IRR	20%				
NPV	23,250				

Table 3.4: Discounted cash flows (nominal values, direct export)

	Year 1	Year 2	Year 3	Year 4	Year 5
INFLOWS					
Sales	94,500	103,950	114,345	125,780	138,357
Total	**94,500**	**103,950**	**114,345**	**125,780**	**138,357**
OUTFLOWS					
Labour	54,000	59,400	65,340	71,874	79,061
Lease	800	220	242	266.2	292.82
Other	15,000	16,500	18,150	19,965	21,962
Total	**69,800**	**76,120**	**83,732**	**92,105**	**101,316**
Capital					
Raft	90,000				
Total	**90,000**				
Net before finance	**(65,300)**	**27,830**	**30,613**	**33,674**	**37,042**
Cumulative	(65,300)	(37,470)	(6,857)	26,817	63,859
IRR	32%				
NPV	22,059				

Table 3.5: Discounted cash flows (constant values, local sales)

	Year 1	Year 2	Year 3	Year 4	Year 5
INFLOWS					
Sales	87,413	87,413	87,413	87,413	87,413
Total	**87,413**	**87,413**	**87,413**	**87,413**	**87,413**
OUTFLOWS					
Labour	54,000	54,000	54,000	54,000	54,000
Lease	800	200	200	200	200
Other	15,000	15,000	15,000	15,000	15,000
Total	**69,800**	**69,200**	**69,200**	**69,200**	**69,200**
Capital					
Raft	90,000				
Total	**90,000**				
Net before finance	**(72,388)**	**18,213**	**18,213**	**18,213**	**18,213**
Cumulative	(72,388)	(54,175)	(35,963)	(17,750)	463
IRR	0%				
NPV	(7,435)				

Table 3.6: Discounted cash flow (nominal values, local sales)

	Year 1	Year 2	Year 3	Year 4	Year 5
INFLOWS					
Sales	87,413	96,154	105,770	116,347	127,981
Total	**87,413**	**96,154**	**105,770**	**116,347**	**127,981**
OUTFLOWS					
Labour	54,000	59,400	65,340	71,874	79,061
Lease	800	220	242	266.2	292.82
Other	15,000	16,500	18,150	19,965	21,962
Total	**69,800**	**76,120**	**83,732**	**92,105**	**101,316**
Capital					
Raft	90,000				
Total	**90,000**				
Net before finance	**(72,388)**	**20,034**	**22,038**	**24,242**	**26,666**
Cumulative	(72,388)	(52,353)	(30,315)	(6,074)	20,592
IRR	10%				
NPV	(6,189)				

Table 3.7: Economic sensitivity analysis

VARIABLE	INCOME	NBF	IRR	NPV
Transport 40% of income	81000	-78800	-10%	-31750
Transport 20% of income	108000	-51800	81%	75868
Production at 40 tonnes	126,000	-33800	191%	147613
Production at 25 tonnes	78,750	-81050	-17%	-40718
Price seaweed at US$1200/tonne	113400	-46400	106%	97391
Price seaweed at US$800/tonne	75600	-84200	-29%	-53273
No labour cost	94,500	-11300	782%	237294
Labour cost at R1800 pppm	94500	-76100	-1%	-20988
R:US$ Exchange rate of 4.9:1	102900	-56900	51%	55540

Income = income in first year
NBF = Net Before Finance (1st year)
pppm = per person per month

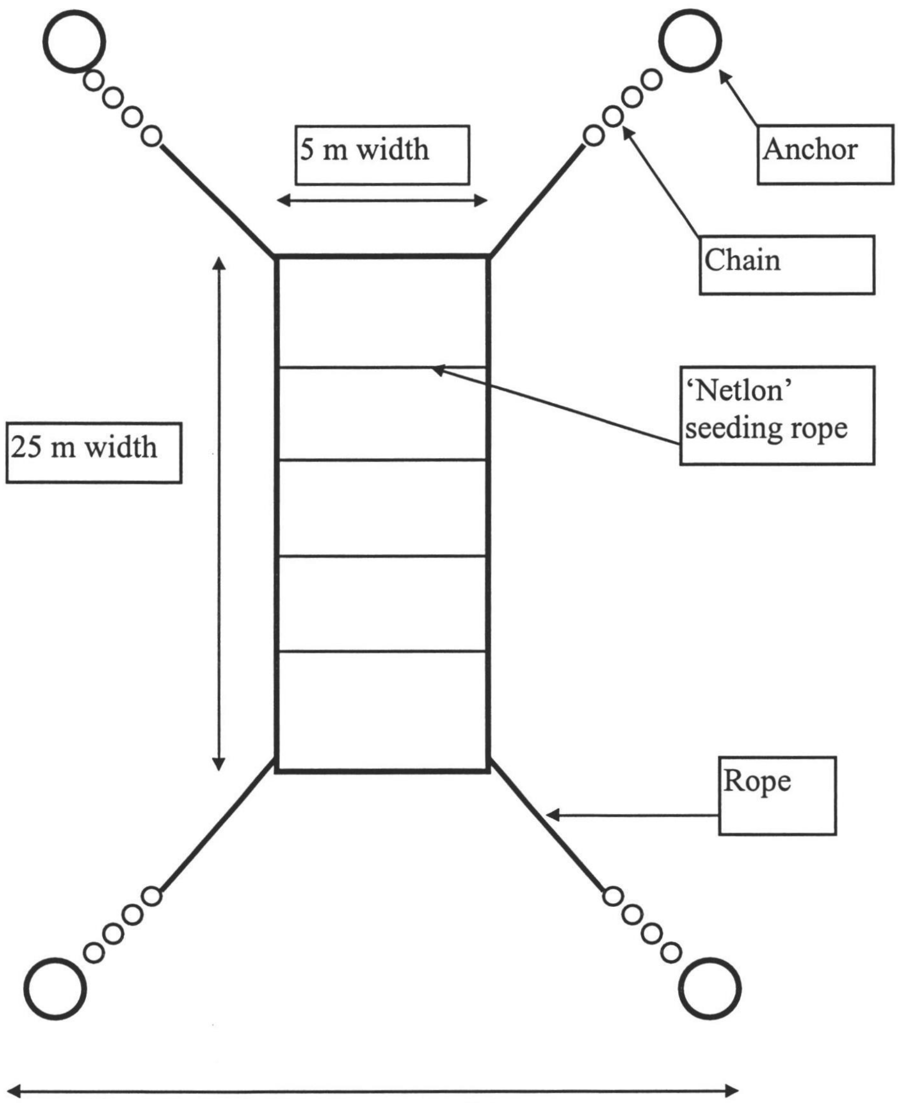
FIGURE CAPTIONS

Figure 3.1. 'Cell' design used in experimental culture (source: Dawes, 1995)

Figure 3.2. Commercial rope raft design for suspended *Gracilaria* cultivation (source: Seaweed Research Unit, Sea Fisheries Research Institute)

Figure 3.3. Experimental rope raft in St. Helena Bay

Figure 3.1



'Cell' design used in experiments

Figure 3.2

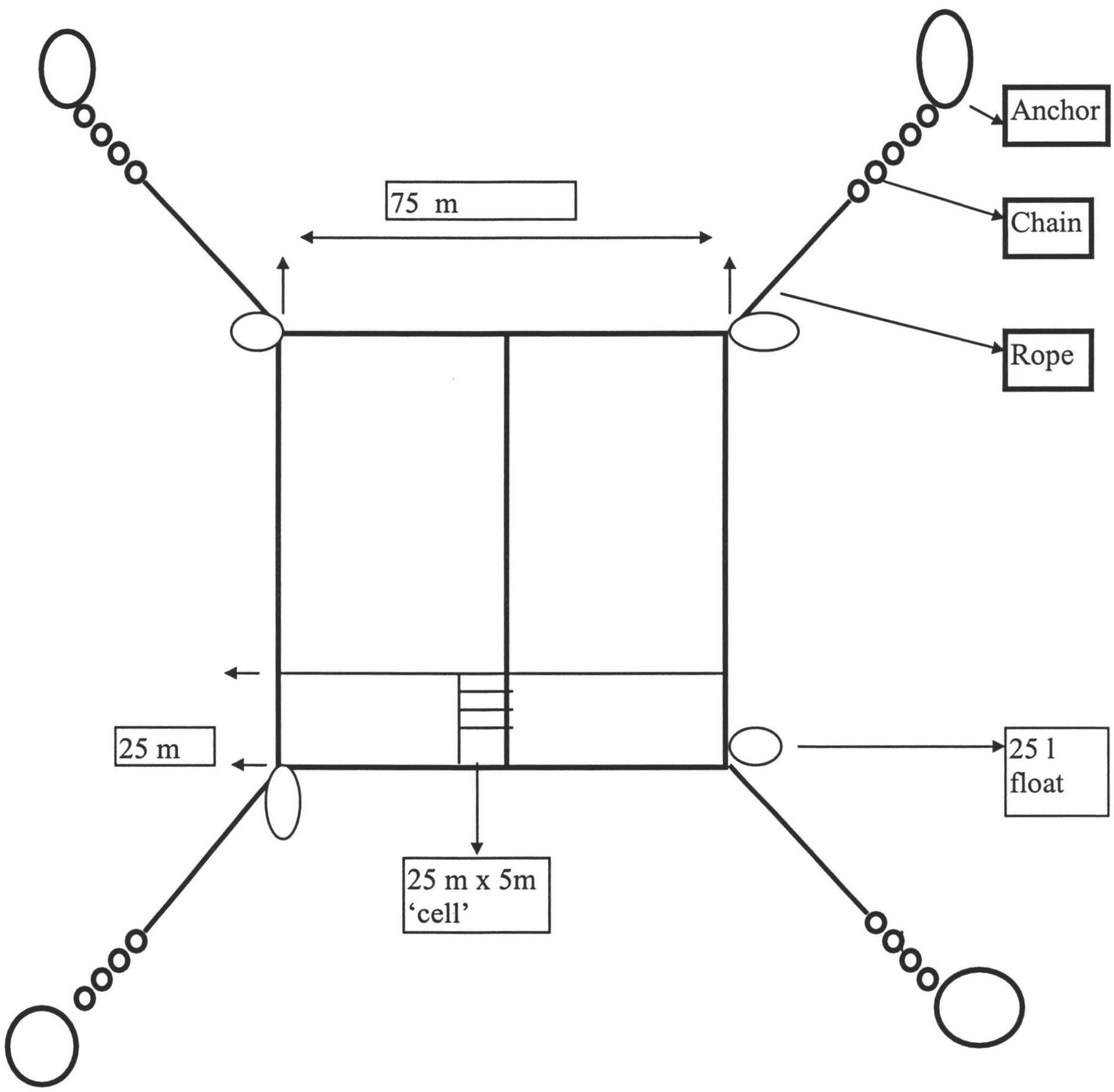


Figure 3.3

CHAPTER 4:

JOURNAL:

Journal of Applied Phycology

Community involvement and mobilisation in the planning and development of a seaweed cultivation industry in St Helena Bay, West Coast of South Africa.

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ABSTRACT

A community in St. Helena Bay was selected to be involved in a pilot community-based Gracilaria cultivation project aimed at establishing an industry in the bay. The objectives of the study were to facilitate community participation in the planning of a seaweed industry, build the capacity of the community in terms of seaweed farming and utilization, and to establish a community-based seaweed farm. A stakeholder analysis was carried out and interested and affected persons contacted. Most were willing to support such a project. Community-based organizations were involved in efforts to facilitate community participation and transfer of knowledge. The local seaweed industry parties were contacted and their support obtained. A Seaweed Mariculture course was presented to the community of St Helena Bay, and planning of a community-based seaweed farm continued after the course. The major obstacle to the establishment of a pilot phase was the difficulty in obtaining water rights, as was also experienced by a local seaweed company trying to obtain water rights for a seaweed farm.

INTRODUCTION

In southern Africa, suspended cultivation of Gracilaria gracilis has been shown to be successful as a commercial enterprise in Lüderitz, Namibia (Dawes, 1995) and experimentally in Saldanha Bay (Anderson et. al., 1992, Anderson et. al., 1996). The results of a site selection (Chapter 2) and feasibility study (Chapter 3) indicated that suspended cultivation of Gracilaria gracilis has a good chance of succeeding as an industry in two sheltered bays on the West Coast of South Africa: Saldanha Bay and St Helena Bay.

The utilization of seaweeds is managed according to a system of concessions, whereby a length of coastline is leased to an approved applicant. The coastline is at present divided into 17 concession areas (Anderson, 1989). In recent years the effect of this system has been under investigation, and means have been sought to improve access to the marine resources for marginalized communities (Share *et. al.*, 1996). Access and policy proposals were researched in 1995 in a project entitled "Evaluation of South African seaweed resources and development of management policy options to allow sustainable utilization by coastal communities". Three reports were submitted on the present system of access and its socio-economic implications and recommendations on a future policy were made. Freese (1995) made a number of proposals including:

- the introduction of a seaweed development project for agar production;
- power to generate revenue from seaweed given to coastal communities or local authorities;
- formation of co-operatives around the collection and export of Gelidium (East Coast).

The proposals made by McQueen (1996) included:

- the allocation of more seaweed concessions, and allow some to be given to the local people;
- replacing the current concession system with one of co-management between local communities, industries and government;
- picking seaweed in a co-operative form of enterprise.

Levin (1996) suggested various income-generating projects along the West Coast instead of an altered management system. These included:

- selling seaweed as food for fish and abalone, as food for pet and livestock, as food for human consumption, or for use in cosmetics and vitamin products.

Unless some of the policy recommendations made in these reports or similar ones are implemented, the coastal communities will not have access rights to the seaweeds in their areas, and will continue to be marginalized by the concession system. The cultivation of seaweed would not impact on the access of existing concessionaires and could potentially allow coastal communities access to revenue not available through existing seaweed utilization. This would also be in line with the government's Reconstruction and Development Programme (ANC, 1994), which is designed to facilitate the socio-economic development of the country.

Similar cases where artisanal seaweed cultivation provided supplementary or subsistence income to coastal communities or is being developed as a community enterprise can be found in St. Lucia (Smith, 1992 and Smith, 1997) and Sri Lanka (C. Amaratunga, pers. comm.). Seaweed farming led to an improvement in the standard of living of farmers in Indonesia (Firdausy and Tisdell, 1992), St Lucia (Smith, 1992) and Zanzibar, Tanzania (Mshigeni, 1994).

Doty (1979) described a general method of realising a nation's seaweed potential, based on tested hypotheses from different countries. The method includes a pre-investment stage, where pre-feasibility and feasibility studies are carried out, and an investment stage, where commercial farming is started. To establish a community-based enterprise, the specific community must first be informed about the available technology and their support and participation obtained. To introduce the concept of seaweed farming, it was necessary to select a community in either Saldanha or St. Helena Bay for a pilot study.

Although no growth or cultivation studies had been conducted in St. Helena Bay when this study was initiated, the community of this bay was selected for a few reasons. Saldanha Bay is a busy industrial port, with limited sea space for mariculture, and industrial development is increasing (CSIR, 1995). Ship traffic is likely to increase with the planned extension of the existing Iron Ore jetty, increasing the possibility of oil spills and user conflicts. Several mariculture projects, including mussel farming, already exist or are in the process of being implemented (V. Pienaar, F. Gaobone, M. Karaan, pers. comm.). Mostly fishing and recreational boats, on the other hand, frequent St. Helena Bay, with no existing mariculture except a land-based oyster hatchery. Like Saldanha Bay, St. Helena Bay is relatively sheltered from the prevailing swell, and Gracilaria gracilis occurs naturally in the bay. This lead to the assumption that G. gracilis cultivation would be possible in St. Helena

Bay as well.

St Helena Bay is a linear town, stretching for about 15 km along the bay. Six communities that could be classified as "historically disadvantaged" in the context of Apartheid policy are found there. These are Laingville, Westpoint, Steenberg's Cove, Sandy Point, Midwest and Stompneus Bay (chapter 2, figure 2.18). The area has a population of about 4000-6000. A socio-economic study of West Coast fishing communities by Schutte (1993) reported an average income of R1435.9 per month, with R140 the minimum and R5416 the maximum for St Helena Bay. An unemployment estimate of 7.1% (based on the responses of heads of households about their full-time occupations) was reported for St Helena Bay during that study. This could be higher in times when the fishing season is closed. In fact, an unemployment figure of 10-30% was estimated by CSIR (1994). Many fishing families live in houses too small for the average number of people reported by Schutte (average 5 persons, with 1 the minimum and 11 the maximum reported per household).

Recent changes in Fisheries policy have allowed entrepreneurs in Laingville to establish a fish processing facility, which opened in late July 1998. Similar changes in seaweed policy could lead to other economic benefits to the community.

Thus the environmental and socio-economic profile of St Helena suggested the possibility that farming of Gracilaria could be introduced as an economic enterprise which could increase the income of at least some members of the fishing community. The possible ways in which seaweed farming can be organised include subsistence farming and commercial farming. Subsistence farming refers to farming for the necessities of life, and the term is often applied in cases where the crop is used for local human consumption. Chakalall and Noriega-Curtis (1992) classified *Tilapia* farmers in Jamaica into subsistence, small-scale and commercial farmers. The distinction was in part based on the size of ponds. Subsistence farms were less than 0.4 ha, small farms were 0.4 to 4 ha, and commercial farms were bigger than 4 ha. Aquaculture farms can also be described in terms of intensity (O'Sullivan and Purser, 1993). Extensive cultivation is similar to natural conditions, and is characterised by low stocking densities, use of naturally occurring feed, relatively low productivity and low cost of production. Semi-intensive culture is characterised by moderate to high stocking densities, moderate to high levels of water quality management, use of naturally occurring and supplementary feed, moderate cost of production and increased productivity. Intensive culture is characterised by high to very high stocking densities, little or no natural feed, control of environmental variables, high capital and operational costs and high productivity.

In the context of this study, community-based farming is seen as extensive small-scale or commercial farms managed by a community structure or co-operative. The objectives of the study were:

1. to provide a model for the facilitation of community participation in the planning and development of a seaweed cultivation industry in South Africa;
2. to build the capacity of the community in terms of seaweed farming
3. to establish a pilot community-managed seaweed cultivation farm in St. Helena Bay.

MATERIALS AND METHODS

i. Stakeholder analysis

Researchers from the Rural Foundation, a non-governmental organization in Stellenbosch, became involved in the study at an early stage. With their help, possible stakeholders that could have an interest in future seaweed farming on the West Coast were identified through interviews, telephone inquiries and literature reviews. Stakeholder analysis and mobilisation was done by identifying all interested and affected parties including government, industry, local beneficiaries and service providers. Representatives of all stakeholder groups were interviewed.

ii. Facilitation of community participation

Interest by the target community in the establishment of income-generating projects in general, and seaweed cultivation specifically, was assessed by conducting interviews with community leaders and representatives from community-based organisations. Formal meetings and workshops with these persons were arranged. Participatory project planning was done during workshops and meetings with the project stakeholders and beneficiaries to brainstorm the various project aspects including: assessing water rights, training and capacity building needs, institutional design, financing and marketing. During the workshops different organisational designs for a future industry were also discussed.

iii. Involvement of local industry

Local seaweed industries were identified and the companies involved in Gracilaria export and cultivation contacted. Potential involvement and roles of these companies in a future industry and in community-based cultivation were discussed with representatives.

iv. Dissemination of information

Brochures and seminars were used initially as a means of disseminating information about seaweed farming and utilisation to community representatives. In July 1997 a Seaweed Mariculture course, developed and organised by the International Ocean Institute (Southern Africa), a non-governmental organisation based at the University of the Western Cape, was presented to a group of community members, under the leadership of B. Brown. A participatory rural appraisal was conducted during the course, and delegates encouraged to plan their own involvement in a future cultivation project. A second course in November 1997 was also attended by a community member.

v. Project planning

Planning of a community-managed seaweed farm continued with the involvement of the Seaweed Mariculture course participants. Several follow-up meetings were held to report on progress and to relay information to previously uninformed members of the community. A community organisation was formed and its members were given advice and support concerning an application for seawater space, the development of a business plan and how to obtain the support of potential investors.

RESULTS

i. Stakeholder analysis

The stakeholders identified and contacted at the beginning of the study include community leaders in St Helena Bay, community-based organisations, industry, research interests, non-governmental organisations and government organisations (Table 4.1). The organisations represented during this initial analysis included five community-based organisations, two from the research community, three from the seaweed industry, two extension and development organisations, and three representing government or other authorities. Most of these parties expressed interest in a future cultivation industry and indicated that they would support a community-based enterprise. The St Helena Bay Fishing Community Trust was identified as an ideal organisation to help co-ordinate meetings and workshops with the community. Opposition from land-based developers to a private company's application for water space to establish a seaweed farm in Stompneus Bay was interpreted as a potential source of conflict for a future community-based seaweed enterprise in the same vicinity.

Several interviews and informal meetings were held from 1996 to 1997 with possible stakeholders and interest groups (Table 4.2). A number of assumptions were made from these interviews. These assumptions, as well as the number of interviews during which the topic was discussed, as listed as follows:

1. The industrial role-players in the Gracilaria gracilis industry are interested in collaborative research and development and involvement of local communities in

a cultivation industry (5).

2. The high percentage of unemployment and seasonal nature of the fishing industry led to a need for alternative employment opportunities in St. Helena Bay (5).
3. Expertise in rural development and aquaculture development is available in the Western Cape and is represented by NGOs as well as consulting services (2).
4. Research institutions are already involved in scientific research on Gracilaria gracilis and their research results would be available for development of a community-based seaweed cultivation project (2).
5. Community members were interested in the prospect of seaweed cultivation and expressed willingness to support the project (1).
6. Funding organisations are available for funding of the project but they have specific criteria, which need to be kept in mind during project development (1).
7. The institutional arrangements and roles of research, industry and extension organisations need to be clarified during project development to avoid duplication of efforts and make the best use of available expertise (2).
8. A community-based seaweed project would be supported by local, provincial and national government authorities, but it must fulfil the legal, environmental and scientific criteria set out by these authorities (3).

ii. Facilitation of community participation

Seven community-based organisations in St Helena Bay were contacted and estimated membership totals obtained from representatives of all these organisations (Table 4.3). These representatives were present at most of the formal meetings and workshops and they confirmed the assumption that the communities were in need of income generating projects. The representatives of the Net-and-Line Fishermen's Organisation and the Fishermen's Widows' Organization were keen to involve their members in the proposed project and to help educate them about seaweed farming.

From 1996 to 1997, 11 formal meetings and seminars were held with community members and other interest groups in Laingville, mostly at the offices of the St Helena Bay Community Fishing Trust (Table 4.4). Minutes can be found in Appendix 2. The largest number of community representatives at any one meeting was 14 and the smallest number was 2. Several agreements were reached. The St. Helena Bay Community Fishing Trust would be the contact organization between the social, business and scientific communities. They would also be responsible for identification and mobilization of entrepreneurs from the community, to be involved in a pilot commercial cultivation project. An NGO (such as the Rural Foundation or the International Ocean Institute) would apply for funding for such a project, as well as arrange for training. Private companies (if any) involved in the project would assist in technical and business training, and scientists from universities and government departments would be asked to assist in the initial research and development phase.

During the workshops and meetings, several variations of a model for a future seaweed industry involving stakeholders were discussed. Figure 4.1 outlines a possible mechanism of organisation discussed during workshops. All the variations discussed included production units (closed corporation, family unit or individual farmer) which would operate farms, and a co-operative or company responsible for marketing, export, maintenance and leases. Each production unit would be responsible for day-to-day farming duties and monitoring. All production units could belong to a co-operative that would be responsible for drying the seaweed, leasing land for this purpose, and carrying out other duties (such as maintenance of anchor systems by qualified divers) that would not be cost-effective if run by production units. The co-operative, private company and other shareholders could form a company on a percentage share basis. This company would be responsible for further processing, lease of water space, marketing and export. The company or co-operative could fulfil the same role as that presently executed by sub-contractors in the present seaweed industry, who act as middlemen between producers (or harvesters and collectors) and seaweed export or processing companies.

iii. Involvement of local industry

Three companies were identified as existing industry stakeholders in a cultivation industry. Taurus Chemicals Ltd is presently the only company exporting G. gracilis from Southern Africa and the company runs a cultivation farm in Lüderitz, Namibia. So they were viewed as a potential local market for cultivated seaweed. Sea Harvest Corporation Ltd ran a pilot commercial cultivation farm in Saldanha Bay from 1995 to 1997. This company was involved in the development of community-managed mussel farming in Saldanha Bay, and their support for a similar initiative in St. Helena Bay, using seaweed cultivation, was discussed with the Aquaculture Manager (M. Karaan, the Rural Foundation and V. Pienaar, Sea Harvest Corporation Ltd, pers. comm.). Both Taurus Chemicals Ltd and Sea Harvest Corporation Ltd indicated strong interest in a potential industry in St. Helena Bay, but no formal agreements concerning sales, marketing or development was entered into.

A private company called Agartek CC lodged an application for water space for seaweed cultivation in Stompneus Bay (St. Helena Bay) in 1995. Interviews with the managing directors of this company revealed that they were keen to involve the local community in their cultivation enterprise. As this corresponded with the objective of the present study, most formal meetings and workshops with community members included the directors of Agartek CC. The verbal agreement reached was that once their application for water space was approved, the directors of the company would make available enough space for a pilot commercial raft to be funded by them or another organization, and operated by entrepreneurs chosen from the community. In this way the first farmers could be trained, and a pilot phase initiated during which growth, agar quality and environmental studies could be conducted. The most important obstacle to this plan was that the provincial government turned down their application for water space and this effectively thwarted all plans for a pilot cultivation phase involving Agartek CC and the community in 1996. The main reason for the refusal was the objections to the sea farm made by a land developer next to the bay in which the farm was to be located.

Agartek CC challenged the interpretation of powers assumed by provincial and national government. At this stage, the St. Helena Bay community became involved in efforts to reverse the decision to turn down the water space application of Agartek CC. Letters were written to several provincial and national ministers requesting their support (Appendix 3), and an interview with the Minister of Environmental Affairs requested. An interview with the provincial Minister of Economic Affairs, Reconstruction and Development took place in October 1996 and resulted in the support of the project from this minister. The issue received media attention, and this aided in educating the community about the legal, environmental and social implications of a farm (see newspaper clippings in Appendix 4). The issue of seaweed mariculture was subsequently clarified and determined to be the responsibility of the national government. The new Marine Living Resources Act (No. 18 of 1998) requires that a recommendation on an application for seaweed farming by national government (represented by the Department of Environment Affairs and Tourism) must be made to the Parliamentary Committee, which then makes a final decision.

A fourth company was identified as a potential industrial partner for the community-based cultivation project. The Abalone Farmers Association of South Africa (represented by D. Katz, pers. comm.) became interested in the project in 1997. Their interest stemmed from the possibility of using Gracilaria as a supplementary feed for abalone. Discussions led to the active involvement of this group in the project in 1998.

iv. Dissemination of information

The brochure used to provide information (Appendix 5) was not very successful. During the seminars, mostly the representatives of community-based organizations were present, but not a large proportion of other members of a particular organization. This excluded a large proportion of the community from the opportunity to ask questions and obtain answers. Most of the meetings and seminars were three to five hours, and this placed a restriction on the amount of useful information imparted to those present. An assessment of the quality of the brochure (in terms of print size and amount of information) led to the assumption that it was not enough to capture the attention of the larger community. This led to the realization that a more comprehensive method of information dissemination was needed. In July 1997, a Seaweed Mariculture course was presented to the St. Helena Bay community by the International Ocean Institute (Southern Africa). Thirteen people attended, including eleven community members from St. Helena Bay, and two students from the University of the Western Cape. This was more effective in educating community members about seaweed utilization and related issues. The course content included seaweed biology, utilization and cultivation, basic business skills, organizational design of an industry, and participatory research (see course report in Appendix 6).

An important part of the course was the participatory rural appraisal held to obtain information about the community from community members. The most important aspects emphasized were the expectations for the course, the problems in the community, causes of problems and ideas about how seaweed mariculture could be used to solve some of the problems. Table 4.5 summarizes the problems and causes, which the community thought, were the most important. The most important problems were listed as drug and alcohol abuse and teenage pregnancies. Poverty, peer pressure and lack of education were cited as the most common causes of problems. Table 4.6 is a representation of the annual cycle of unemployment. The greatest unemployment phases are January to February, and June to July.

During the course these community members decided to combine efforts to establish a community-managed seaweed farm. Table 4.7 summarizes the steps identified by delegates, which were needed to establish community-based seaweed farming in St. Helena Bay.

v. Project planning

The project-planning phase was largely the results of the efforts started during the participatory rural appraisal. Most of the tasks outlined in Table 4.6 were attempted. After the course in 1997, several meetings were held during which efforts were made to involve more members of the St. Helena Bay community in the project. Formal meetings were held in Stompneus Bay, Midwest and Steenberg's Cove (as listed in Table 4.4). The project was planned in seven stages (Table 4.7), with the first phases including the initial research, and the next phase being the Project Planning phase. This should result in a registered community organization taking responsibility for the project, an application for seawater space by this organization, and a business plan to be used for obtaining funds for a pilot farm. Funding for the Project Planning phase was obtained from the Department of Trade and Industry in 1997. The St. Helena Bay Community Seaweed Initiative was the result of the efforts of community members. This body, which has no legal status yet, assumed the responsibility for the seaweed cultivation project.

DISCUSSION

i. Stakeholder analysis

During the study it became clear that seaweed cultivation may have an impact on land-based developers and property owners, and that some people may see cultivation rafts as visual pollution or an obstruction to recreational activities such as swimming and boating. Thus the stakeholder list will have to be revised and the support of all parties ensured. Opposition by any one of the interested and affected parties may halt the project, as was the case with the water space application of Agartek CC.

The interviews with interested and affected persons and the links established during those interviews led to the development of a community-based seaweed cultivation project as a multi-disciplinary, multi-institutional project. Because of the support from major role-players (community, industry, research, extension, development and government agencies), the project has a good chance to succeed in reality, provided that the chosen site is economically and environmentally viable. The idea of a multi-disciplinary approach to mariculture is also supported by Bailly (1989), because the management of mariculture activities require the knowledge of economists and sociologists especially.

ii. Facilitation of community participation

The formal meetings and seminars succeeded in introducing the concept of seaweed farming to community representatives, and confirmed the assumption that the community needed additional means of income generation. The absence of any cultivation or experimental data in St Helena Bay at that stage made education about the technology difficult, because the nearest practical example was in Saldanha Bay, about 20 km away. However, representatives from especially the Net-and-Line Fishermen's Organisation remained interested in the project. This indicated that the fishermen were keen to explore the possibility of seaweed cultivation. It may have been useful to involve a social scientist from the beginning of the project to obtain information on the knowledge about and interest in seaweed farming from a sample of all inhabitants. This would have made subsequent project planning easier, and could have sped up the process. Such surveys were done by Vuki *et. al.* (1992a and 1992b) about the prospects for giant clam farming in Fiji, following the reduction of natural stocks of giant clams. The authors investigated the knowledge and ideas of villagers about giant clam abundance, use, harvesting methods and need for cultivation, before deciding on developing a village clam farming project.

The development of a community-based activity can be influenced by inherent social systems and cultural beliefs, and the failure of development proponents to understand family structures, indigenous knowledge and the patterns of existing employment (Corbin and Young, 1997). This was the case in the beginning of the project, as the social and cultural systems in the community were only understood comprehensibly after the Seaweed Mariculture course. Before that, a lack of understanding led to an underestimation in the importance of differences within the St. Helena Bay society. An example is the fact that no active fisher attended the Seaweed Mariculture course, even though they were enrolled, because of the abundance of snoek at the same time and their obligation to provide for their families. Thus, in further development of the project, an understanding of community dynamics and customs is essential before planning can take place.

The potential industry structure as discussed in meetings may or may not be viable for the industry. The structure of the industry in reality would depend on factors such as ownership of the rafts, cost-effectiveness of centralised functions and the relationship between producers and buyers. The success of seaweed co-operatives may also depend on factors such as managerial skills of farmers. Pollnac and Poggie (1991) found in a comparative study of capture fisheries and mariculture in Ecuador that social solidarity and managerial effectiveness respectively contributed to the success of co-operatives in the two types of fisheries. The formation of seaweed co-operatives would need to be investigated in terms of the skills of fishers, who are expected to provide most of the labour force for a future seaweed cultivation industry in South Africa.

iii. Involvement of local industry

The interest from local companies interested in buying seaweed was seen to be a positive factor in the planning of a community-based seaweed cultivation project. Negotiations for community involvement and practical training will be continued with Agartek CC if their farming application is approved. Sea Harvest Corporation Limited and Taurus Chemicals Ltd. remained interested in the enterprise. The Abalone Farmers Association of South Africa provided material input and is committed to helping the St. Helena Bay community with the establishment of G. gracilis cultivation. It is thus assumed that a ready local market for farmed seaweed exist.

The water space application of Agartek CC led to progress in the clarification of government policy about seaweed mariculture. The national government now has the responsibility to make a recommendation to Parliament, which will make a final decision. This will make it easier for new applicants to have their applications processed.

iv. Dissemination of information

The Seaweed Mariculture course was successful in providing community members with relevant information needed to make informed decisions about seaweed cultivation. A few local teachers attended the course, and some indicated that they were keen to use their knowledge to teach others interested in the project. The importance of a comprehensive method of information dissemination was demonstrated in the constructive involvement of course delegates in the project and the initiative they took in further planning.

Education is thus a crucial aspect of the industry development and future management. In a discussion about the fisheries management policy of Puerto Rico, Kimmel and Appeldoorn (1992) outlined the importance of education of not only fishermen, but also those involved in management. Without it, management policies will not be successful. Education is especially important if the industry is to be developed fully without having a negative impact on its long-term sustainability.

McArthur (1994) described a participatory rural appraisal (PRA) as a process based of creating dialogue and generating information based on the assumption that for lasting change to occur, community residents must participate in an active co-learning process with researchers. The PRA conducted in 1997 succeeded not only in educating the researchers involved in the project about the St. Helena Bay community, but also in giving community members a chance to analyse problems in the community and think about solutions. Their involvement in the PRA motivated delegates to implement steps for a seaweed project, which they themselves identified. Researchers also learnt more about the community from the participants. The assumptions about high unemployment and the socio-economic needs of the community were confirmed.

v. Project planning

The ongoing involvement of community members in efforts to establish a community-managed seaweed farm has resulted in several funding applications for different phases of the project being submitted to different funding bodies. The St. Helena Bay Community Seaweed Initiative was also a result of their continued efforts, and this body is taking responsibility for further development of the project. At present the Initiative consist of people who attended meetings between 1996 and 1998 and some who attended the Seaweed Mariculture course. However, a legal business entity allowing future involvement of previously uninvolved community members has yet to be established. Potential investors were contacted in 1998, and letters of intent obtained from two of them. Funding has been obtained from the Department of Trade and Industry, and this will be used to apply for seawater space for a pilot community-based G. gracilis cultivation farm in St. Helena Bay. More than one potential farming area of one hectare each, in different areas in the Bay, will be applied for. This will allow for the testing of growth and quality in different environmental conditions, to ensure that a choice of farming areas are available when the commercial farming commences. The pilot will be operated for at least one year before a decision on expansion or termination will be made. The environmental, economical and socio-economical viability of such a project will be investigated during the pilot phase. Those committed to the project have demonstrated a willingness to contribute in kind to the project, such as lodging and meals for research personnel, office facilities and organization of workshops. Mobilisation of community members is still an ongoing process and is accelerated by the activities of the Community Seaweed Initiative.

The model used here was successful in terms of capacity building of community members in St. Helena Bay. More inhabitants of St. Helena Bay are able to make an informed decision about Gracilaria farming than was the case at the start of the study. At least 12 members have received initial training, and can use their knowledge to educate others. Even if Gracilaria farming proves to be uneconomical, knowledge about the economic importance of seaweed and business practices can be used to investigate other economic opportunities. Capacity building of science students has also taken place. Seven students at third-year and Honours level have attended the Seaweed Mariculture course, and it is envisaged that social science, economics and political science students will be recruited to do research during the pilot phase in St. Helena Bay.

A community-based Gracilaria farming enterprise in St. Helena Bay is expected to take a few years before becoming established. A pilot farm is expected to run for at least one year, with training and development of initial farmers. If it is economically viable, expansion will take place in stages, with at least another two years of development and training. The size of farms or scale of the industry will depend on factors such as the carrying capacity of the bay, viability of specific sites, available markets and individual farmers. It is also possible that the idea of small-scale or community-based mariculture will not be viable for this industry. An example of an aquaculture industry which was successfully introduced but did not fully realise the objective of rural development through small-scale activities, is *Tilapia* farming in Jamaica (Chakalall and Noriega-Curtis, 1992). The general trend was that small-scale and commercial farmers with larger farms were in a better position than subsistence or small-scale farmers with small farms to obtain services such as credit, marketing advice and extension.

It is clear that the idea of community-development and capacity building through seaweed farming has considerable potential and support from major role-players. However, all the issues must be carefully considered at every stage of development. The political, social, economical and biological environment will influence the project and cannot be considered separately. Political ecology is a theoretical and methodological approach to the integration of social, cultural, economic, political and environmental factors in anthropological and ecological studies. Stonich (1995) used political ecological analysis to describe the environmental quality and social justice implications of development strategy using shrimp mariculture in Honduras. She examined the interconnections between the development model, policies of the state and competition among classes and interest groups, and argued that problems of social justice and environmental quality can only be understood in terms of the underlying social structure. The introduction of shrimp mariculture in Honduras was a response to the economical crisis, and the industry was so successful that it became the third biggest foreign exchange earner in 1987. However, the down side to the economic success was the damage to the environment, especially the destruction of mangrove forests, and the increasing poverty of communities adversely affected by environmental damage and diminished access to natural resources. Bailey (1988) described Ecuador as an example where mangrove forests have been destroyed for shrimp farming, and social injustices resulted from unequal access to knowledge, finance and institutional resources. The social structure in the St. Helena Bay community, as well as the political and economic environment of South Africa, must be taken into consideration to ensure that seaweed mariculture does not become an exclusive enterprise only accessible to those who have access to information and finance. Existing divisions between poorer and richer segments of the community can lead to social injustice if equitable involvement and access does not take place.

The development of a country's seaweed potential usually goes through several stages. In South Africa the seaweed was already utilised and exported. The need for seaweed cultivation was recognised and experiments started, thus obtaining the necessary biological and technological information for successful cultivation. A pilot commercial project in Saldanha Bay, although unsuccessful, provided more information about suitable sites. A feasibility study was done with a view to developing community-based seaweed culture. Potential markets were explored and seaweed export companies contacted. Community members were educated about seaweed farming, and they have seized the idea to develop a seaweed farming industry. What still needs to be done, is a pilot community-based farm, and expansion to a full-scale industry. In Tanzania, the development of the Eucheuma farming industry also followed several steps. Pilot farms were used for education and popularising the idea, and results proving the viability of farming were used to produce a seaweed farming manual and to obtain industrial and governmental support. Villagers started farming seaweed and the industry developed into an economically and environmentally viable industry, with socio-economic benefits (Mshigeni, 1994). Doty (1979) outlined several phases for a seaweed development project, which can be summarised as follows:

A. Pre-investment stage

1. Establishment of introduction objectives and conventions
2. Pre-feasibility phase
3. Feasibility phase

B. Investment stage

1. Establishment of industry conventions and goals
2. Demonstration farm establishment
3. Capitalisation of product purchasing
4. Encouraging self-conviction in the people that they should farm seaweed
5. Implementation of export and marketing
6. Stabilisation of the industry

In the present study, more or less the same steps have been taken as in the process outlined above. The feasibility phase of the Pre-investment stage were completed. The next phases in the Investment stage can now be continued. The outline is useful in developing the Gracilaria cultivation project in South Africa, as it would reduce the possibility of making the same mistakes as seaweed development workers in other countries.

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Table 4.1: Results of Stakeholder analysis.

ORGANISATION	CONTACT PERSON	TEL. NO.	CODE
Steenberg's Cove Housing Committee	Bernitto Afrika	02283-61275	C
St Helena Bay Fishing Community Trust	Quinton Jordaan	02283-61446	C
Net and Line Fishermen Association, St Helena Bay	R. Jordaan	02283-61521	C
Agartek	Frik Basson, John Robinson	021-790 3096	I
Sea Harvest Corporation Limited	Vossie Pienaar	02281-	I
Sea Fisheries Research Institute	Robert Anderson	021-650 3717	R
Cape Nature Conservation	Jenny Nicholson/Dennis Leydler	021-483 3586	G
Portnet	Tim Pretorius	02281-357221	G
Food and Allied Workers Union	Randall Abdul	02281- 61100 - (w)	C
West Coast Transitional Council	Norman Cloete	02281-32083 (w)	G
Fisher's Widows' Organisation	Fan Julius	02283-61302 (h)	C
The Rural Foundation	Wilfred Wentzel	021-887 6870 (w)	E
International Ocean Institute	Derek Keats	021-959 2304 (w)	E/R
Weskus Agricultural Organisation	Sharon February	083 626 4573	C/I

ORGANIZATION CODES

C = Community organisation

R = Research organisation

I = Industry organisation

E = Extension and development organisation

G = Governing authority

Table 4.2: List of interviews and meetings held from 1996 to 1997, with the aim of identifying stakeholders, work out strategy for study and establish links for future negotiations.

DATE & PLACE	PERSON/ORGANISATION	TOPIC CODE	TOPIC SUMMARY
03-02-96; Edgemead	J. Robinson (director, Agartek)	I	Water application in St Helena Bay; nature of future collaborative research and development
06-02-97; Rondebosch	A. Semphill (Urban Projects Team)	N	Efforts underway to help resident of Steenberg's Cove build or buy own houses; possibility of seaweed farming as income generating project
14-02-96, Vredenburg	N. Cloete (principal, Weston High School)	N	Need for income-generating projects on West Coast
14-02-96; Steenberg's Cove	A. Sneyders (resident, Steenberg's Cove)	N	General history of Steenberg's Cove, fishing industry, unemployment problem
14-03-96; Bellville	M. Karaan (Rural Foundation)	E	Portfolio of Foundation, outcome of workshop with RDP-forum in Saldanha Bay
09-05-96, St Helena Bay	W. Mouton, (ex-mayor, St Helena Bay)	N	Socio-economic background and stakeholders in St Helena Bay
09-05-96; St Helena Bay	N. Cloete, Weston High School	N	Housing problem in Steenberg's Cove

Table 4.2: Continued

17-05-96; Stellenbosch	J. Robinson, F. Basson, (Agartek); M. Karaan, (Rural Foundation)	I	Report back on progress, possibility of sub-lease of water space
28-05-96; Cape Town	R. Martin, S. Hanivall, J. Levin, C. McQueen, (Environmental Monitoring Group), M. Karaan, K. Salie (Rural Foundation); R. Anderson (Sea Fisheries Research Institute);	R	Small-scale seaweed farming in the Western Cape
12-08-96; Cape Town	J. Robinson, (Agartek)	I	Information for pre-feasibility study
16-08-96; Saldanha Bay	V. Pienaar (Sea Harvest Corporation Limited); S. February, E. Talliard (West Coast Agricultural Organisation); M. Karaan, L. Hobson (Rural Foundation)	I	Feasibility of mussel farming in Saldanha Bay; report on progress and processes.
22-08-96; Saldanha Bay	V. Pienaar (Sea Harvest Corporation Limited);	I	Preliminary talks: involvement of Sea Harvest in seaweed cultivation, especially as seaweed buyers
03-10-96; Stellenbosch	M. Karaan (Rural Foundation); C. Heineken (Aquaculture Technical Services)	E	History of Mussel farming in Saldanha Bay
18-10-96; Saldanha Bay	A. Swanepoel, B. Ndlovo (Portnet); M. Karaan (Rural Foundation)	G	Portnet role in mussel farming

Table 4.2: Continued

30-10-96; Cape Town	C. Nissen, N. Michaels, P. Vogel (Provincial Ministry of Economic Affairs and RDP); M. Karaan, W. Wentzel (Rural Foundation); L. Mckent (Stellenbosch Business Centre);	G	Problem of accessing water rights; discussion of seaweed farming as economic enterprise
14-01-97; UWC	D. Keats, (UWC); L. Hobson, M. Karaan (Rural Foundation); J. Robinson, F. Basson (Agartek); R. Anderson (Sea Fisheries Research Institute)	R/In	International Ocean Institute of Southern Africa and its role in seaweed mariculture training; possibilities of funding a test raft in St Helena Bay
30-01-97; Vredenburg	N. Cloete (Weston High School)	C	Report back on activities; future of seaweed cultivation project
23-04-97; University of Cape Town	J. Robinson, F. Basson (Agartek); J. Bolton (University of Cape Town); D. Keats (UWC); R. Anderson (Sea Fisheries Research Institute)	In	Overall objectives of each organisation with future seaweed farming
02-05-97; Cape Town	C. Wyeth (CSIR)	F	Funding possibilities for pilot seaweed farm
20-06-97	D. Leydler (Cape Nature Conservation)	G	Role of CNC in resource management and St Helena Bay conflict

Table 4.2: Continued (explanation of topic codes)

TOPIC CODES AND NUMBER OF INTERVIEWS:

I = Industrial support:	5
N = Need for economic opportunities:	5
E = Extension services available:	2
R = Research:	2
C = Community involvement:	1
F = Funding agencies available:	1
In = Institutional aspects of future industry:	2
G = Support from and role of governmental authorities:	3

Table 4.3: List of Community-based organisations in St Helena Bay and membership estimates (obtained from by contact persons).

ORGANISATION	MEMBERSHIP	CONTACT PERSON
Steenberg's Cove Housing Committee	12	Bernitto Afrika
St Helena Bay Fishing Community Trust	4000-6000	Quinton Jordaan
Net and Line Fishermen Association, St Helena Bay	220	Andrew Karelse
Food and Allied Workers Union	8000-10000 (West Coast total)	Randall Abdoll
RDP-Forum	12	Bernitto Afrika
Fisher's Widows' Organisation	60	Fan Julius
Pelagic sector		Donnie Erasmus

Table 4.4: Formal meetings and seminars with community members and other stakeholders from 1996 to 1997, with the aim of introducing the idea of seaweed farming in St Helena Bay, disseminating information, obtaining support and mobilising communities.

DATE & PLACE	ATTENDANCE	NUMBER OF COMMUNITY MEMBERS	TOPIC
30-05-96; Laingville	F. Basson, J. Robinson (Agartek); B. Brown (UWC); M. Karaan, (Rural Foundation); M. Rosant, E. Swartz, B. Afrika (RDP-forum); R. Jordaan, C. Jordaan, J. Carolus (Net -and Line Fishermen's Organisation; C. Zincke (St Helena Bay Community Trust), N. Cloete (Local Council), D. Erasmus (Pelagic Sector); M. Maas-Olsen (Vredenburg Community Trust)	9	Refusal of water application of Agartek by Provincial Government; how community is affected; steps to oppose decision
11-06-96; Laingville	M. Karaan, K. Salie, (Rural Foundation); B. Brown (UWC) F. Basson, J. Robinson (Agartek); E. Swartz, B. Afrika (St Helena Bay Housing Committee and RDP forum); R. Roberts, Q. Jordaan (St Helena Bay Community Trust), A. Karelse (St Helena Bay Net and Line Fish Organisation)	5	Letter of intent to be signed by all parties, Letter of dissatisfaction to Department of Environmental Affairs and Tourism.

Table 4.4: Continued

30-06-96; Laingville	M. Karaan, (Rural Foundation); B. Brown (UWC); N. Cloete (Steenberg's Cove Housing Committee); D. Jordaan, A. Lesch, R. Jordaan, A. Karelse (Net and Line Fishers' Organisation); J. Robinson (Agartek); P. Goliath (Pelagic Sector); Q. Jordaan (St Helena Bay Community Trust); M. Maas-Olsen (Vredenburg Community Trust)	7	Seminar on seaweed cultivation: methods, use of seaweeds etc.; Report back on negotiations with politicians
18-10-96; Laingville	M. Karaan (Rural Foundation); B. Brown (UWC); N. Cloete (Local Council); P. Jordaan (Net and Line Fishers Organisation); F. Basson, J. Robinson (Agartek)	2	Decide on agenda for meeting with Minister Pallo Jordan
19-04-97	Mr. N Cloete (St. Helena Bay Community Trust; Net and Line Fishermen), F. Julius (Fishers' Widows Organization), B Afrika (Local RDP forum), C. Jordaan , R. Abdol, (FAWU;) B. Brown (UWC)	5	Feedback given about progress since October 1996, when the last meeting took place. Information about the Seaweed Mariculture Course to be distributed and potential participants briefed
28-05-97; Laingville	A. Karelse, A. Lesch, R. Jordaan, R. Abdol, C. Jordaan (Net and Line Fishers Organisation); Joseph Wakibia (UWC); B. Brown (IOI-SA); B. Africa (St Helena Bay Housing Committee)	6	Seaweed Mariculture Course to be presented in July
31-07-97; Laingville	T. Afrika, C. Snyders, A. Snyders, Q. Jordaan, J. Smit, (ex-delegates of Seaweed Mariculture course) B. Brown	5	Report back on progress regarding the community-based seaweed cultivation project

Table 4.4: Continued

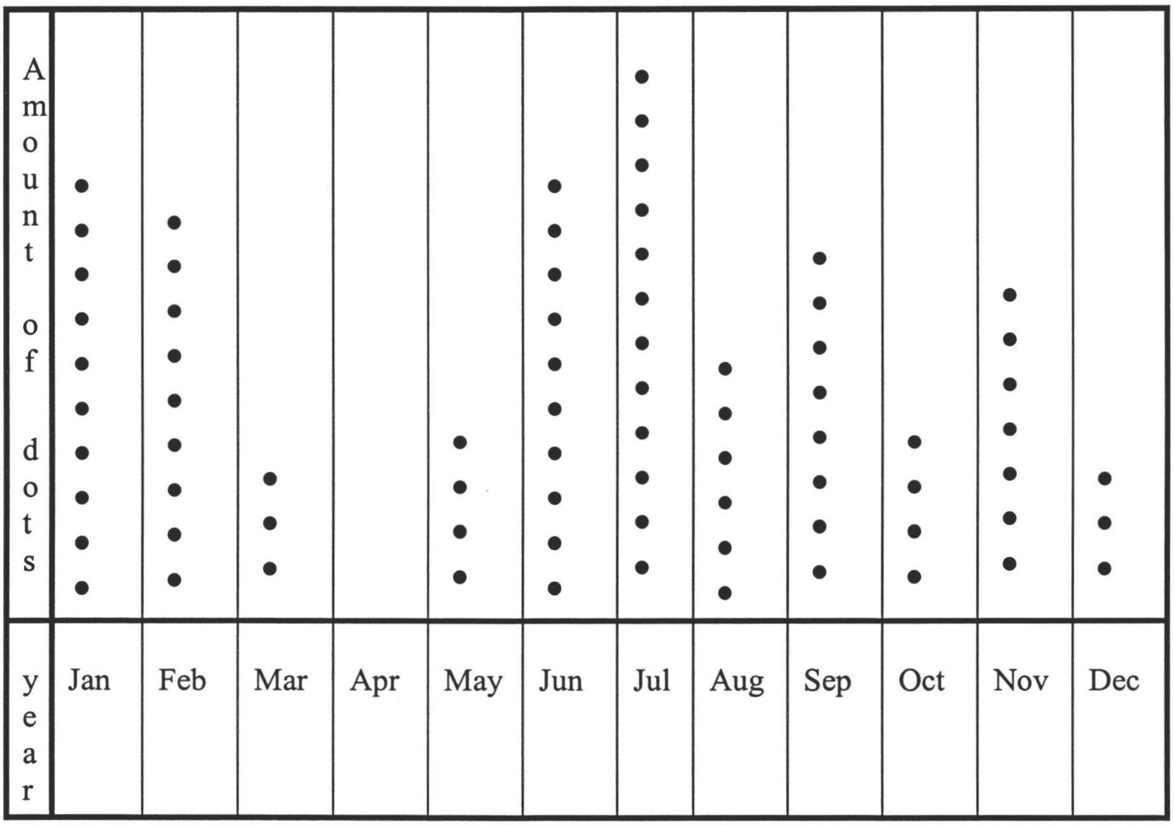
18-08-97; Stompneus Bay	J. Jantjies, (resident) T. Afrika, J. Smit, (ex-delegates) B. Brown, N. Prins (UWC)	3	Meeting to provide information about course and progress in community-based seaweed cultivation project, continue community mobilisation
19-08-97; Sandy Point	J. Maarman, W. Benjamin, F. Cloete, A. Jordaan, R.Afrikaner, Johannes Maarman, M. Njikelana, S. Gwanya, B. Titi, I. Olivier, V.W. Lali, C. Lisani, G. Tidy (residents); T. Afrika, (ex-delegate), N. Prins, B. Brown (UWC)	14	Meeting to provide information about course and progress in community-based seaweed cultivation project; continue community mobilisation
19-08-97; Steenberg's Cove	C. Solomons, C. Kearns, A. Sneyders, Q. Jordaan, T. Afrika (ex-delegates); F. Snyders, M. Ruiters, S. Hansen, C. Sneyders, A.W. Snyders, T. Luyt, (residents); B. Brown, N. Prins (UWC)	11	Meeting to provide information about course and progress in community-based seaweed cultivation project; continue community mobilisation
26-10-97; Laingville	C. Jordaan, C. Solomons, A. Snyders, P. Jordaan, B. Brown	4	Report back by B. Brown on progress made since last meeting

Table 4.5 Problems in the community and causes of problems (from the participatory rural appraisal in 1997).

PROBLEMS	DOTS	CAUSES OF PROBLEMS	DOTS
crime gang violence	3	lack of education	8
drug and alcohol abuse	9	peer pressure	12
lack of recreational facilities	5	poverty	7
advice office lacking	8	no interest	3
parents have no control over their children no vision for the future lack of education	4	crime	3
teenage pregnancies single parents due to premarital sex	8	funds	6
poverty (financial) unemployment	3	unemployment	1

Dots represent the number of people in a group of 13 who felt that a particular issue was a problem or a cause of problems in the community. The more dots, the bigger the problem or the more important the cause.

Table 4.6: Representation of unemployment pattern in St. Helena Bay (information obtained during participatory rural appraisal with delegates at Seaweed Mariculture course, 1997)



Months of unemployment and seasonal work

Dots represent the number of people in a group of 13 who felt that unemployment was a problem in a particular month. The largest number of dots means the highest percentage of unemployment in a specific month.

Explanation of unemployment problem (tendency):

Unemployment during January and February due to:

- shortage of factory work
- seasonal and permanent workers are on holiday
- school pupils seek employment

Unemployment during June and July due to:

- winter season
- Anglers are most affected
- fish resources are overused/exhausted

Table 4.7: Lists of activities for development of community seaweed project, as identified by course participants in July 1997.

Dots represent the importance of an activity according to each of the 13 people in the group. The more dots allocated to an activity, the more important is the execution of the task.

GROUP A

Nuclear idea: Determine the right procedure to:
(A) Farm seaweed, harvest and pack
(B) Obtain water rights

Activity	Who?	With whom?	Time?	Result	dots
Enquiries at government institution	Jimmy	Tracey	End of July	information received	22
Application letters written	Jimmy	Quinton	First week in August	confirmation that letters were written	14
Applications faxed and followed by calls to confirm receipt	Quinton	Colleen	First Thursday in August	copies of letters faxed	10
Repeated telephone calls to quicken process	Colleen	Quinton	2 times a week	answer from authorities	12

GROUP B

Nuclear idea: (A) Transfer of knowledge and information
(B) Begin experimental phase

Activity	Who?	With whom?	Time?	Result	dots
(A) Get support and help form larger community	Oom Christy	F. Links Colleen	20-30 July 1997	Date and arrangements for next workshop (Talk to school pupils)	12
(A) More workshops, pamphlets, contact schools	Same as above	Same as above	Same as above	Same as above	8
(B) Choose suitable area for farming	Oom April	Bernadette	25 July	Chart showing co-ordinates and size	19
(B) Choose best type of organisation and register with	Clint	Jimmy	15 Aug	Registration documents	14

correct authority					
(B) Find place to do land-based part of farming activities (land, factory, erfen, etc.)	Bernadette	Oom April Oom Christy	20 Aug	Lease or sales contracts	5
(B) Write application for water rights for experimental phase as well as for future expansion	Bernadette		1 Aug	Typed application with maps	6

GROUP C

Nuclear idea: Co-ordination and planning of seaweed project

Activity	Who?	With whom?	Time?	Result	dots
Community meeting	Timothy	Marjorie	July 97	Minutes	18
Nominations for a project leader	Chairperson of community meeting	community	July 97	Minutes	11
Identify commitments of leader	meeting	Chairperson		Minutes	7
Business plan	chosen leader	committee	Aug 97	professional business plan	14
Negotiations with opponents	leader	opponents	Sept 97	approval or disapproval of project	14

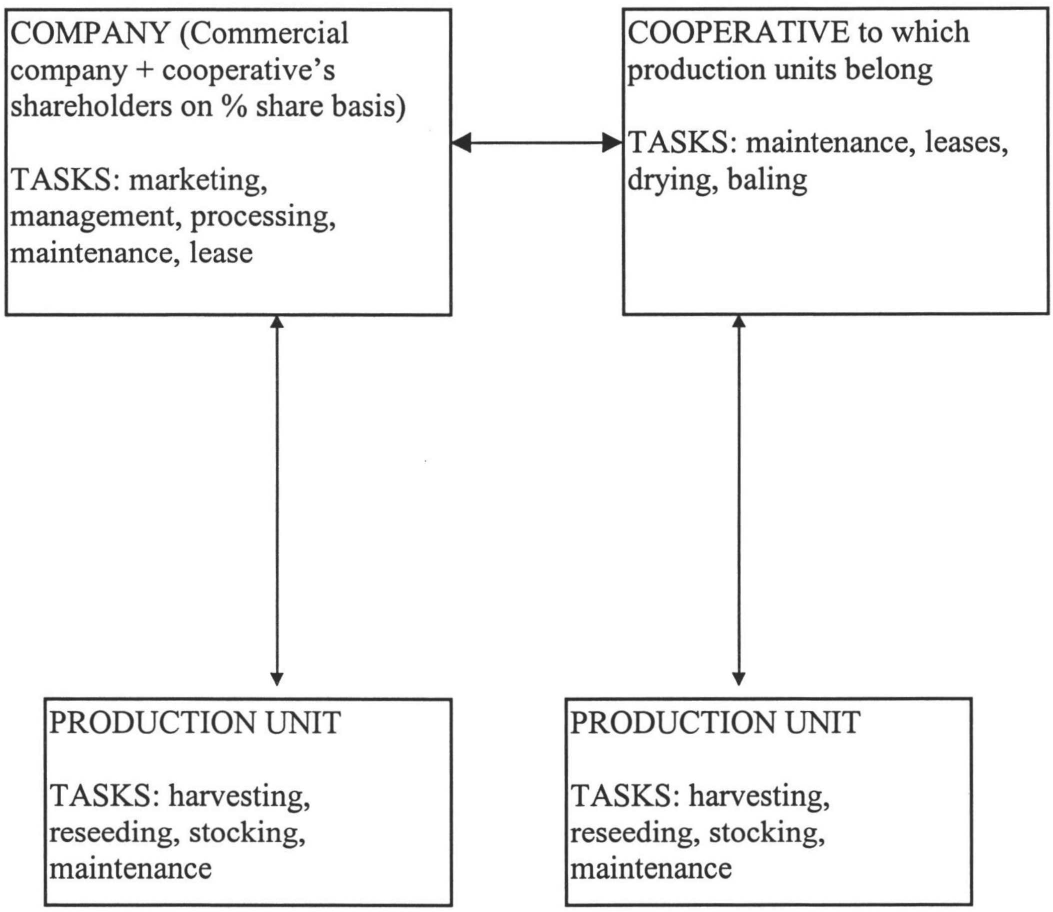
Table 4.8: Stages of the Community-based Seaweed Cultivation Project

DESCRIPTION	COMPONENTS
• INITIAL RESEARCH	• Pre-Feasibility study • Community involvement • Site selection
• CAPACITY BUILDING	• Community facilitation • Seaweed Mariculture course • Involvement and training of students
• PROJECT PLANNING	• Business plan • Community organization • Water application
• PROJECT IMPLEMENTATION	• Pilot seaweed culture raft construction and implementation
	• Research and Training: community members and science students
	• Support services
	• Networking and international exposure
	• Research assistance
	• Publication
	• Administration and management
• MONITORING AND EVALUATION	• Environmental impact monitoring and managing • Assessment of management practices
• MARKET RESEARCH AND DEVELOPMENT	• Advertising • Market identification and development • Product development
• EXPANSION TO INDUSTRY	• Involvement of more community entrepreneurs • Utilization of other economically important seaweed

FIGURE CAPTIONS:

Figure 4.1: Diagram of possible organisation of future seaweed cultivation industry

Figure 4.1:


COMPANY (Commercial company + cooperative's shareholders on % share basis)
TASKS: marketing, management, processing, maintenance, lease
COOPERATIVE to which production units belong
TASKS: maintenance, leases, drying, baling
PRODUCTION UNIT
TASKS: harvesting, reseeding, stocking, maintenance
PRODUCTION UNIT
TASKS: harvesting, reseeding, stocking, maintenance

APPENDIX 1:

JOURNAL OF APPLIED PHYCOLOGY: INSTRUCTIONS FOR AUTHORS

JOURNAL OF APPLIED PHYCOLOGY

Instructions for authors
January 1994

General

Journal of Applied Phycology publishes original articles relevant to practical uses of algae, including fundamental research, development of techniques and commercial applications. The scope includes algal biotechnology and genetic engineering, tissue culture, culture collections, commercially useful micro-algae and their products, marine culture, algal inoculation and soil fertility, pollution and fouling, monitoring, toxicity tests, toxic compounds and antibiotics. Each part of the journal also includes a section of camera-ready copy for brief notes and information on new products, patents and company news.

THERE IS NO PAGE CHARGE, provided that the number and size of tables and figures is reasonable. In order to avoid long tables, species lists and other protocols, authors may deposit such material with any official repository and indicate this in the text. The National Technical Information Service of the U.S.A. is an example, but authors may select an institution of their choice, with the only restriction that data must be available for free consultation.

All papers should be written in English. Four different categories of contributions are published:

1. Research paper: 5–15 printed pages including tables, figures and references to the literature.
2. Short research note or comment on recently published papers: 2–4 printed pages including an abstract and key words. These short papers will be given priority.
3. Review paper: 10–25 printed pages. Papers which provide overviews for a broad readership are especially welcome. Prospective authors should consult with the editor before submitting a review, either directly or through a member of the editorial board. Authors are responsible for obtaining copyright clearance.
4. Brief notes for the camera-ready appendix to each number of the journal on topics of general interest such as new products, patents and company news.

Editorial policy

Journal of Applied Phycology prefers the final submission of papers to be in LaTeX; however, papers for conventional typesetting are also welcome.

For the purpose of refereeing, papers for publication should be submitted initially as hard copy (threefold) to the editor or assistant editors (for addresses see **Mailing** section on page 654), or to other members of the editorial board.

The eventual supply of accepted-for-publication papers in their final form on MS-DOS or Apple Macintosh diskettes in LaTeX, together with a hard copy version (in case anything needs to be checked), will aid more rapid publication.

A LaTeX style file can be obtained from the Publisher (E-mail address: SURF406@KUB.NL; postal address, see page 654 (attention of Editorial Department)).

A guide to the Kluwer LaTeX style file is also available on paper and in electronic form, and will be published in the journal periodically.

Manuscripts will first be checked for language, presentation, and style. Manuscripts which are substandard in this respect will be returned to their authors without review. Such manuscripts may be resubmitted after all necessary adjustments have been made.

Papers which conform to journal scope and style are sent to outside referees. *Journal of Applied Phycology* endeavours to publish any paper within 4 months *after acceptance*.

Preparing the manuscript

Manuscripts should conform to standard rules of English grammar and style. British or American spelling may be used, but must be consistent throughout the article.

Conciseness in writing is a major asset. It improves greatly the readability of a paper. Ambiguous statements, vague expressions and long and pointless series of adjectives should be avoided. Authors are also warned against a sloppy use of scientific expressions. Examples are such terms as physicochemistry (of water), where physical and chemical properties are meant and not the physical chemistry of water, the non-interchangeable use of variables (or variates, or environmental factors) and parameters etc. Authors are warned against the erroneous use of period and comma in numerical values. Remember that in English ten thousand is written 10,000 while ten, exact to three decimals, is written 10.000.

THREE COPIES of the manuscript should be submitted. They should be free of handwritten corrections. They should be double spaced throughout, typed on only one side of the paper, with 2–3 cm margins on either side. Tables and illustrations should also be submitted in triplicate, but it is not essential to submit the originals of the figures with the first version of the text.

White paper of good quality and standard size (21 × 29 cm) should be used. Word-processed manuscripts should be printed in letter quality or near-letter quality mode. Dot (matrix) printed copies are difficult to read, and will be returned. Lines should NOT be adjusted to a standard length.

The contents of the manuscript should be well organized. Page one should show the title of the contribution, name(s) of the author(s), address(es) or affiliation(s) and up to eight keywords. An appropriate fax, phone or email number (in parentheses) may follow the corresponding author's address. The abstract should appear on page two. The body of the text should begin on page three. It should be free of footnotes and divided into sections and subsections.

A typical organization might be:

- Introduction
- Materials and methods
- Results
- Discussion
- Acknowledgements
- References
- Tables
- Figure captions.

It is almost always better to separate Results and Discussion in a full-length research paper. Approximate locations for tables and figures should be indicated in the left margin of the text.

All words to be published in italics should be underlined in the text.

Tables

Tables should not duplicate figures and *vice versa*. They should be numbered consecutively in Arabic numerals, and bear a descriptive legend on top. They are to be presented individually, on separate sheets of white paper. Authors should try to fit tables in one column (7.5 cm wide), but large tables may be printed over two columns.

Vertical lines are not to be used and horizontal ones should be kept to a minimum. See below for unit abbreviations.

Figures

All figures should be numbered in Arabic numerals, either on top or on the back and identified by the author's name. The top of the figure should also be indicated. Figure captions should be grouped on a separate sheet(s) of paper, after the tables. Do not type captions on the figures themselves.

Photographs should be original, glossy prints, and not cuttings from books or papers.

Colour photographs will not normally be accepted unless the author agrees to pay for the extra cost.

Figures will mostly be printed to fit one column width of the journal, so it is important to consider how well the figure will reduce. Particular features to consider are to use thick lines, large symbols and text and sufficient space between text and lines to permit satisfactory reduction. (80% of authors fail to follow these simple guidelines.)

As far as possible, avoid the use of shading. If it is essential for clarity, use types of shading that will reduce satisfactorily.

Do not surround figures with unnecessary boxes or add upper and right-hand lines to graphs, unless these lines are needed to provide additional scales.

While some computer graphics packages are excellent, several widely used ones are inadequate to produce journal-quality figures. If you do not have access to a good software package, you will need to add additional lettering and delete nonsense such as 0.00 for 0 on the axes.

Quantities, units, symbols and their abbreviations

Standard international units (S.I. system) are, in principle, the only ones acceptable. These are common examples:

1. Basic quantities, units and their symbols

Quantity	Unit	Symbol	Wrong (derived) symbols or wrong abbreviations
length	meter	m	mikron, Å, mile, foot, in.
mass	kilogramme	kg(1)	kgr, ounce, ...
time	second	s(2)	sec
electrical current	ampere	A	
amount of matter	mole	mol(3)	

(1) The gramme, g, equals 10^{-3} kg and is a widely used unit of mass, although only the kg has a definition as a *basic* unit in the S.I. system.

(2) In wide use, and bearing separate names, are the following multiples of the second: minute (min); hour (h); day (d); year (annum): (y, yr, a).

(3) The dimension of the mole is that of a *number*, of a given entity, which is to be specified (molecules, atoms, ions...). In practical water chemistry, the concentration of matter (mol m^{-3}) is used, and often not distinguished from the mole itself.

2. Some decimal prefixes for S.I.-units

giga	G	[illegible]
mega	M	[illegible]
kilo	k	[illegible]
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

3. Some derived SI-units with and without a name and their symbols

	Unit	Symbol	Wrong unit or symbol	Comments
surface	square metre	m^2	acre	hectare (ha) is tolerated
volume	cubic metre	m^3	gallon	the volume taken by 1 kg of water is 1 dm^3 but litre (L) is tolerated, as well as ml (cm^3), but not cc
speed	metre per second	$m\ s^{-1}$	knots, miles per hour	
concentration	mole per cubic metre	$mol\ m^{-2}$		in ionic balances, meq L^{-1}
B(C_B)force	newton	$N = kg\ m\ s^{-2}$	dyne	
pressure	pascal	$Pa = N\ m^{-2}$	bar, atm, torr, mm Hg, mm H_2O...	
energy, work, amount of heat	joule	j = Nm	cal, kWh, erg HP, CV...	
power	watt	$W = J\ s^{-1}$		
electrical tension	volt	$V = W\ A^{-1}$		
electrical resistance	ohm	$\Omega = V\ A^{-1}$		
electrical conductance	Siemen	$S\ cm^{-1}$	mho, mho cm^{-1}	in freshwaters, the range is mostly μS (at a specified temperature)
light intensity	photon flux density (or irradiance)	μmol photon $m^{-2}\ s^{-1}$		usually given for PAR (Photosynthetically Active Radiation)
radioactivity (1)	bequerel	$Bq = s^{-1}$	1 curie (Cu) = 37.10^9 Bq	
equivalent absorbed dose (1)	Sievert	$Sv = J\ kg^{-1}$	rem = 10^{-2} Sv	

4. Combined expressions in text, tables and figures should be presented using negative exponents. Examples are given in the table below. (It is recommended that L be used for litre.)

Preferred	Rejected
$g\ C\ m^{-2}\ h^{-1}$	$g\ Cm^2/h$
$kg\ m^{-2}\ s^{-1}$	$kg{\cdot}m^2{\cdot}s^{-1}$
	$kg \times m^{-2} \times s^{-1}$
	$kg/m^2/s$
$meq\ L^{-1}$	meq/L^{-1}
‰, $g\ L^{-1}$, $g\ kg^{-1}$	ppt
$\mu g\ L^{-1}$, $\mu g\ kg^{-1}$	ppb
$mg\ L^{-1}$	ppm

5. Chemical symbols

Ions: PO_4^{3-} is preferred over PO_4^{---}

Fe^{2+} is preferred over Fe^{++}

Equivalents (or milliequivalents) and moles (or millimoles) are both acceptable, if properly defined.

Compounds: more and more abbreviations are being introduced for chemical compounds. Some, like DO, EDTA, HEPES are widely known, but it is advisable to give a full statement of the meaning when first used in the text. Such usage is compulsory for less familiar acronyms. Excessive use of abbreviations is discouraged.

6. Biological nomenclature

Authors are urged to comply with the rules governing biological nomenclature, as expressed in the International Code of Botanical Nomenclature, the International Code of Nomenclature of Bacteria and the International Code of Zoological Nomenclature.

Authors are urged to check the correct spelling of all scientific names appearing in their texts.

When a species name is used for the first time in an article it should be stated in full. The authority for a species used for research purposes should be given in Materials and methods.

7. Chemical nomenclature

The conventions of the International Union of Pure and Applied Chemistry, and the recommendations of the IUPAC-IUB Combined Commission on Biochemical Nomenclature should be applied.

References to the literature

1. Citation in the text:

Use the name and year system: Adam (1983) or (Adam, 1983). For two authors, use: Adam and Eve (1982), not Adam & Eve or Adam et Eve. For more than two authors, use *et al.*: Adam *et al.* (1982). Initials should be used in the case of personal communications (pers. comm.), which need not be repeated in the reference list. Reference can also be made to a particular page, table or figure in published work, as follows: Brown (1966: p. 182) or Brown (1966: p. 182, Fig. 2).

2. Citation in the list of references:

All publications cited in the text, and only these, should be listed alphabetically after first authors. If an author published several papers in the same year, they should appear as Adam, 1980a, 1980b,... This also applies to citations in the text. If an author has published both alone and with (a) co-author(s), the papers which he authored alone should be ranked first, followed by the ones with one co-author alphabetically after the name of the co-authors (not chronologically), followed by the ones with two-co-authors, etc.

Initials of authors should always follow family names:

Casey RP, Lubitz JA, Benoit RJ, Weissman BJ, Chau H (1963) Mass culture of *Chlorella.* Food Technology 17: 85–89.

Prospective authors are urged to give attention to details of punctuation in this example.

Compound names: alphabetization by first word of the family name is preferred: Von Stroheim, Van Straelen should appear under V, De Ridder and Du Plessis under D. Authors should carefully check and conform to capitalization and spacing in such names. For non-European names, where the use of a family name is substituted by other systems (as in Arabic and several Asiatic cultures), authors are requested to indicate clearly on their manuscript which name they wish to use as the homologue to a family name. However, Chinese names should usually be written in full, starting with the family name (1-syllable name), followed by the given name (2-syllable name) written without hyphen and no capital for second syllable, e.g. Liu Chungchu.

Publications should always be cited in their original language, except if in a non-Latin alphabet. For the latter a Latin letter-by-letter transliteration is preferred, but an English translation of the title may be added with the original language indicated between square brackets at the end of the reference.

Papers which are unpublished or in press should be cited only if formally accepted for publication. Unpublished, internal reports are not acceptable in reference lists, unless they are available for general distribution.

Avoid the use of 'Anonymous'. If no author is ascertainable, list reference by name of sponsoring body, or name of editor.

In a continuous series of article citations from a single journal, do not use *ibid.* instead of the journal abbreviation.

3. Journal citations and abbreviations

3.1 If the title of a journal is a single word, *do not* abbreviate. Examples: Behaviour, BioScience, Biotechnology, Experienta, Growth, Hydrobiologia, Photosynthetica. Do not insert a comma between the name of the journal and the volume number.

3.2 Journals and book series that appear on a regular basis should be abbreviated (example 1). Several systems are in use but *Journal of Applied Phycology* uses a standard which is based on the 'World List of Scientific Periodicals', published by Butterworths, London, with certain simplifications.

Note that adjectives are only capitalized if they are the first word of a journal's title. Abbreviated words are followed by a period (Journal = J.), contracted words are not (Board = Bd, not Bd.; other examples of contractions are: Doctor = Dr, circa = ca, Figures = Figs, but Figure = Fig.).

Issue numbers should be added only (between brackets) if every issue starts with page one. Volume numbers should be expressed by Arabic numbers in all cases.

If editorial corrections to a reference list are needed and are of minor importance, the editor's office will see to them without prior consulting with the authors. Authors should not change an editor's correction back to a wrong citation at the proof stage.

3.3 Edited symposia, special volumes or issues, etc., published in a periodical.

Author(s), year of publication. Title of paper. In editor(s), title of special volume, periodical (abbreviated, cf. supra), vol: pp. (example two).

3.4 Books

Author(s), year. Title. Publisher, city: pp. (example three).

3.5 Multi-author books

Author(s) of chapter, year, title of chapter. In editor(s), title of book. Publishers, city: pp.

Examples

Edwards P (1980) The production of micro-algae on human wastes and their harvest by herbivorous fish. In Shelef G, Soeder CJ (eds), Algae Biomass. Production and Use. Elsevier/North Holland Biomedical Press, Amsterdam: 191–203.

Harvey W (1988) Cracking open marine algae's biological treasure chest. Biotechnology 6: 487–495.

Hutchinson GE (1975) A Treatise on Limnology, 3. J. Wiley & Sons, New York, 660 pp.

Metting B (1988) Micro-algae in agriculture. In Borowitzka MA, Borowitzka LJ (eds), Micro-algal Biotechnology. Cambridge U.P., Cambridge: 288–304.

Final recommendations

Before mailing a manuscript to *Journal of Applied Phycology*, proofread the final version thoroughly and correct any left-over errors. In particular, check the spelling of all scientific terms, Latin names of animals and plants, figure captions and tables. Are all units S.I.? Is all lettering properly composed and will it be readable after reduction? Are all numerical values and mathematical symbols exact? Are locations of figures and tables indicated in the margin? Make certain that every reference is abbreviated correctly, and appears both in the text and reference list.

To those scientists who use English as a foreign language, we strongly recommend that their manuscript be read by a native English-speaking colleague.

JOURNAL ABBREVIATIONS

Adv. ecol. Res.
Am. J. Bot.
Analyt. chim. Acta
Analyt. Chem.
Ann. Biol. lac.
Ann. Fac. Sci. Marseille
Ann. Hydrobiol.
Ann. Limnol.
Ann. appl. Biol.
Ann. Bot.
Appl. envir. Microbiol.
Aquat. Bot.
Arch. Biol.
Arch. envir. Contam. Toxicol.
Arch. Hydrobiol.
Arch. Mikrobiol.
Arch. Microbiol.
Aust. J. mar. Freshwat. Res.
Bact. Rev.
Biochem. J.
Biol. Bull.
Biol. Fert. Soils
Biol. Rev.
Biotech. Bull.
Bot. mar.
Bot. Notiser
Bot. Rev.
Bot. Tidsskr.
Br. J. exp. Biol.
Br. phycol. Bull.
Bull. envir. Contam. Toxicol.
Bull. Fish. Res. Bd Can.
Bull. mar. biol. Lab. Woods Hole
Bull. mar. Sci.
Bull. Mus. Hist. nat., Marseilles
Bull. Mus. natn. Hist. nat., Paris
Bull. natn. Sci. Mus., Tokyo
Bull. Soc. r. Bot., Belg.
Cah. Biol. mar.
Cah. O.R.S.T.O.M. ser. Hydrobiol.
Can. J. Bot.
Can. J. Earth Sci.
Can. J. Fish. aquat. Sci.
Can. J. Microbiol.
Comp. Biochem. Physiol.
C. r. Acad. Sci. Paris (= C.r. hebd. Seanc. Acad. Sci., Paris)
C. r. Trav. Lab. Carlsberg
Crit. Rev. Microbiol.
Curr. Sci.
Deep Sea Res.
Econ. Bot.
Ekol. pol.
Envir. Pollut.
Envir. Sci. Technol.
Estuar. coast. mar. Sci.
Evol. Biol.
Exp. Cell Res.
Folia limnol. scand.
Freshwat. Biol.
Gewäss. Abwäss.
Helgoländer wiss. Meeresunters.
Hyacinth Cont. J.
Hydrobiol. Bull.
Indian J. Limnol.
Int. Revue ges. Hydrobiol.
Int. Revue ges. Hydrobiol. Hydrogr.
Jap. J. Limnol.
Jap. J. Parasitol.
Jap. J. Wat. Pollut. Res.
J. agric. Sci., Peking
J. agric. Sci., Tokyo
J. am. Wat. Wks Ass.
J. appl. Ecol.
J. Bact.
J. Bot., Paris
J. Cell Biol.
J. cell. comp. Physiol.
J. Cell Sci.
J. Cons. perm. int. Explor., Mer.
J. Ecol.
J. envir. Qual.
J. exp. mar. Biol. Ecol.
J. Fac. Sci. Hokkaido Univ.
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APPENDIX 2:

MINUTES OF FORMAL MEETINGS AND WORKSHOPS WITH COMMUNITY MEMBERS

A.

MINUTES OF A MEETING HELD BETWEEN AGARTEK, THE RURAL FOUNDATION, DIFFERENT SECTORS OF ST HELENA BAY, AND THE UNIVERSITY OF THE WESTERN CAPE. HELD IN THE ST HELENA BAY COMMUNITY TRUST BOARDROOM AT 15H00 ON THURSDAY, 30 MAY 1996.

1. **OPENING AND WELCOME**

Mr Norman Cloete opens the meeting with prayer. Reverend C. Zincke (Chairperson) welcomes everyone and introduce the different sectors.

2. **MEMBERS PRESENT**

Rev. C. Zincke (chairperson), Frik Basson, John Robinson, (AGARTEK), Mohammed Karaan, Lizl Hobson (Rural Foundation), Norman Cloete (Local Government), Erlo Swartz, Timothy Afrika, Marco Rosant (Reconstruction and Development Forum), Donnie Erasmus (Pelagic Sector), Charles Jordaan, Robert Jordaan, J. Carolus (Net and Line Fishers Organisation), Mike Maas-Olsen (Vredenburg Community Trust), Quinton Jordaan, Naomi Koopman, Sharon Links (St Helena Bay Community Trust), Bernadette Brown (University of the Western Cape).

3. **PURPOSE OF MEETING**

Mr. N. Cloete gives a short outline of the purpose of the meeting. Agartek applied for sea water space for seaweed cultivation in St Helena Bay, but the Provincial Government turned down the application.

4. **THE PROPOSAL OF AGARTEK**

Mr Frik Basson gives background to the Seaweed Project and the reasons why the area applied for is the best place for seaweed cultivation. He emphasizes the participation of the community. He discusses the different options of a company or corporation for community involvement. The project is still new, and scientists need to be involved in the research and development of the seaweed cultivation component. He gives a broad overview of the financial impact on the community and economic growth.

5. **OVERVIEW OF RURAL FOUNDATION:**

Mr Mohammed Karaan gives a short overview of the purpose of their organisation, that is, to contribute to the economic growth of the rural communities. He explains the mussel project implemented in Saldanha Bay. The services of the Rural Foundation is Entrepreneurship, Business training, development facilitation, financing, feasibility studies and legal advice. Ms B Brown is busy with her Masters Degree at the University of the Western Cape and is working with the Rural Foundation on the Seaweed Project. She expresses her dissatisfaction with the decision of Minister

K. Meiring to disapprove the water application of Agartek.

6. **SOLUTIONS:**

After several opinions have been aired and information obtained about the Seaweed Project, Mr Karaan proposes that a committee must be appointed to take further steps. Members appointed to the committee were Ds C Zincke (Community Trust), Messrs M. Karaan (Rural Foundation), F Basson (Agartek), N Cloete (Local government), M Rosant (RDP), R Jordaan (Net- and Linefish Organisation), and Ms B Brown (UWC). Agartek must first appeal against the decision by Provincial Government so that they can know exactly why their application was not approved. After that the committee must be informed about these reasons so that they can send a written objection to the Department of Environment and Cultural Affairs.

7. **CLOSING**

The chairman thanks everyone for their presence. The meeting ends at 17h15 pm.

B.

MINUTES OF A MEETING HELD BETWEEN AGARTEK, THE RURAL FOUNDATION, DIFFERENT SECTORS OF ST HELENA BAY, AND THE UNIVERSITY OF THE WESTERN CAPE. HELD IN THE ST HELENA BAY COMMUNITY TRUST BOARDROOM AT 15H00 ON TUESDAY, 11 JUNE 1996.

1. **OPENING AND WELCOME**

Mr B. Africa opens the meeting with prayer. Reverend C. Zincke (Chairperson) welcomes everyone.

2. **MEMBERS PRESENT**

Rev. C. Zincke (Chairperson)

Members: Frik Basson, John Robinson, (AGARTEK), Mohammed Karaan, Khalid Salie, Bernadette Brown (Rural Foundation), Erlo Swartz, Bernitto Afrika (St. Helena Bay Housing Committee Trust), Raymond Roberts (St. Helena Bay Community Trust), Andrew Karelse (St. Helena Bay Net and Line Fishers Organisation), Quinton Jordaan (St. Helena Bay Community Trust)

3. **ABSENTEE LEAVE**

Excuses received from: Mrs. Sharon Links, Mr. Charles Jordaan

4. **MINUTES OF PREVIOUS MEETING**

Meeting of 30 May 1996

Corrections:

The word Begins is incorrect and should read begins.

The sentence which reads Mr. Frik Basson Begins to give background information about the

Seaweed Project and the reasons why this specific place looks advantageous was without a doubt first choice to commence such a project, must read Mr. Frik Basson begins to give background information about the Seaweed Project and the reasons why this specific place was without a doubt first choice to commence such a project.

The word Minister P. Meyer is incorrect and should read Minister P. Meiring.

These minutes are accepted unanimously by those present .

5. **AGREEMENT BY PARTIES (LETTERS)**

Letter One

Mr. M. Karaan suggests that a letter of conditions be compiled and that the different parties that are present should sign it. The letter must read as follows:

We the following parties agree to work together and the goals are the following:

1- Successful appeal against the disapproval of the seaweed project

2- Successful implementation of a community-based project.

Letter Two

Mr. Karan also mentions that a letter has to be written to the department of Environmental Affairs (Min. D. De Villiers, Hannekom and Meiring) wherein the various persons who have been chosen to represent their sectors must sign. The following must appear in the letters:

1- The seaweed project is planned thus that the boats will have access to the small boat harbour b.m.o. a channel and that the public will not have a problem with the seaweed, because it is located 300m from the bank.

2- Photographic evidence of the same project in Namibia showed that this type has a minimal visual impact.

3- St. Helena Bay and Saldanha Bay are the only two coastal places that are good for cold water seaweed. Scientific evidence showed that Saldanha Bay is not suitable for the implementation of the project, but St. Helena Bay is.

4- The seaweed project can create permanent jobs for 200 people. It can also lead to the development of new entrepreneurs

5- The impact that the harbour will have on a traditional fishing area has not been discussed with the community yet, as decreed by law. Nonetheless, the seaweed project has been unapproved due to the small boat harbour and this has cancelled out development of a community-based project in this area in the industry.

An appointment with them must be requested in the letter.

6. ARRANGING OF APPOINTMENTS

Mr. M. Karaan mentions that Rural Development will arrange the appointments.

7. WATER RIGHTS FOR PILOT PROJECTS

A decision is made to leave this issue till after the committee has met with the ministers.

8. LEGAL ASPECTS OF SCHEME

This will be left for the next meeting

9. CLOSING

Ds. Zincke thanks everyone for their attendance and adjourns the meeting at 12h00.

C

MINUTES OF A SEAWEED MEETING HELD BETWEEN AGARTEK, THE RURAL FOUNDATION, DIFFERENT SECTORS OF ST HELENA BAY, AND THE UNIVERSITY OF THE WESTERN CAPE. HELD ON TUESDAY, 30 JULY 1996 AT 14H00

1. OPENING AND WELCOME

Mr. Olsen (Chairperson) welcomes all those present

2. MEMBERS PRESENT

Chairperson: Mr. M. Maas-Olsen

Members: Mr.: M. Karaan, N. Cloete, D. Jordaan, J. Robinson, R. Jordaan , A. Karelse, P. Goliath, Q. Jordaan, A. Lesch; Ms.: B. Brown, L.Hobson

3. ABSENTEE LEAVE

Excuses received from:

Ds. C. Zincke

4. AIM OF MEETING

Informative meeting and slide show for the community of St. Helena Bay and surrounding areas. Report back from negotiators regarding application process.

5. ARRANGING OF APPOINTMENTS

5.1 Mr. Mohammed Karaan

Mr. M. Karaan refers to the negotiation committee that was appointed at the first meeting 30 May 1996. Mr. Karaan met with Minister Derek Hannekom and motivated that the Seaweed project should log in with the Department of , rather than Environmental Affairs. He was in favour of the project. He also requested that we keep him informed about the project. The Minister was also asked to oppose Shelley Point Developers.

Further contact was made with Minister Pallo Jordan's office to inform him of the project. He informed us that he is giving attention to the project and that he will contact us in connection with a meeting.

Rural Foundation also informed Minister Chris Nissan's Department (Economic Affairs and RDP) about the project and also requested a meeting.

5.2 Mr. John Robinson

Mr. Robinson mentions that he held a meeting with Environmental Affairs and that they maintained that we have no case. He also mentions that the local government has authority over the industry, but not over the source which falls under Central government.

He mentions further that our attorney and the attorney who deals with environmental affairs of the government will meet tomorrow (Wednesday 31 July) to determine whether Sea Fisheries was mistaken to turn down our application and that our attorney should persuade the government's attorney to support us. He mentions that the entire system is unfair and that we have been treated badly by the Provincial Government.

He also mentions that Agartek approached the Public Protector and explained everything to him and he is awaiting feedback.

6. FEASIBILITY

Ms. Bernadette Brown

She gives an explanation about the Seaweed and demonstrates by means of slides how it is planted, which supplies are needed , transported, dried, cultivated and how it looks after all these processes.

7. RESOLUTION

1. Agartek was requested to make a proposal regarding the types of co-operation models between them and the community.
2. Meetings will be arranged with various Ministers. Preferably in St. Helena Bay otherwise the negotiation committee will have to go to Cape Town. Mr. P. Goliath is co-opting on the negotiation committee.
3. The Mayor and Ms. Jenny Shreiner must be informed about the project in order for them to negotiate in favour of the project. Mr. N. Cloete will take the initiative.
4. Negotiations and contact has to be arranged with the department of Economic Affairs and RDP for support and funding for the project. Rural Foundation will take the initiative.
5. A petition will be drawn up in favour of the project. A concept will be drafted and each sector will recruit members. A decision from Environmental Affairs will have to be awaited before the above-mentioned can be executed.

6. Agartek will negotiate with Public Protector and the legal advisor to Environmental Affairs to get the application through.

7. The women will be actively involved in this initiative.

8. CLOSING

Meeting adjourned at 17H00.

D

AGENDA - MEETING WITH ST. HELENA BAY COMMUNITY IN LAINGVILLE: 18 OCTOBER 1996

Members present: M. Karaam, F. Basson, J. Robinson, Q. Jordaan, B. Brown, T. Africa

Apologies: Norman Cloete, Cassie Zincke

1. **INTRODUCTION AND WELCOME**

Chairperson (M. Karaan)

2. **LETTER FROM MINISTER HANEKOM**

M. Karaan

Motivation of letter:

To try and compel Brittania Development to co-operate with community.

Frik Basson says that Provincial government does not have the right to decide about mariculture (from legal advice) - this resides with the state; cabinet must endorse it, therefore all further mariculture is influenced. He suggests that we must persuade cabinet to make a final decision regarding this issue. He asks if Agartek must request that provincial government hand over the entire file to Pallo Jordan.

Bernadette must write up all discussions about agreements and also models of co-operation which was discussed with Agartek.

3. **AGENDA OF PROPOSED MEETING WITH MINISTER PALLO JORDAN AT 11H00 ON 31.10.96**

PROPOSAL FOR TOPICS TO DISCUSS:

3.1.Origin and merit of project	B. Brown
3.2.Supervision of St. Helena Community	C. Zincke/N.Cloete
3.3.St. Helena Fishers (objections)	Robert Jordaan
3.4.Project supervision	M. Karaan

The Agenda may change after Agartek meets with the Minister on 29 October.

Frik says there is a misconception by provincial government with regard to the amount of people from every Community-Based Organisation : it is important to ascertain how many people are represented per organisation. A demographic profile can be obtained from Norman Cloete.

4. AGARTEK MEETING

29.10.96

Agartek will meet with Minister Jordan on 29 October to discuss their application for water space.

5. REQUESTS FROM THE MINISTER AND QUESTIONS TO BE ASKED

QUESTION 1:

a) What is Minister's point of view regarding the legal aspect: National/Provincial?

b) If National, how does he want us to go about it: procedure to obtain water rights

c) If Provincial, we request that Minister try to revise legislation; or which other suggestions does he have

d) Is it possible for him to appoint/refer someone specifically to handle this issue, who reports directly to him?

Proposals to Minister

Aim: to commence with project:

Minister must state whether he agrees

Who has the authorization; central / provincial government?

6. ARRANGEMENTS - TRAVEL

Arrangements : 5 people can go to the meeting with Minister Pallo Jordan.

Should anybody want to attend a meeting with Chris Nissan in Raegis House (Adderley street) on 30.10.96 at 11h00, please contact Mohammed.

7. THANKING AND CLOSING

Chairperson (M. Karaan)

E

MINUTES OF A WORKSHOP IN ST HELENA BAY ON 19 APRIL 1997.

This was an informative workshop. Feedback was given about progress since October 1996, when the last workshop took place. Information about the Seaweed Mariculture Course were distributed and potential participants briefed.

Attendance: Mr N Cloete (St Helena Bay Community Trust; Net and Line Fishermen), Mrs Julius (Fishers' Widows Organisation; tel 02283-61302)), Mr B Afrika (Local RDP forum; tel 61310 -w), Mr Clive Jordaan (tel 61210 -w - label store; 61603 -h and Mr Abdol, (FAWU; tel 61100 -w) Ms B Brown (tel 021-959 2594 -w; 9335734 -h)and Ms C Blaauw (UWC)

Apologies: Mr Swarts, Mr Markhoff

1. **WELCOME BY MR CLOETE.**

Opens with prayer; assures those present that the small number of people does represent all of the community-based organisations in the community.

2. **PRESENT STATUS OF PROJECT (MS B BROWN).**

She explains why other parties originally intended to speak at the meeting could not attend (mainly because the issue of water rights have not been resolved yet). She gives a broad background to the Seaweed Mariculture Project. A pre-feasibility study done in 1996 indicated that seaweed farming on suspended rope rafts have a good possibility of being successful in St Helena Bay, but that an experimental phase is essential before further predictions can be made. Agartek has been involved in negotiations and preliminary planning for a future industry, and the needs of the community assessed. The present position is that everything is dependent on securing water rights. Agartek's application has been approved by National Government, and turned down by Provincial Government in 1996. The question of the ultimate responsibility for water rights have not been resolved yet. Thus the community also have to wait until it has been sorted out.

3. **PROGRESS:**

The International Ocean Institute has been established at UWC. The NGO received a small amount of money to develop and present a seaweed mariculture course. The course will be about the development of skills, especially technological and business skills concerning the seaweed farming industry. It will take place in July, and the first course is aimed at the community in St Helena Bay, because the community is already aware of the future plans and has been involved in preliminary planning. The next course will be in October/November, and will be more general. The reason why the course precedes an experimental phase, is that there is no guarantee when water rights will be sorted out. It is better to get interested persons trained now, so that they can take the opportunity to get involved in seaweed farming when it arises. The business skills learned can also be used in other industries. The course can be done by anybody who is able and willing. No special skills are needed.

4. **GENERAL.**

A next meeting is planned where a representative from the National Government could be invited. Bernadette communicated with Dr van Zyl, of the Sea Fisheries Research Institute. He is willing to attend, if possible. Mr Jordaan reports on the RDP meeting, where the course has been mentioned. He will tell more people at the next RDP meeting. Mrs Julius asks what about the widows of fishermen, who live in dire poverty. The fishing community must look after them. Bernadette explains that they will be able, if willing, to participate in farming activities. She explains the different phases to emphasise the time frame: 1. Experimental phase for at least one year (20 x 5 m); 2. Pilot commercial raft for another year (75 x 75 m); 3. Full-scale industry only after that. Thus for the first two years after initial start of project there may not be any income. Previous studies have shown that about 2 people can work on one commercial raft (full-time). There is a possibility of income generation. Presently the project is theoretically viable; the next step is to examine the practical viability. Mr Africa sees the project as a vehicle for community empowerment. Mr Abdol wants more information about the course (time schedule, etc.). Mr Cloete says that the Youth Centre is a good place to present the course. The contact person is Mr Jordaan. Food is also served at the centre. Mr Africa wants to know more about the practical aspects of the course. Bernadette says there is a possibility of asking the Seaweed Research Unit or the Sea Fisheries Research Institute for permission to visit their rafts. Mr Cloete proposes that Sea Harvest can be asked to take a few people to Lüderitz to visit the farms there. Mr Cloete will make copies of the forms, Messrs Abdol and Jordaan will speak to people in the factories, especially seasonal workers. Bernadette asks is the Xhosa-speaking people are included in the CBO's. Mr Jordaan says they are included in FAWU. Bernadette asks how many people are represented by each CBO. The answers: FAWU includes Velddrif people; St Helena Bay Community Trust includes everyone in St Helena Bay (Quintin Jordaan has access to the numbers, which can be between 4000 and 6000) FAWU includes 8000-10 000 people from Saldanha Bay to Port Nolloth; RDP represents Laingville to Stompneus Bay. 14 members are only for housing. Bernadette will contact everyone present for the next meeting.

5. **NEXT STEP:**

the representatives at this meeting will distribute information about the course.

6. Mr Cloete ends the meeting at 12h00.

APPENDIX 3:

LETTER OF OBJECTION TO THE DISAPPROVAL OF AGARTEK'S WATER SPACE APPLICATION

12 June 1996

The Minister of Environmental Affairs and Tourism
120 Plein Street
CAPE TOWN
8001

Dear Dr. de Villiers,

RE: AGARTEK SEAWEED PROJECT

We, the undersigned parties, herewith wish to express our dissatisfaction with the decision taken by Mr. Kobus Meiring, Provincial Minister of Finance and Cultural Affairs, whereby an application for the lease of sea-space for the purpose of mariculture in St. Helena Bay has been refused. According to correspondence received from Mr. Meiring's Department, the reason for his refusal are:

- The seaweed project will hinder access to a proposed small craft harbour.
- The seaweed project will hinder recreational activities such as swimming, sailing, water - skiing and other water sports.
- The seaweed project will have an unacceptable visual impact.
- Other, more suitable are available for the implementation of the seaweed project.
- The seaweed project will hinder the utilisation of the area by the general public.

However, we believe that the above reasons are not sufficient motivation for refusing the application because:

1- The seaweed project is planned in such a way that boats will have easy and unrestricted access to the small boat harbour, by means of an access channel. The seaweed project is also situated 300m off-shore, so the public still has unrestricted access to the beach.

2- Photographic evidence of a similar project in Namibia shows this tipe of activity to have a minimal visual impact. Unfortunately no scientific method exists in which to measure visual impact, so this matter will remain subject to personal interpretation, especially from a sector of the public which do not depend on the sea as its only source of livelihood and who will only be resident in the area as holiday makers.

3- St. Helena Bay and Saldanha Bay are the only areas feasible for cold water seaweed mariculture. Scientific evidence proves beyond all doubt that Saldanha Bay is not an alternative site for the implementation of this project, and that the suggested site is the only suitable site for the implementation of this project.

4- The seaweed project could generate up to 200 new, permanent jobs. It could also enable previously disadvantaged individuals to become entrepreneurs in their own right. A separate effort headed by the Rural Foundation and University of the Western Cape has been ongoing independently from Agartek's project since 1995. This separate project's aim is to investigate the feasibility of mariculture in Saldanha Bay and St. Helena Bay, with the objective to introduce marginalised communities to this concept.

5- The impact which the harbour will have on a traditional fishing area has not been discussed nor approved by the local community, as required by the law. Yet the seaweed project has been rejected in favour of the harbour development, where as the local community has not been consulted over the harbour project.

Agartek will create a local market for these smaller scale projects and has also agreed to allocate space on their project to a group selected from the local communities. The fact that Agartek's application has been turned down, effectively halts any chances of any party establishing a community based mariculture industry in this region.

Therefore we, the undersigned, appeal you to assist us by using your best endeavours in having Mr. Meiring's decision altered, so that a suitable compromise can be reached which will enable these projects to materialise.

We kindly request you to allow us the opportunity to meet with you at your earliest convenience in order that this matter can be discussed in broader detail.

Your Sincerely,

PARTY	**DESIGNATE**	**SIGNATURE**
LYN EN NETVISVERENIGING	P.R. JORDAAN	P R Jordaan
RDP. ST. HELENABAAI	M. ROSANT	M Rosant
ST. HELENABAAI GEMEENSKAPSTRUST	C.ZINCKE	[signature]
STEENBERG'S COVE GEMEENSKAPSKOMITEE	N. CLOETE	[signature]
AGARTEK	F. BASSON	[signature]
LANDELIKE STIGTING	M. KARAAN	[signature]

APPENDIX 4:

NEWSPAPER CLIPPINGS

Argus May 31 / June 1 '97.

PROVINCIAL GOVERNMENT OF THE WESTERN CAPE

ST HELENA BAY: STOMPNEUS BAY: (SHELLEY POINT): PROPOSED LEASING OF AN AREA OF APPROXIMATELY 4.0 ha IN EXTENT FOR THE RECLAMATION & CONSTRUCTION OF A SMALL CRAFT HARBOUR AND A SLIPWAY BELOW THE HIGH-WATER MARK OF THE SEA OPPOSITE ERF 2814: MESSRS BRITANNIA BAY DEVELOPERS (PTY) LTD

Notice is hereby given in terms of Section 3(5) of the Sea-Shore Act, 1935 (Act 21 of 1935) that the Provincial Government: Western Cape is currently considering an application for a lease agreement with Messrs Britannia Bay Developers (Pty) Ltd in which provision is made for the proposed leasing of an area of approximately 4.0 ha in extent for the reclamation and construction of a small craft harbour and a slipway, below the high-water mark of the sea at Shelley Point, Stompneus Bay.

A locality sketch of the area affected by the above-mentioned lies for inspection at the office of the Director: Cape Nature Conservation, Provincial Government: Western Cape, Room No 204, Utilitas Building, 1 Dorp Street, Cape Town.

Objections to the proposed lease must be lodged with the Director: Cape Nature Conservation, Private Bag X9086, Cape Town 8000, on or before 30 June 1997.

STE600200/33

17:08 97 TUE 08:45 FAX 02281 32487 WESKUS DRUKKERS

Die Weslander 2 Mei 1997

DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM

ST HELENA BAY SEAWEED PROJECT

Notice is hereby given in terms of Section 6(3) of the Sea-Shore Act, 1935 (Act no 21 of 1935) as amended, that the Department of Environmental Affairs and Tourism is considering letting approximately 40 ha of sea-space below the high water between Stompneuspunt and Stompneusbaai to the firm Agartek CC, for the cultivation of seaweed by using the raft method.

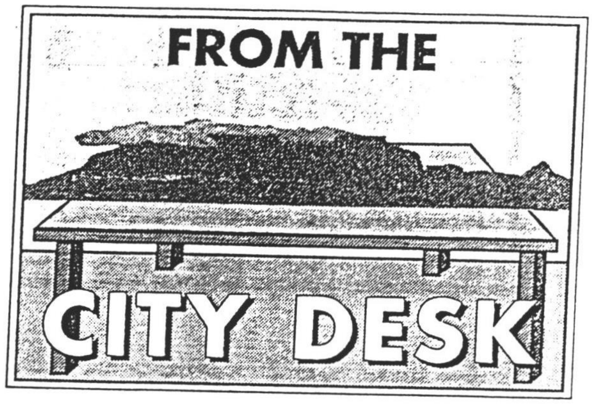
This notice substitutes the notice published in the Weslander on 25 April 1997.

DEPARTEMENT VAN OMGEWINGSAKE EN TOERISME

ST HELENABAAI SEEGRASPROJEK

Ingevolge Artikel 6(3) van die Strandwet, 1935 (Wet 21 van 1935) word hiermee bekend gemaak dat die Departement van Omgewingsake en Toerisme van voorneme is om 'n gedeelte van die see ongeveer 40 ha tussen Stompneuspunt en Stompneusbaai, benede die hoogwatermerk aan die firma Agartek BK te verhuur, vir die kweek van seegras deur gebruik te maak van die vlot metode.

WESKUS DISTRIKRAA...



Seaweed plan hits heavy weather

ENTREPRENEUR Frik Basson could be forgiven if he believes it's time to chuck in the towel and shelve plans to start a seaweed farm at St Helena Bay, on the Cape west coast.

His idea is to cultivate seaweed on submerged rafts that can be tended by up to 200 local stakeholders and processed for agar, a vegetable emulsifier widely used in the food, cosmetic and medical industries.

His venture is supported by the Director of Sea Fisheries and the Sea Fisheries Research Institute, the Council for Scientific and Industrial Research and leading UCT marine botanists.

They say seaweed farming is a highly acceptable method of renewable resource utilisation with real prospects of job creation. They also say it is environmentally friendly — and St Helena Bay is probably the most suitable site for such a project.

However, the Western Cape provincial authorities did not share this view but felt a seaweed farm was incompatible with public enjoyment of the sea. Specifically, recreation associated with a planned small boat harbour at the Shelley Point luxury development.

The Western Cape's outgoing conservation chief, Johan Neethling, must perhaps be forgiven for his antipathy to a seaweed farm near a prestigious small-boat harbour on the West Coast. After all, he is an enthusiastic yachtsman.

It is perhaps not strange, then, that the province's most senior conservation official did not order his departmental experts — or Basson, for that matter — to carry out a detailed study on the potential impacts of seaweed rafts on the marine environment. Or invite experts to give their views.

Basson appealed and said he was prepared to resite his rafts. He could also run the project on a five-year experimental basis while the small boat harbour was constructed. Throughout, the mariculture specialists insisted that recreational boating and seaweed farming could co-exist.

This view was even shared by former Environment Minister Dawie de Villiers, who urged Western Cape Environment MEC Kobus Meiring to reconsider his position. To no avail.

Basson approached the Public Protector and Environment Minister Dr Pallo Jordan for clarity. But developments are slow.

Some 17 months later, Basson is back to square one. At least, presumably, his application is being processed by the proper national authority.

Jordan is a busy man and his office took nearly five months to answer our written questions about the seaweed saga. But when his answers came, they were clearly set out, well-considered and thorough.

While expressing hesitation about intervening in a provincial matter, Jordan did stress that South Africa may well be required to conduct full-scale environmental impact assessments (EIA) before any commercial use of marine areas, such as Agartek's application for St Helena Bay, can be sanctioned.

"I may well decide to request a full-scale EIA in this case before the application is finally approved. However, I need to investigate the whole matter before reaching such a decision," he said with a measure of reassurance.

Sunday Times Metro. May 1997.

APPENDIX 5:

BROCHURE ON SEAWEED UTILIZATION

Saldanhabaai en St. Helenabaai is die enigste plekke langs die kuslyn van Suid-Afrika wat moontlik geskik is vir die verbouing van *Gracilaria*, as gevolg van hul beskutheid. Saldanhabaai, hoewel bewys as geskik vir verbouing, is 'n besige industriële hawe. St. Helenabaai, aan die ander kant, het min skeepsverkeer en gebruike anders as visvang en ontspanning. Dus lyk dit of St. Helenabaai die geskikste is vir die ontwikkeling van 'n seewierverbouing-industrie wat uiteindelik genoeg seewier sal produseer om selfs 'n prosesseringsfabriek op te rig. Indien dit 'n suksesvolle bedryf is, sal daar dus werksgeleenthede in St. Helenabaai geskep kan word. Ongelukkig is daar tot dusver geen eksperimente in hierdie baai uitgevoer om te bepaal of seewierverbouing werklik moontlik is nie.

Dit is dus raadsaam om hierdie projek te inisieer met 'n loodsfase waarin eers geëksperimenteer kan word waarna implementering van die totale projek stapsgewys kan geskied.

5. DIE SEEWIER-VERBOUING PROJEK: DOELSTELLINGS

Die Landelike Stigting is 'n nie-regerings organisasie wat ekonomiese ontwikkeling in die platteland te promoveer. Hulle is dus betrokke om 'n seegras-verbouings industrie in St. Helenabaai op die been te help bring.

Agartek is 'n privaat maatskappy wat juis 'n geruime tyd al die moontlikheid van seegras verbouing en verwerking ondersoek. Hulle stel belang om 'n samewerkings ooreenkoms met die projek te bewerkstellig sodat beide produksie en verwerking plaaslik kan geskied.

Die volgende aspekte sal aandag geniet:

1. 'N Volledige lewensvatbaarheidstudie
2. Bekom van die nodige finansiering
3. Toegang tot markte
4. Onderhandelinge met prosesseerders
5. Bekom van waterregte
6. Beding vir staatsondersteuning en befondsing
7. Seleksie van projek begunstigdes
8. Ontwerp van totale projek konsep
9. Inwin van regsadvies

HOEKOM WORD SEEWIERE VERBOU?

- 'n KORT VERDUIDELIKING VAN DIE GEBRUIKE EN EKONOMIESE BELANGRIKHEID VAN SEEWIERE, EN DIE IMPLIKASIES VIR DIE WESKUS VAN SUID-AFRIKA

Saamgestel deur Bernadette Brown (Universiteit van Wes-Kaapland) en Mohammed Karaan (Landelike Stigting)

DIE POTENSIAAL VAN *Gracilaria gracilis* (OOK HIER BEKEND AS SEEGRAS) IN SUID-AFRIKA, MET SPESIALE VERWYSING NA DIE WESKUS

1. WAT IS SEEGRAS/ALGE?

Alga is die Latynse woord vir seegras, of plante wat gewoonlik in vars of seewater groei. Die Latynse of wetenskaplike name van alge, soos ook alle lewende organismes, bestaan uit twee dele, a genusnaam en 'n spesifieke naam, bv. *Gracilaria* (genus) *gracilis* (spesie). Alge verskil in grootte vanaf kleiner as wat die oog kan sien (mikroskopies) tot plante wat 60 meter lank kan word (makroskopies).

Die ekologiese belangrikheid van alge lê in hul vermoë om koolstofdioksied vanuit die atmosfeer te neem en deur 'n proses genaamd fotosintese in organiese produkte te omskep. Dit is hierdie organiese produkte wat deur veral die mens gebruik word. Produktiwiteit kan ook gemeet word in terme van massavermeerdering (gram per vierkante meter per dag) in gevalle waar seewiere verbou word.

Die mees belangrike omgewingsfaktore wat produktiwiteit affekteer is ligsterkte en beskikbaarheid van voedingselemente.

APPENDIX 6:

SEAWEED MARICULTURE COURSE REPORT

Pacem in maribus

COURSE REPORT:

<u>SEAWEED MARICULTURE FOR COMMUNITY DEVELOPMENT</u>

30 JUNE TO 11 JULY 1997

COORDINATOR:

BERNADETTE BROWN

INTERNATIONAL OCEAN INSTITUTE SOUTHERN AFRICA

COURSE REPORT:
SEAWEED MARICULTURE FOR COMMUNITY DEVELOPMENT

DATE: 30.06.97-11.07.97
LOCATION: STEENBERG'S COVE, ST HELENA BAY, SOUTH AFRICA

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The International Ocean Institute of Southern Africa would like to thank Prof Derek Keats, Director of IOI-SA, for his foresight, without which the course would not have been made a reality. The staff of the Botany Department, University of the Western Cape, especially Gavin Maneveldt, Jocelyn Collins and the technical personnel, are thanked for their help and expertise in designing the certificates and layout of the report.

COURSE REPORT: SEAWEED MARICULTURE FOR COMMUNITY DEVELOPMENT:
VENUE: Steenberg's Cove Hotel, Steenberg's Cove, St Helena Bay, South Africa
DATES: 30 June 1997 to 11 July 1997

EXECUTIVE SUMMARY:

LIST OF DELEGATES:

NAME	SEX	OCCUPATION	**TELEPHONE**	TOWN
ANDREW BOSCH	M	Executive Secretary	+27-2883-61446	Laingville
APRIL SNEYDERS	M	Fisherman (retired)	NONE	Steenberg's Cove
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CHRISTIAN J.KEARNS	M	Fisherman (retired)	NONE	Steenberg's Cove
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JIMMY WILLIAMS	M	Teacher	+27-2283-61316	Laingville
MELLISA HARPER	F	BSc. student	+27-21-317838	Cape Town
NATALIE PRINS	F	Honours student	+27-21-903 5414	Cape Town
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RIAAN ALEXANDER	M	Unemployed	+27-2283-61085	Laingville
TRACY AFRICA	F	Standard 9 student	+27-2288-30925	Laaiplek

COURSE CONTENT:

INTRODUCTION AND PARTICIPATORY RURAL APPRAISAL
Governmental organisation, laws and policies; Participatory Rural Appraisal; Seaweed biology, significance and distribution; The seaweed industry in Southern Africa; Experimental cultivation in Saldanha Bay; Seaweed management and socio-economic implications; East African research on seaweeds; Practical exercise (collection, identification); Uses, harvesting and farming of seaweeds; Pre-feasibility, feasibility study and application procedures; Harvesting and cultivation of other marine organisms; Conflict between land and sea utilisers; Policies and acts guiding marine resource utilisation;

BUSINESS SKILLS TRAINING
Identification of Entrepreneurial opportunities; Creative techniques; Profile of an entrepreneur; Marketing vs sales; Knowledge of the market and marketing strategies; Promotion; Basic sales techniques; Buying and buying lists; Costing; Price determination; Costing of producer; Bookkeeping; Making a bookkeeping system; Basic management functions; The Business Plan.

INSTITUTIONAL DESIGN AND PROCEDURES
Economic organisation of seaweed cultivation; Nature of community participation; Participation models and forms of business; Appraisal of models; Assistance to community-based industrial development

PREPARATORY WORK DONE FOR SEAWEED MARICULTURE PROJECT:
During the last three days of the course, delegates decided to establish a seaweed mariculture farm, with the assistance of IOI-SA and the University of Stellenbosch. A draft business plan was drawn up and given to the Provincial Minister for Economic Affairs, Reconstruction and Development. A time schedule was drawn up and each delegate charged with the responsibility for a task. The aim is to establish a community-managed farm by the end of the year.

FOLLOW-UP:

Several meetings were held since July 1997 to report on progress, spread information and decide on next steps:
31 July 1997: Meeting with 5 ex-delegates in Laingville (Strategic planning)
18 August (Stompneus Bay), 19 August (Midwest) and 20 August (Steenberg's Cove):Public meetings with community members (Information dissemination, course reportback).
IOI-SA and the University of Stellenbosch are involved in efforts to obtain funding to help the community establish their mariculture farm. A funding proposal was submitted to the South Africa-Netherlands Research Programme for Alternatives in Development (SANPAD).

EXPECTED OUTCOMES:

- Registered community organization to take responsibility for mariculture project
- Water lease for at least 5 years
- Comprehensive business plan with which to apply for funding
- Pilot seaweed mariculture project in St Helena Bay
- Practical Training of community members on pilot farm
- More specific training for community project leaders

NOTES:

Empowerment of community members was achieved. Capacity building is still taking place, as delegates are willing to teach other community members the same skills they obtained.

COURSE REPORT: SEAWEED MARICULTURE FOR COMMUNITY DEVELOPMENT:
VENUE: Steenberg's Cove Hotel, Steenberg's Cove, St Helena Bay, South Africa
DATES: 30 June 1997 to 11 July 1997

SPONSORSHIP:

The Seaweed Mariculture Course was funded by the Government of the Netherlands, through the International Ocean Institute Southern Africa (IOI-SA). The course was coordinated and presented by staff of IOI-SA. Professionals from the University of Stellenbosch also developed and presented modules.

INTRODUCTION

Experimental cultivation of seaweed, especially *Gracilaria gracilis*, has been ongoing in South Africa for a number of years. St Helena Bay, on the West Coast of South Africa, has been identified as one of the most suitable areas for the introduction of a *Gracilaria* cultivation industry. As a result of past political ideologies, some of the local inhabitants are impoverished and dependent on an unstable fishing industry for their livelihood. A need for information and technology transfer was identified in during a study aimed at involving those communities in the establishment of a seaweed cultivation industry.

TARGET AUDIENCE

The course was intended for members of the St Helena Bay community, specifically those who were regarded as historically disadvantaged under previous government rule. No qualification other than literacy was required. It was also targeted at students from the Botany Department interested in or doing related studies.

DETAILED COURSE REPORT

OBJECTIVES

The 10-day training course was held to provide basic practical and technical training about mariculture of *Gracilaria gracilis*, specifically, and seaweed mariculture in general. It aimed to stimulate interest in the marine environment and its sustainable management, to provide participants with the basic skills to farm not only seaweed, but any other marine resource such as mussels, as a business enterprise, and to pave the way for economic empowerment of the target community.

13 people attended the course. 11 persons were from the targeted community, and 2 were students from the University of the Western Cape. All were South African nationals.

LANGUAGE OF INSTRUCTION:
The language of instruction was Afrikaans.

WEEK 1

On Monday, 30 June, the course was officially launched by Professor Derek Keats, Director of IOI-SA, in the Steenberg's Cove Hotel, St Helena Bay. He explained the background and mission of IOI.

Ms Bernadette Brown, the course coordinator for IOI-SA, explained the background of the seaweed farming industry in relation to her project and the course. She explained the objectives of the course and asked participants to write their expectations for the course.
Ms Brown delivered a talk about the political situation in South Africa, explaining the difference between national, provincial and local governance. She explained how the new constitution was put together and what it meant for people in South Africa.

MODULE 1: PARTICIPATORY RURAL APPRAISAL
INSTRUCTOR: Mr MOHAMMED KARAAN

OBJECTIVES:

- to obtain information about the history of the fishing industry and the effect of its present status on the inhabitants of St Helena Bay
- to help participants communicate their expectations for the future, and their expectations of the proposed industry

Mr Mohammed Karaan, lecturer in the Faculty of Agricultural Economics at the University of Stellenbosch, started a Participatory Rural Appraisal. He explained why a PRA is necessary, and asked participants to explain their history, problems and future expectations. The PRA lasted from Monday afternoon to Tuesday.

On Tuesday, 1 July, Mr C. Zincke, a reverend from the community, was supposed to deliver a talk about community involvement in management practices. This was cancelled.

MODULE 2: TECHNICAL AND PRACTICAL ASPECTS OF SEAWEED MARICULTURE
INSTRUCTORS: Ms BERNADETTE BROWN
Mr HENRY ENGLEDOW

OBJECTIVES:

- to provide participants with information about seaweed cultivation methods
- to give a background to the legislation involved
- to provide participants with a method of planning and implementing a seaweed cultivation project

On Wednesday, 2 July, the section on technical and practical aspects of mariculture was introduced by Ms Brown. Mr Henry Engledow, lecturer at the University of the Western Cape, delivered lectures on the biology, significance and distribution of seaweeds.
Mr Klaus Rotmann, managing director of Taurus Products, a seaweed exporting company, explained the history and status of the present seaweed industry in Southern Africa.
Mr Anthony Smit, Ph.D. student at the University of Cape Town, presented a talk about the experimental cultivation of *Gracilaria gracilis* in Saldanha Bay.
Mr André Share explained the socio-economic implications of current seaweed management practices in South Africa, and the need to change aspects of the current laws pertaining to seaweed management and utilization.
Mr Joseph Wakibia, M.Sc student at the University of the Western Cape, described cultivation of *Euchema* in East Africa.
Ms Natalie Prins and Mr Henry Engledow coordinated a practical session in which participants were asked to draw illustrations of local seaweeds and identify them, making use of sketches in their training manuals.

On Thursday, 3 July, Mr Henry Engledow discussed the uses, harvesting and farming of seaweeds. Ms Bernadette Brown explained what pre-feasibility feasibility studies are and why they are necessary. She also explained the procedures for application for water space and the laws and policies guiding water use.
Mr Henry Engledow discussed general mariculture of marine organisms, such as mussels and oysters.
Messrs Frik Basson and John Robinson, directors of Agartek cc., explained their role in the seaweed industry in South Africa, and the interaction they had with community leaders in their quest to obtain water space for seaweed mariculture.
Mr Richard Martin gave an outline of the processes which led to the formulation of a new Marine Resources policy, and explained the contents of the White Paper on Fisheries Policy, recently accepted by parliament.
A field excursion to an oyster nursery in St Helena bay took place in the afternoon. Technicians explained the procedures followed in oyster culture, and the market specifications.

On 4 July an excursion was arranged to the mussel and seaweed farms of Sea Harvest Company, a national fishing company. A boat excursion took place, where participants were taken to the mussel rafts. Technicians explained the methology and technology of mussel culture. The skipper of the boat took participants to an experimental seaweed raft belonging to the Seaweed Research Unit of the Sea Fisheries Research Institute.

WEEK 2:

MODULE 3: BASIC BUSINESS SKILLS
INSTRUCTOR: Mr IEGSHAAN ARIEFDIEN
OBJECTIVES:

- to teach participants the how to manage a seaweed farm as a business
- to provide participants with the skills to start any business

On 7 July the basic business skills module was started by Mr Iegshaan Ariefdien, a researcher and business consultant at the Center for Entrepreneurship, Graduate School of Business, University of Stellenbosch. He gave lectures on how to identify entrepreneurial opportunities, what creative techniques are, the profile of an entrepreneur, marketing vs sales, knowledge of the market and marketing strategies. A case study was discussed. Videos were used as visual aids. Lectures on promotion, basic sales techniques and buying were delivered.

On 8 July Mr Ariefdien continued lectures on price determination, costing of producer, bookkeeping and establishing a bookkeeping system.

On 9 July Mr Ariefdien continued with lectures on basic management functions, and business plans. Delegates were encouraged to draw up a business plan for utilization and cultivation of seaweeds in their area.

MODULE 4: INSTITUTIONAL DESIGN
INSTRUCTOR: Mr MOHAMMED KARAAN
OBJECTIVES:

- to teach participants how to plan a seaweed cultivation industry, and not only a farm
- to provide information about models of organisation and how to choose the best model for community-based production

On 10 July Mr Mohammed Karaan started lectures on the institutional design of a seaweed industry. Models on the economic organisation of a seaweed cultivation industry was discussed. Lectures were given on the nature of community participation, on participation models and on forms of businesses. An appraisal of these models was done.

On 11 July Mr Karaan concluded the participatory rural appraisal started in the first two days. A strategic plan for the establishment of a community organization and a community-managed seaweed industry was drawn up. The course was evaluated by participants.
Mr Ariefdien evaluated the business plan, and this plan, together with the strategic plan, prepared for deliverance to Mr Chris Nissen.
Mr Nissen, the Provincial Minister of Economic Affairs and Reconstruction and Development, delivered a lecture on assistance to community-based industrial development.
Certificates were issued to delegates by Prof DW Keats and Mr Ariefdien. The course was officially ended during a formal lunch attended by participants, guest speakers and instructors.

COURSE EVALUATION

ASPECT	1	2	3	4	5	6	7	8	9	10	11	12	13
DEVELOPMENTOF ENTREPRENEURSHI P SKILLS	4	4	3	4	5	5	5	4	4	3			
PROJECT DESIGN ASPECTS	4	4	4	3	4	4	5	5	4	4			
KNOLEDGE ABOUT SEAWEED CULTIVATION	5	5	4	5	4	4	5	5	4	5			
PRACTICAL HELP FOR COMMUNITIES	4	4	4	4	4	4	5	4	3	4			
BETTER VISION ABOUT JOB CREATION	4	5	4	4	5	4	4	5	5	5			
SELF EMPOWERMENT	5	5	5	5	5	5	5	5	5	5			
LEARNED HOW TO TRANSFER KNOWLEDGE	5	5	5	5	5	5	5	5	4	5			
EXPANSION OF KNOWLEDGE ABOUT ST HELENA BAY	5	3	5	5	5	5	5	5	5	5			
ATMOSPHERE AND PARTICIPATION IN DISCUSSIONS	5	4	5	5	4	5	5	5	5	4			

Participants were asked to grade aspects of the course on a scale of 1 to 5. 10 Participants completed the evaluation sheet, from a total of 13.
The lowest grading was 3 and the highest 5. A grading of 4 or 5 was obtained for most aspects.

APPENDIX 1:

COURSE INSTRUCTORS:

NAME	ADDRESS	TELEPHONE	EMAIL
Bernadette Brown	IOI-SA, Department of Botany, UWC, Private Bag X17, Bellville, 7535	+27-21-959 2594	bern@botany.uwc.ac.za.
Mohammed Karaan	Faculty of Agricultural Economics, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa	+27-21-808 4759	asmk@maties.sun.ac.za
Iegshaan Ariefdien	Center for Entrepreneurship, Graduate School of Business, University of Stellenbosch, PO Box 610, Bellville, 7535	+27-21-918 4286	iarief@maties.sun.ac.za
Henry Engledow	IOI-SA, Department of Botany, UWC, Private Bag X17, Bellville, 7535	+27-21-959 2594	henry@botany.uwc.ac.za

APPENDIX 2:

STUDENT ASSISTANTS

NAME	ORGANIZATION	TELEPHONE
Khalid Salie	University of Stellenbosch	+27-21-808 4770
Willem Farmer	University of Stellenbosch	+27-21-808 4759
Wendy Engel	University of Stellenbosch	+27-21-808 4759
Natalie Prins	University of the Western Cape	+27-21-959 2301
Melissa Harper	University of the Western Cape	+27-21-959 2301

APPENDIX 3:

GUEST SPEAKERS

GUEST SPEAKER	ORGANISATION	TELEPHONE	TOPIC
ANDRÉ SHARE	Seaweed Research Unit, Sea Fisheries Research Institute	+27-21-650 3715	Seaweed management and socio-economic implications
RICHARD MARTIN	ZILLE, SHANDLER AND ASSOCIATES.	+27-083 261 5091	Policies and acts guiding marine resource utilisation
KLAUSS ROTMANN	TAURUS ATLANTIC PRODUCTS	+27-11-803 8330	The seaweed industry in Southern Africa: history, markets and probems.
ANDREW WOOD	SEA HARVEST FISHING COMPANY	+27-2881-54136	Floating raft farming in Saldanha Bay
CHRIS NISSEN	Provincial Administration: Ministry of Economic Affairs, Reconstruction and Development	+27-21-438 4302/2	Assistance to community-based industrial development
JOHN ROBINSON and FRIK BASSON	AGARTEK CC	+27-21-790 3096	Case study: conflict between sea and land utilisers
FREDDY GAOBONE	MUSSEL FARMER, SALDANHA BAY	+27-2281-42 066	Experiences of a mussel farmer
SHARON FEBRUARY	WEST COAST AGRICULTURAL ORGANIZATION (WCAO)	+27-083 626 4573	The role of WCAO in providing support to black farmers
JOSEPH WAKIBIA	UNIVERSITY OF THE WESTERN CAPE	+27-21-959 2594	East African research on seaweeds
AJ SMIT	UNIVERSITY OF CAPE TOWN	+27-21-650 2447	Experimental *Gracilaria* cultivation in Southern Africa

APPENDIX 4:

SYLLABUS:

WEEK 1:

<u>MODULE 1:</u> INTRODUCTION AND PARTICIPATORY RURAL APPRAISAL

MONDAY, JUNE 30:

9H30 - 10H15: Introduction and objectives
- Prof Derek Keats; Ms Bernadette Brown

10H15-10H30: Governmental organisation, laws and policies: background
- Ms Bernadette Brown

11h00-16H00: Participatory Rural Appraisal
- Mr Mohammed Karaan

TUESDAY JULY 1:

9h00-16h00: Participatory Rural Appraisal
- Mr Mohammed Karaan

<u>MODULE 2:</u> TECHNICAL AND PRACTICAL ASPECTS OF MARICULTURE

WEDNESDAY, JULY 2:

9h00-9h45: Seaweed biology, significance and distribution
- Mr Henry Engledow

9h45-10h30: The seaweed industry in Southern Africa
- Mr Klaus Rotmann

11h00-12h00: Experimental cultivation in Saldanha Bay
- Mr Anthony Smit

12h00-13h00: Seaweed management and socio-economic implications
- Mr André Share

14H00-14H30: East African research on seaweeds
- Mr Joseph Wakibia

14h30-16h00: Practical exercise (collection, identification)
- Ms Natalie Prins and Mr Henry Engledow

THURSDAY, JULY 3:

9H15-10H30: Uses, harvesting and farming of seaweeds
- Ms Bernadette Brown

11h00-12h00: Pre-feasibility, feasibility study and application procedures
- Ms Bernadette Brown

12h00-13h00: Harvesting and cultivation of marine organisms
- Mr Henry Engledow

14h00-15h00: Case study: conflict between land and sea utilisation
- Mr Frik Basson and Mr John Robinson

15h00-16h00: Policies and acts guiding marine resource utilisation
- Mr Richard Martin

16h00-18h00: Excursion to oyster nursery in St Helena Bay

FIELD EXCURSION

FRIDAY, JULY 4:

9h00-16h00: Excursion to mariculture farms in Saldanha Bay

- Mr Andrew Wood

WEEK 2

MODULE 3: BUSINESS SKILLS TRAINING

MONDAY JULY 7:

INSTRUCTOR: - Mr Iegshaan Ariefdien

9h15-10h00:	Objectives of module
10h00-10h30:	Identification of Entrepreneurial opportunities
10h00-11h00:	Creative techniques
11h15-12h00:	Groupwork - Profile of an entrepreneur
12h00-13h00:	Marketing vs sales
13h30-14h15:	Knowledge of the market and marketing strategies: Case study
14h15-15h00:	Promotion
15h15-16h00:	Basic sales techniques
16h00-16h30:	Buying and buying lists

TUESDAY JULY 8:

9h15-10h00:	Overview of previous day's work
10h00-10h30:	Costing
10h00-11h00:	Price determination
11h15-12h00:	Costing of producer
12h00-13h00:	Case study
13h30-14h15:	Introduction: Bookkeeping
14h15-15h00:	Overview of Bookkeeping
15h15-16h00:	Making a bookkeeping system
16h00-16h30:	Case study

WEDNESDAY JULY 9:

9h15-10h00:	Overview of previous day's work
10h00-11h:	Basic management functions
11h15-12h00:	Introduction: Business Plan
12h00-13h00:	Importance of business plan
13h30-14h15:	Formulation of business plan
14h15-15h00:	Summary and evaluation
15h15-16h30:	Groupwork: Business plan

MODULE 4: INSTITUTIONAL DESIGN AND PROCEDURES

THURSDAY, JULY 10:

9h15-10h30:	The economic organisation of seaweed cultivation - Mr Mohammed Karaan
11h00-13h00:	Nature of community participation - Mr Mohammed Karaan
14h00-15h00:	Participation models and forms of business - Mr Willem Farmer
15h00-16h00:	Appraisal of models - Mr Mohammed Karaan

PRA CONCLUSION, COURSE EVALUATION AND CERTIFICATE AWARDS

FRIDAY, JULY 11:

9h15-10h30:	PRA conclusion

	- Mr Mohammed Karaan
11h00-12h00:	Course evaluation and business plan evaluation
	- Mr Mohammed Karaan
12h00-13h00:	Assistance to community-based industrial development
	- Mr Chris Nissen
13h00-15h00:	Certificate awards and course closure

APPENDIX 5:

LIST OF PARTICIPANTS

NAME	ADDRESS	EDUCATION LEVEL	SEX	OCCUPATION	TELEPHONE
ANDREW BOSCH	P.O. Box 118 Atlantic 7384	Standard 10 2yr. Management	M	Executive Secretary	+27-2883-61446
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QUINTON JORDAAN	P.O. Box 77, Atlantic, 7384 Laingville 7384	Standard 10	M	Administrative clerk	+27-2883-61446
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