Socio-economic and biological aspects of the live reef food fish trade and its development in Solomon Islands

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Preface

This paper is one in a series relating to Project ANRE1/1998/094: *Sustainable Management of the Live Reef Fish Trade-Based Fishery in Solomon Islands*. The project is financed by the Australian Centre for International Agricultural Research, and involves researchers from Solomon Islands and Australia. Support is also provided by various non-government organisations and other agencies that are active in resource management in Pacific island nations. The focus of the research is to develop a management plan that supports the sustainable utilisation of the target species in the Live Reef Food Fish Trade. Research activities are underpinned by biological considerations, but have substantial social and economic elements as these are seen as an important component of the 'sustainability equation' for the fishery.

1. Introduction

The expansion of the Live Reef Food Fish Trade (LRFFT) in the Asia-Pacific region occurred in response to massive demand from the restaurant market in Hong Kong, southern China and other centres with large Chinese populations such as Taipei, Kuala Lumpur and Singapore. The demand is driven both by socially desirable "conspicuous consumption" (Bentley, 1999), and the belief that the ultimate freshness of fish, cooked and served minutes after being personally chosen from an aquarium, enhances virility and general health (Erdmann & Pet-Soede, 1996). Lau & Parry-Jones (1999) stated that the estimated annual value of live fish imported into Hong Kong for food now exceeds US$500 million. In market analyses reported by Rimmer *et al.* (1997), it was concluded that the market was expected to double every six years. However, Johannes & Riepen (1995) indicated that existing supply sources were expected to be insufficient to satisfy projected demand.

The overwhelming consumer demand for grouper and Maori wrasse, the species most favoured by consumers, has encouraged importers to venture ever further, seeking previously untapped stocks of the target species. The fishery has encountered many problems. Fishing methods, such as the use of sodium cyanide, have resulted in the destruction of fish habitat and the poisoning of smaller fish and invertebrates, upsetting trophic relationships. Research into the species targeted for the LRFFT is in its infancy, but it is known that the Maori wrasse (*Cheilinis undulatus*) lives for many decades and exhibits a slow growth rate, which generally accompanies low replacement capacity. The species is a *k*-selected life history strategist and is highly susceptible to overexploitation (Sadovy, 1997). Maori wrasse and groupers (mostly *Plectropomus* spp. and *Epinephelus* spp.) aggregate to spawn in accordance with highly predictable environmental variables (Pet & Pet-Soede, 1999) and it is these aggregations that have been targeted for the LRFFT.

The fishery has proved highly unsustainable. In the Philippines and Indonesia, stocks of grouper and Maori wrasse have been severely depleted. Importers have simply moved on to exploit stocks from coral reefs further afield, including the South Pacific. There is concern about the degree of post-harvest mortality, which is sometimes as high as 90 per cent (Sadovy, 1998a). Concerns also arise about the amount of incidental bycatch and about appropriation of economic rent by non resource-owners. Unsustainable exploitation of nearshore marine resources has grave implications for many thousands of coastal communities in South-East Asia and the Pacific. In Solomon Islands, the 1986 census indicated that 83 per cent of households were engaged in fishing. With estimated population growth running above three per cent, the population will double in the next 20 years, intensifying pressure on marine resources and the need to consolidate food security.

The aim in this paper is to assemble background information that can be used to aid in developing management strategies for sustainable and equitable exploitation of resources for the LRFFT in Solomon Islands.

2. History and Development of the Asian Live Reef Food Fish Trade

Johannes & Riepen (1995) stated that Hong Kong fishers first began to exploit reefs for live food fish in the South China Sea as early as 1968. Live fish had, customarily, been kept specifically for consumption shortly after killing, but mostly these were freshwater species or a few locally caught marine species. After 1968, however, consumers were increasingly exposed to large and colourful tropical reef fish. Rapid growth in South-East Asian economies gave rise to a burgeoning class of affluence among business people. A new genre of social elite arose whereby one's status was announced by one's willingness and ability to pay extraordinary sums of money to publicly consume these fish. Consumption of freshly killed fish is thought to redeem "life strength". From an ethereal perspective, Oomen (1998 p.58) pointed to the cultural connection between freshly killed live reef fish and the Chinese myth of the rebirth of a celestial sea dragon out of a 1,000-year-old Maori wrasse or a spotted coral trout. Oomen described the process of "choosing a live reef fish, ordering it to be prepared according to a culturally acknowledged recipe and consuming the dish with appropriate manners" as taking part in an ancient performance. Eating effigies of mythical creatures strengthens one's life force and suggests congruence between ancestral devotion and rebirthing of celestial beings. Johannes & Riepen (1995) suggested, however, that the state of the Hang Seng Index was a better indicator of local demand for live reef fish.

With the rise in demand, Hong Kong fishers exploited and depleted the more remote reefs and islands of the South China Sea. In 1975, the trade moved into the Philippines. The coral reefs of the Philippines and the vast archipelago of Indonesia, represent some of the biologically richest regions in the world (Barber & Pratt, 1997). It was amid this biological wealth and diversity that much of the supply of aquarium fish, which filled collections in the United States and Europe (Dufour, 1997), were gleaned from as early as 1957. Barber & Pratt (1997) stated that 85 percent of ornamental aquarium fish are captured in the Indo-Pacific region. From 1962, the collection process involved stunning the fish with a concentration of sodium cyanide, making them easier to capture (McAllister *et al.,* 1999). It is not apparent exactly when the use of cyanide spread to the LRFFT. The trade in live food fish in the Philippines today is greatly reduced because of reef degradation caused by the use of chemicals and explosives. The extent of damage to reefs from destructive fishing practices has affected the ability of inhabitants of coastal villages to live in their customary manner. Filemon Romero, former chancellor of Mindanao State University, quoted in Alvarez (1996 p22), stated that "coral reef degradation has cost the country a lot in terms of fish production loss, diminished income possibilities and the high incidence of malnutrition, undernourishment, unemployment and urban migration".

The massive industrial cities of southern China are home to the fastest growth in demand for live reef fish (Lau & Parry Jones, 1999). China has achieved extraordinary economic growth for a number of years and the cities in the south of the country have experienced phenomenal growth, both

in terms of population and prosperity. The demand from wealthy Chinese in the business centres of Taipei, Kuala Lumpur and Singapore continued to grow and companies expanded the search for the desired species in Palau and Indonesia in an effort to capitalise on the potential wealth generating opportunity.

Bentley (1999) stated that the trade was established in the western reefs of Indonesia in 1985 and spread quickly to the extensive reefs of eastern Indonesia, where Indrawan (1999) noted that the export peak was reached by 1993. The bubble burst in 1996 when exports declined sharply (Bentley, 1999). Johannes & Riepen (1995) stated that Indonesia accounted for more than half of the total wild-caught reef fish supplied to Hong Kong and Singapore. These figures were similar to those reported by Bentley (1999) but were refuted by Erdmann & Pet-Soede (1996), who calculated that Indonesia's export of live food fish for the same period was between a third and two thirds of that from the Philippines. This serves to highlight the difficulty in quantifying the extent of the trade and rates of exploitation of these species. Both authors emphasised the boom and bust nature of the industry in Indonesia and concurred in foreseeing the collapse of the fishery there in the mid to late 1990s. Lau & Parry-Jones (1999) highlighted the difficulty in obtaining reliable figures on imports by source from Hong Kong. Locally registered vessels in Hong Kong are exempt from declaration of live reef food fish. As there are about 1,600 locally licensed vessels, the recorded import level is potentially much less than the actual import level.

Operations in the LRFFT originally began with foreign vessels and crew. Large, self-contained vessels that took the fish to the market themselves dominated the trade. However, the structure of the trade was to change. Local fishers were enticed into the industry by the lure of the relatively high value of live fish and exporters found it cheaper to employ locals than to bring in their own crews (Bentley, 1999). Additionally, legislation made it necessary to hire local fishers in some areas. Transport arrangements, primarily for transport to Hong Kong but also to Malaysia and Singapore, saw the introduction of specialised Live Fish Transport Vessels (LFTV). Fishers captured live fish and stored them temporarily in specially fitted saltwater compartments within the hulls of their craft, the size of which varied depending on the scale of the operation.

Companies set up holding pens in proximity to major fishing areas. Indrawan (1999) reported that these typically consist of wooden planks and nylon nets, tied to plastic drum buoys. One holding pen typically includes four to eight cages measuring three by three by four metres. Each fisher's daily catch is weighed before being placed in the pen and the fisher is paid according to the catch. When the accumulated catch is sufficient to warrant transport, which is ideally 15 tonnes but could be as much as 30 tonnes, the LFTV transports the catch to market. These conditions vary regionally. In areas where airfreight is both viable and accessible, fish are often shipped by air.

2.1 Present Situation

The LRFFT now straddles a large area of the tropical marine environment. In many locations, the trade is yet to experience the type of degradation experienced in the coral reefs and coastal communities of the Philippines and Indonesia. The trade is characterised by its mobility. There is no bricks-and-mortar infrastructure. There is minimal involvement of local communities in the market chain beyond capturing live fish for collection, and the operation can be conducted in regions remote from urban facilities and services. Holding pens are collapsible and the whole operation can relocate at short notice upon the exhaustion of resources at a particular site. The downward trend in the productivity of reefs in the Philippines and Indonesia, and the consistently high and probably growing demand has encouraged companies to establish the trade in the Western Pacific and the Indian Ocean. From 1992, live reef fish export operations were established in Papua New Guinea (PNG) and, soon after, spread east to Solomon Islands and the Marshall Islands, and west to the Maldives. Operations began on Australia's Great Barrier Reef in 1995, while Kiribati, Fiji and the Seychelles commenced shortly thereafter. Fledgling operations have commenced ever further afield in the Indian and Pacific Oceans (Johannes & Riepen, 1995).

Expansion into the Western Pacific brought with it some unexpected problems for consumers in the importing countries. For example, there is a growing risk to consumers of ciguatera poisoning (Sadovy, 1998b). Ciguatoxins are naturally occurring in reef predators. Ciguatera poisoning is caused by a neurotoxin found in dinoflagellate algae called *Gambierdiscus toxicus* and *Ostreopsis lenticularis.* The toxin first affects the coral-grazing fish and is then passed up and through the food chain to the piscivorous fish, notably grouper, and finally to humans. The toxin is not affected by either cooking or freezing (Bomber, 1991). The species that are implicated in ciguatera outbreaks are those which are targeted for the LRFFT. Sadovy (1999) reported that some of the Western Pacific sites being exploited proved to be sources of significant numbers of ciguatoxic fishes, which resulted in hundreds of cases of ciguatera poisoning in Hong Kong. Sadovy also cited a case where 10 tonnes of contaminated fish from Fiji were imported. Health authorities prevented the sale of the fish to the public but the fish were re-exported to Mainland China.

Stewart (1999) reported a recent outbreak of ciguatera poisoning, which prompted some in Hong Kong to call for the banning of the sale of live reef fish for consumption. Thirty people, aged two to 80, were struck down with fevers, vomiting, chills, sweat, muscle fatigue and numbness. Stewart explained that in the previous year there were 420 ciguatera victims in 117 separate cases. Larger fish are thought to contain higher concentrations of ciguatoxins, as the toxins are believed to accumulate with the passage of time. Sadovy (1999) noted that the growing frequency of these outbreaks prompted health authority warnings suggesting the consumption of smaller fish. This has resulted in dampened demand and deflated prices for larger specimens but, concomitantly, a greater proportion of juveniles being sold in retail outlets. This does not augur well for the long-term health of these fisheries.

With the LRFFT expanding its geographical distribution, it is important that the countries now embracing the industry learn from the mistakes and consequences of the trade in countries such as the Philippines and Indonesia. Bentley (1999 p.9) highlighted this in noting that “for most regions, once exports began, it took only three to four years for them to reach a peak and then to decline. Like a wave, the industry has spread throughout the country; live fish exports rising and falling in its wake”. This serves to emphasise the need to manage live reef fisheries in a fashion that allows fisheries resources to be exploited in a sustainable manner. The short-term gains by a relative few in countries such as the Philippines have resulted in longer-term hardships for many. Degradation of coral reefs and overexploitation of targeted species need not be the consequences of resource exploitation for the LRFFT.

3. Current research and research outcomes in relation to the Asian LRFFT

Most of the literature concerning the LRFFT specifically, is available as a result of the Live Reef Fish (aquarium and food) Trade Special Interest Group, set up in 1996 to operate as a network of individuals connected to the live reef fish trade. Submissions are published by the Secretariat of the Pacific Community (SPC) in the Live Reef Fish Information Bulletin. Research efforts concerning the Asian LRFFT have focused quite heavily on the use of cyanide, both for the LRFFT and the aquarium trade. The Information Bulletin has generated input from researchers, government, and industry representatives from most of the countries that are involved in the LRFFT. There is, however, scant biological research, anywhere in the literature, concerning the target species, especially the Maori wrasse. There is an extensive body of literature addressing the role of customary systems of marine tenure in managing fisheries resource use.

3.1 Cyanide Use and Effects

The use of cyanide, as a technique for capturing fish, is far from unique to the LRFFT. Barber & Pratt (1997) pointed out that, since the 1960s, more than a million kilograms of sodium cyanide had been squirted onto coral reefs in the Philippines alone, in order to stun and capture ornamental aquarium fish for pet shops in Europe and North America. Dufour (1997) noted that, due to the

difficulty of raising ornamental fish in captivity, the fishery was based on collection from the natural environment. This collection accounted for about 100 tonnes worldwide annually by the late 1990s and included millions of specimens. Dufour added that the aquarium fish trade had doubled since the early 1980s and attributed the increase, primarily, to an increase in air traffic resulting from increased tourism to tropical countries since about 1980. This served to intensify the use of cyanide on coral reefs, particularly in the Philippines and Indonesia (Fox, 1997).

Alvarez (1996) reported that there was more than 4,000 cyanide-using aquarium fish gatherers in the Philippines and another 2,000 engaged in live food fish collection. Barber & Pratt (1997) endorsed these figures, and added that the number of cyanide fishers in the Indo-Pacific region was probably about 20,000. In the early 1960s, there were only three companies exporting aquarium fish from the Philippines and the export of live food fish did not exist. By the 1990s, there were about 45 ornamental fish exporters in the country, and eight companies exporting live food fish. Philippine government statistics showed that as many as six million aquarium fish were exported in 1996 (Barber & Pratt, 1997).

Johannes & Riepen (1995) described the process of capturing fish with the use of cyanide. The diver chases a large fish into a hole within the coral reef framework. The diver squirts the sodium cyanide solution into the hole then waits. While smaller fishes and invertebrates in the vicinity die from the poison, the larger fish is stupefied. The diver smashes his way through the coral that harbours the fish. When he reaches the fish, he forces a hook, attached to a rope, through its lips and returns to the skiff to place it in the seawater holding tank. Sometimes the fish escapes or is stupefied but is unable to be retrieved. Either way, the destruction to the reef and smaller organisms is the same. The rate of post-harvest mortality is often 40-60 per cent before the fish are transported to market, mostly because of poor handling and storage techniques. More fish die in transit before they reach their final destination. For every fish that dies, another must be caught to meet the seemingly insatiable demand.

The impact on coral reef habitat and on smaller fish and invertebrates caught in the cloud of cyanide, is devastation. In a study of the effects of cyanide on coral, Jones (1997) concluded that, at the concentration of cyanide commonly used by the fishers (20 parts per thousand), a reduction or cessation of respiration would ensue. Jones & Hoegh-Guldberg (1999) added that this would result in a dissociation of the coral-algal symbiosis by affecting the photosynthesis of the zooxanthellae and result in the inevitable bleaching of the coral. The consequences of this are a reduction in phototrophic potential and a decrease in growth rate and fecundity. Jones (1997) stated that re-establishing the symbiosis could take six months to a year or more. Broken corals may take many years to re-establish as habitat for large demersal fish species. Barber & Pratt (1997) described the physical damage to the reef matrix from the use of a crowbar to pry apart the coral heads to reach the stunned fish. Pet & Pet-Soede (1999) explained that when a single grouper is captured, more than a square metre of coral is destroyed when the fish is removed from its hiding place. Erdmann & Pet-Soede (1996) described the scene of a fully exploited reef in eastern Indonesia as being completely devoid of serranids of all ages, and a ring of dead, bleached coral surrounding every hole in the reef structure.

3.2 Hazardous Diving Practices

Pet-Soede & Erdmann (1998) noted that many divers are supported by hookahs. Hookah divers, whether using cyanide or setting traps, are mostly unfamiliar with dive physics and diving physiology. Jacques (1997) account of his studies in Indonesia highlighted the human cost of the LRFFT in remote coastal villages. Jacques described the well organised and well financed operation in eastern Indonesia, where a fleet of numbered, fibreglass vessels operated with a crew of two. One dived and the other tended the compressor. He witnessed one diver make nine rapid descents and equally rapid ascents in 90 minutes. There were no decompression stops. The company had told the villagers how much money they could make but gave them scant diving tuition. Johannes & Djohani

(1997) noted that divers cited chronic debt as the reason for breaching dive safety standards. Hookah gear costs about US$800, a sum that is well beyond the means of the majority of divers. The divers borrow the money from intermediaries who buy their catch. The intermediaries pressure the divers to repay the debt as quickly as possible, urging them to make four dives a day for an average duration of 40 minutes at depths of up to 45m. Johannes & Riepen (1995) stated that thousands of divers have been paralysed and hundreds killed in the past several years in the Philippines and Indonesia because of decompression sickness (the bends). Squire (*pers. comm*., 2000) pointed out that divers were aware of the onset of symptoms of the bends but referred to them as "sea ghosts". Most of the divers are young men for whom fear of sea ghosts was considered a slight on their manhood. Consequently, they continued to dive, ignoring the symptoms, to their peril.

3.3 Exporting Countries

3.3.1 Philippines and Indonesia

Alvarez (1996) reported that in the first six months of 1996, 19 local companies exported a total of 479 tonnes of live grouper and Maori wrasse with an estimated value of about US$30 million from the Philippines. Fishers were paid as much as US$14kg^{-1} for live grouper and twice as much for live Maori wrasse. The intermediaries would sell the fish to Manila-based exporters for about US$36kg^{-1}. After costs such as airfreight, packaging and handling, the profit to intermediaries was estimated by the International Marinelife Alliance (IMA) to be about US$8kg^{-1}. This equates to a profit of more than US$3.8 million for the intermediaries alone for a period of six months. Alvarez added that the LRFFT effectively heralded the end of the widespread use of dynamite in "blast fishing" in the mid 1980s because the income potential from capturing live fish far surpassed that of the dead catch. Unfortunately, the substitute method was often sodium cyanide. The establishment of the LRFFT and the spiralling demand for aquarium fish from the mid 1980s resulted in the application of cyanide escalating to about 400,000kg annually (Alvarez, 1996). The Haribon Foundation (1998) stated that intermediaries act as creditors and cyanide peddlers. The fishers usually have little option but to channel their catch through intermediaries or be faced with transporting their live catch directly to Manila to avoid them.

The inequitable, oppressive trading system faced by fish collectors resulted in many village fishers being heavily in debt. The need to meet repayments accentuated the need to capture as many fish as possible. There is significant incentive for indebted fishers to use whatever means possible to maximise their catch (Haribon Foundation, 1998). Barber & Pratt (1997) stated that poverty was not the root cause of cyanide fishing. However, poverty is certainly an inevitable result of cyanide fishing. Dead reefs yield no fish or invertebrates. Whenever these food sources begin to recover, they are harvested by villagers, thus prolonging re-establishment. Economic dislocation in the countryside from debt and depleted subsistence resources has led to malnutrition and urban migration (Alvarez, 1996). In some areas of the Philippines, coral reefs have suffered as a result of pollution from urban runoff, sedimentation from logging and mining operations, and eutrophication from poor agricultural practices (Johannes & Riepen, 1995). In addition to these impacts on food sources, destruction of reef ecosystems also detracts from the country's ability to fully capitalise on other potential sources of income such as the lucrative dive tourism market.

Recognising the extent and ramifications of the problem of destructive fishing techniques, in 1991 the Philippines government (in association with IMA) developed and implemented the Cyanide Fishing Reform Program. Barber & Pratt (1997) reported that cyanide fishers were often eager to give up using the poison if viable alternatives were offered and greater equity could be demonstrated through a fair price being offered for their catch. Barber & Pratt noted that the cyanide fishers are a small and discrete group that is simply responding to very specific incentives. The use of cyanide is illegal, but there is scant enforcement of the law and bribery and corruption are rife (Johannes & Riepen, 1995).

The Haribon Foundation (1998) highlighted the open access nature of the marine resources in the Philippines. Fishers lack incentive to conserve and protect their coral reefs. If one fisher does not catch a particular fish, then somebody else will. This encourages fishers to maximise their personal gain at the expense of restraint for the sake of conservation. Johannes & Riepen (1995) reported that decentralisation of fisheries management was gradually being established in the Philippines, whereby local marine tenure is granted to fisher associations. This results in community-based control of marine resources. Enforcement is supported by the navy. Local government has jurisdiction over municipal waters up to 15km from shore. These factors offer improved property rights and a sense of ownership of marine resources, so that the owner accrues all the benefits from the resource but is equally responsible for any detriment that is caused. This gives fishers greater incentive to use their resources in a sustainable manner.

In Indonesia, degradation of reef resources from mining operations, blast fishing and sodium cyanide application, for both the aquarium trade and the LRFFT, has reduced the viability of reef systems as a vital source of food and as a potential income earner. The World Bank (1997) noted that a high demand for marine products, opportunities for substantial private gains, weak enforcement of existing laws, and an open access regime that discourages community action, exacerbate these threats. Cesar *et al.* (1997 p.346) estimated that "the large-scale poison fishery create(d) a net quantifiable loss of US$46 million over four years. Alternatively, a sustainable hook-and-line fisheries option could create foreign exchange for the country, jobs for an estimated 10,000 Indonesian fishers for many years to come, and net benefits of some US$328.1 million".

Pet-Soede *et al.* (1999) analysed the economic costs and benefits of blast fishing in Indonesia. Analysis of the benefit gained from three scales of operation indicated that, at the individual household level, the differences between the three types of operations showed clear incentives for scale enlargement. The economic costs to society were found to be four times higher than the total net private benefits from blast fishing in areas with high potential value from tourism and coastal protection. Edinger *et al*. (1998) surveyed 15 reefs in three regions of Indonesia and found that bombed or anchor damaged reefs were 50 per cent less diverse in shallow water (3m depth) than were undamaged reefs in the same region. Reefs subject to land-based pollution (sewage, sedimentation, and/or industrial pollution) showed 30-50 per cent reduced diversity at 3m, and 40-60 per cent reduced diversity at 10m depth relative to unpolluted comparison reefs in each region. The World Bank (1997) estimated that as much as 70 per cent of the reefs of Indonesia are in poor to fair condition, primarily due to sedimentation, land-based pollution, coral mining, physical damage, and over-extraction of marine products.

The World Bank (1997) stated that implementation of management plans in Indonesia was constrained by lack of funds and staffing. Marine management has been hampered by weak enforcement of existing regulations, and lack of delineation of user property rights for nearshore areas. Mantjoro (1996) suggested that lessons could be learned from the Para fishing community. Fishers there founded the basis of management, established an effective organisation, constructed the equity share principle, invented and enforced regulations, and meted out the punishments for non-compliance. The delegation of authority to the local community, to establish their own sea tenure system, is considered a pivotal element in the management of communal property resources. The World Bank (1997) added that reef management has been most successful where communities have been organised and empowered to manage local reef resources. Local government endorsement of management plans and recognition of community user rights is essential to ensure the sustainable use of marine resources.

3.3.2 South Western Pacific

Several companies from Hong Kong established the trade in PNG by 1992, where the remote and extensive coral reefs were considered to be the "new frontier" for the industry (Johannes & Riepen, 1995 p.49). The vast and scattered nature of the coral reef assemblage in Papua New Guinea,

together with the paucity of fisheries management resources, limit the degree to which management and enforcement are possible. Kirkpatrick & Cook (1997) reported that in an effort to head off the establishment of a cyanide fishing foothold there, The Nature Conservancy and other Non Government Organisations (NGOs) united to design and implement a major conservation education program in villages to combat the practice.

From 1994, two companies set up operations in Solomon Islands at Marovo, Vella La Vella and Roviana Lagoons, then later in the northern atoll of Ontong Java (Johannes & Lam, 1999). Smith (1997) reported that, from late 1994, three operations were established in the Republic of Marshall Islands, with joint ventures set up between local entrepreneurs and companies from Hong Kong and Taiwan. Fishing for live coral trout began in earnest on the Great Barrier Reef in Australia in 1995 (Elmer, 1998); Kiribati began operation in early 1996 (Sommerville & Pendle, 1999); and Fiji began cautiously pursuing the opening of live fish operations in 1998 (Yeeting, 1999).

On the other side of the Pacific Ocean, a live fishery has operated in California since 1988. The target species are different from those targeted for the Asian LRFFT, although the fishery was initially established in order to service demand from the local Asian community (Tegner & Dayton, 1997). In the Indian Ocean, Shakeel & Ahmed (1997) stated that the fishery for live groupers started in the Maldives in 1994; and Bentley & Aumeeruddy (1999) described the experimental export of live fish from the Seychelles in 1998. There are also fledgling operations in Eritrea, Tanzania, Kuwait, Malaysia, Vietnam, Thailand, Tonga and Vanuatu (Johannes & Riepen, 1995; Barber & Pratt, 1997). Elmer (1998) reported that the LRFFT on Australia's Great Barrier Reef has attracted considerable interest from commercial operators since 1995. In 1998, there were about 110 licensed operators and there was an estimated direct capital investment of AUD$19 million in boats and land-based premises, exclusively for live fish operations. The trade in Australia is largely free of many of the destructive and unsustainable aspects that characterise the fishery in developing countries in the Asia-Pacific region.

3.4 Aquaculture/Mariculture

Rimmer *et al.* (1998) stated that there was increased interest in grouper mariculture throughout the world, but particularly in the Asia-Pacific region because of the level of demand and the potential returns from the product. Most fish culture in South-East Asia is based on the collection of juveniles from the wild and their grow-out in captivity to marketable size (Sadovy & Pet, 1998). Dato-Cajegas *et al.* (1998) noted that commercial hatchery production is restricted to Taiwan, although experimental hatcheries were establishing throughout Asia. Johannes & Ogburn (1999) added that Taiwan still imports wild-caught grouper fry because it has not yet been able to produce fry in sufficient numbers in its hatcheries.

Most of the marine fry imported to Hong Kong comes from Taiwan, Thailand and Japan (Lau & Parry-Jones, 1999). Sadovy & Pet (1998) stated concern that the collection of wild juveniles for grouper mariculture may be another capture fishery. This concern is based on the timing of peak rates of mortality among grouper juveniles. Less than one per cent of larvae survives the pelagic larval development stage before settlement on coral reefs. There is then intense predation by larger fish associated with the reef (Bell *et al.,* 1999). If the peak mortality period is during the planktonic phase, then the post-settlement harvesting of juveniles may be unsustainable because the fishing mortality would represent a substantial proportion of total mortality, and the fishery would need to be managed to avoid overfishing. Williams (1996) noted that this is an important link between aquaculture and fisheries that is often ignored because the sectors have been viewed in isolation. However, Bell *et al.* (1999) argued that if sections of reef are quarantined from predatory fish, the postlarvae could be harvested in a way that does not jeopardise natural rates of replenishment.

Johannes & Ogburn (1999) pointed out that hatchery technology for grouper is not yet well established and that, despite extensive research, commercial success has been limited due to the high

level of mortality. Dato-Cajegas *et al.* (1998) recorded survival rates of between five and 15 percent. This was financially acceptable, given the high value of the product, but it hindered further development of the hatchery sector in Asia. Bell *et al.* (1999) stated that it is better to first establish successful grow-out aquaculture of high-value species of reef fish. Propagating larvae from hatcheries incurs high cost. Munro & Bell (1997) endorsed the use of wild caught juveniles and added that the use of juveniles from hatcheries was often associated with alterations to the gene pool and the transfer of diseases.

Current research into grouper mariculture in the Asia-Pacific region has emerged from Thailand, Indonesia, Philippines and Japan. Development of effective hatcheries has been a major focus of research. The species that frequently feature in aquaculture ventures and research are the estuary cod (sometimes called green grouper), *Epinephelus coioides* and the Malabar grouper, *E. malabaricus* (Johannes, 1997a). The grouper aquaculture research effort has covered aspects of hatchery spawning (*e.g.* Sugama *et al.,* 1998), feeding (*e.g.* Millamena & Golez, 1998; Ordonio-Aguilar & Ohno, 1998; Toledo, 1999*)*, ambient conditions (*e.g.* Caberoy & Quinitio, 1998a), parasite infestations (*e.g.* Koesharyani *et al.* 1998), the effects of steroid variation on the timing of sex reversal (*e.g.* Lee *et al.,* 1998; Yashiro *et al.,* 1998), handling requirements (*e.g.* Caberoy & Quinitio, 1998b) and the mitigation of viral infection (*e.g.* Chi *et al.,* 1999; Lee *et al.,* 1999). A cooperative network has been established for the exchange and dissemination of research information in the region (Rimmer *et al.,* 1998).

4. Sustainability issues and concerns relating to the LRFFT in the South Pacific

The South Pacific region is a large and diverse area covering the western and central Pacific Ocean. There are 16 independent States which, with the exception of Australia and New Zealand, are small island developing States and territories. These States are primarily comprised of a single island or a group of sparsely distributed islands. Notable exceptions are the Melanesian nations of PNG, Solomon Islands and Fiji. All of the developing States, except PNG, have low land to exclusive economic zone ratios, fragile physical environments, a high level of dependence on fish for food, narrow and undiversified economic bases and limited scope for land-based economic activity. Consequently, marine resources in the Pacific Islands are critical to the culture, subsistence and economic development of the region (FAO, 1997).

Fisheries on Pacific Island reefs are still overwhelmingly subsistence fisheries. Only 20 per cent of the fish and invertebrates that are taken from Pacific Island coral reefs enter the cash economy. Export fisheries represent about 10 per cent of the total landed catch from Pacific Islands but they give rise to most of the perceived problems (Adams & Ledua, 1997). Export of bêche-de-mer and trochus comprise the majority of invertebrate exports but these do not form part of the diet of Pacific Islanders (Adams *et al*., 1996). Of greater concern is the impact of intensive fishing effort on fish species that do form a vital component of villagers' diet and have not, previously, been exploited on a commercial scale equivalent to that which has been seen in the LRFFT.

The LRFFT in the South Pacific has largely been devoid of the types of destructive fishing methods that accompanied the trade in Indonesia and the Philippines. However, intensive fishing effort, concentrated on seasonal spawning aggregations, has a devastating effect on recruitment of juveniles of the target species to the fishery in subsequent years. Johannes *et al.* (1999) suggested that the effect of such fishing on spawning aggregations could lead to the collapse and local extinction of the aggregations. The aggregations may take years to recover due to problems within the spawning aggregation when the sex ratio is not conducive to optimal spawning behaviour. In some cases, the aggregations do not recover at all. As village communities have fished these aggregations for generations for subsistence, there is an urgent need to the address the unsustainable commercial exploitation of these resources.

The value of the LRFFT, in combination with the paucity of alternative sources of income, has made

the trade an attractive proposition to village fishers. The trade contributes significantly to the local and central economies of participating nations, but there is concern about the impact on local ecosystems and long term sustainability (Hamilton & Walter, 1999). The effect of exploitation of reef fish, on this scale, is not necessarily well known to most subsistence fishers and traditional reef owners. The activities on fishing grounds have, consequently, been focused on the vigorous exploitation of the spawning aggregations. The timing and location, extent and duration of such aggregations is well known among fishing communities, and the speed with which fishers are able to earn a relatively large sum of money from fishing has encouraged many fishers to join the trade, thereby intensifying the pressure on spawning aggregations.

Adams (1998) stated that almost all nations, throughout the South Pacific, practice some form of localised stewardship over land and sea resources. There is no delineation between land and sea. This usually involves ownership of reefs and lagoons, and sometimes a substantial portion of open sea, by a matrix of relatively small social units. However, population pressure, transmigration of cultural groups, colonialism, and integration into the cash economy has, in some cases, severely eroded traditional authority (McManus, 1996). Effective control over activities on fishing grounds is exercised where customary marine tenure, or some other form of local control over fishing grounds, exists. Exclusion rights are pivotal to management success (Solomon Islands Fisheries Division & The Nature Conservancy (SIFD & TNC), 1999). Modern management of inshore resources in the South Pacific, particularly for nations actively participating in the LRFFT, should emphasise local empowerment in combination with centralised guidelines and an appropriate legislative framework.

Hviding & Baines (1994) pointed out that modern fisheries management has a largely biological focus that ignores the role of the fishers and fishing communities. Local level, common property type systems of marine tenure regulate access to, and use of, resources and, as such, function as fisheries management systems. Johannes (1998b) noted the cumbersome nature of centralised fisheries management that relies heavily on the collection of data. By the time the data are collected, a small problem may have become a catastrophe. An integrated approach to fisheries management is recommended widely throughout the literature. This requires definition of custom tenure boundaries and customary rights to access and resource use. Traditional owners have a vested interest in managing their marine estate efficiently and in a sustainable manner.

In Australia, the LRFFT is practiced in what is currently believed to be a sustainable manner. Entry in to the fishery is restricted and fishers do not, by their own volition, target spawning aggregations. Clearly, there is a greater injection of capital into live reef fish operations in Australia. There is greater access to research findings regarding the target species and current management strategies from around the world. Efficient handling, storage and transport techniques and arrangements have resulted in negligible post harvest mortality. The ease of access to information needs has resulted in fishers making informed decisions with regard to exploiting the resource for which they have permitted rights to access commercially.

5. The impacts of fishing spawning aggregations

Domeier & Colin (1997 p.699) broadly defined a spawning aggregation as “a gathering of conspecific fish, for the purposes of spawning, that consists of fish densities significantly higher than are found during the non-reproductive period”. Many marine fishes aggregate to spawn according to a highly variable regime of environmental parameters. Spawning occurs in well-defined aggregation sites. Some fish travel many kilometres from their home site to attend. The aggregations often take place at specific times of day and at specific times in the lunar or tidal cycle and at recurring seasons every year. The occurrence of spawning aggregations is, consequently, highly predictable (Sadovy, 1996). Reef fishing in general affects the population structure, growth, reproduction and distribution of target species and has indirect effects on non-target species and invertebrate populations. These effects are accentuated by fishing spawning aggregations and are potentially serious if there is intensive fishing effort for commercial exploitation. Johannes (1997b) stated that the emphasis of

fishers in the LRFFT of targeting spawning aggregations of groupers was making these aggregations exceptionally vulnerable to overexploitation.

Overexploitation of these resources, in this manner, is the result of common property resources being treated in the same manner as open access resources. Common property resources are those which are owned by a well-defined group or community. If the property rights pertaining to the resource are clearly defined, then the group or community has the incentive to manage the resource appropriately because group members are, equally, the recipients of all benefits arising from exploiting the resource, and responsible for any detriment caused to the resource. Open access resources, on the other hand, are those that nobody owns so there is no incentive for an individual to restrict their own level of exploitation. In the case of fishing spawning aggregations, the system of access rights for fishers associated with different clan groups through blood lines, marriage and residence, complicates the definition of property rights for a particular community. The exclusivity of access to certain fishing grounds is not clearly determined for a particular community because individual fishers with ties to other clan groups may claim access rights through various levels of association.

It is uncertain why species aggregate to spawn. It is thought that the timing and location of aggregations is to benefit egg dispersal and aid larvae in finding food and avoiding predation (*e.g.* Doherty *et al*., 1985). However, Colin (1992) suggested that there is no dispersal advantage gained from using a specific site and time to spawn. Boulert (1996) stated that spawning sites are often located on down-current sides of reefs, promoting transport off the reef, if not out of the reef system as a whole. The aggregating behaviour of many reef species has been a focal point for artisanal fishers. Parrish (1999) noted that fishers capitalise on experiential knowledge of fish behaviour and ecology by following recurring environmental signals. In this way, provision of food is more easily assured.

Fishing of spawning aggregations may have adverse effects for the population structure and reproductive potential of the target species. Jennings & Lock (1996) noted that about 50 spawning aggregation sites for the Nassau grouper *Epinephelus striata* are known in the Caribbean. However, one third of these aggregations no longer form due to heavy fishing pressure. Beets & Friedlander (1999) found two grouper spawning aggregations that were eliminated by intensive fishing. Species within another intensively targeted aggregation recorded a dramatic size decrease, while the sex ratio was highly skewed to 15 females to one male, which indicated the potential for sperm limitation in the aggregation. Overfishing has been implicated in the disappearance of spawning aggregations throughout the world (*e.g.* Colin, 1992; Aquilar-Perera & Aguilar-Davila, 1996; Domeier & Colin, 1997). Johannes *et al.* (1999) listed five Pacific island locations where grouper stocks had been eliminated as a result of fishing spawning aggregations.

Complex socio-behavioural structure is associated with spawning aggregations (Zabala *et al.,* 1997). Territoriality and a ritual, phased arrival and departure from aggregations, occur frequently. The actual timing of egg fertilisation within a spawning aggregation may constitute only a small percentage of the time that the species aggregate. Sadovy (1996) stated that intensive fishing effort that focuses on spawning aggregations may alter the structure of the aggregation, whereby spawning behaviour is disrupted, resulting in a reduction of reproductive output. The long-term effects of intensive aggregation fishing are largely unknown. Johannes *et al.* (1999) described the short-term effects of such fishing as a sudden drastic decline and cited reports of disappearing spawning aggregations of grouper throughout the Caribbean Sea. Targeting spawning aggregations in this way can increase the likelihood of localised removal of species that may constitute a significant component of dietary protein for local people. In areas of the world that have high population growth - most of the developing world – this form of fishing may seriously endanger future food security.

6. The coral reef finfish fishery in Solomon Islands

The coral reef finfish fishery in Solomon Islands is the major provider of food for the majority of the population. Solomon Islanders rely heavily on marine resources and have one of the highest per capita rates of seafood consumption in the world. The Asian Development Bank estimated, in 1997, that the national subsistence catch in Solomon Islands exceeded 13,200 tonnes annually and was likely to increase in line with population growth (ADB, 1998). Local markets, that service urban centres, partially support the cash needs of village fishers. In Western province, these include the fisheries centre in Munda, a small number of tourist facilities and logging camps, and the transport of finfish in eskies to the fish and produce markets in Honiara.

Richards *et al*. (1994) reported that about 180 species of reef fish, from 30 families, are caught from shallow water by the Solomon islands domestic fishery. The catch is comprised, mostly, of Lutjanids (snappers), Serranids (groupers and rock cods), Lethrinids (emperors), Scombrids (mackerels) and Carangids (trevallies). Fish from these families are associated with reef and lagoon habitats. Local knowledge of the behaviour of fish in adjacent fishing grounds, such as the locations and timing of spawning aggregations, enable fishers to efficiently exploit finfish resources. In the presence of spiralling population and high consumption rates of fish, it is unlikely that the nations' food supply can withstand the commercial exploitation of the coral reef finfish fishery in the unsustainable manner that has characterised the LRFFT in the five years of operation in Solomon Islands.

The LRFFT has, however, provided an attractive commercial opportunity for fishers in rural communities that have become increasingly cash dependent. Spawning aggregations are traditionally targeted for subsistence in Solomon Islands. ACIAR (1999) stated that the future of the LRFFT in Solomon Islands is dependent on maintaining viable breeding populations of targeted species. Therefore, spawning aggregations must be afforded some protection and enforced by local custodians of customary marine estates. The lucrative live fish export market places considerable pressure on inshore resources as the short-term gains afford villagers temporary financial relief. There is an absence of alternative sources of income in many coastal villages in Solomon Islands and the LRFFT is, potentially, a means to providing steady income.

7. The development of the LRFFT in Solomon Islands

Johannes (1999) stated that an Australian invested in a Hong Kong-backed company called *Ika Holdings*, which started the LRFFT in Solomon Islands, in 1994, at Vella La Vella Lagoon in Western Province. The company initially fished throughout the year but this proved not to be viable. This was largely due to substantial post-harvest losses from poor handling, storage and transportation of live fish. Pulse fishing, targeting seasonal grouper spawning aggregations was adopted, first in Marovo Lagoon then in Roviana Lagoon. Smith & Johannes (2000) noted that *Ika Holdings* closed down in 1997, as a result of the Asian economic crisis, but the same people started a new company called *Asia Pacific Imports and Exports Company Ltd*, owned by three Solomon Islanders and one Australian (SIFD, 1999). This company expanded the operation to include the remote northern atoll of Ontong Java. The regions in Solomon Islands where the LRFFT was practiced are indicated in Figure 1.

Concern about the LRFFT in Solomon Islands arose in November 1997, when a foreign investor surveyed Isabel Province for possible fishing grounds (ACIAR, 1999). The company was issued with a license to buy a variety of marine resources from local reef owners, including live fish (Smith & Johannes, 2000). However, the vessel carried equipment consistent with that found on-board cyanide fishing vessels in Indonesia and the Philippines. In response to complaints from the Arnavon Marine Conservation Area Management Committee, advice was sought, by the Solomon Islands government, from a leading tropical fisheries consultant, which later resulted in a moratorium, imposed on all new live fish export licenses, on the 6th February 1999. A preliminary assessment of the trade was undertaken in December 1997. Problems identified included under-valuation of live fish, under-payment for live fish and biased weighing and under-reporting of the amount of fish exported. Primarily, fishing during spawning aggregations was the catalyst for immediate action to develop a strategy to manage the LRFFT in Solomon Islands (ACIAR, 1999). The extent of the live fish catch in the three regions where the trade operated is shown in Table 1.

Table 1. Live fish purchased by *Ika Holdings* in the Solomon Islands, 1996 - l998

Region	1996	1997	1998	**TOTAL**
Marovo Lagoon				(unit: kg)
Telina	12,585	11,668	8,459	**32,712**
Vacambo	7,660	5,968	5,886	**19,514**
Uepi (Charapoana)	5,014	6,800	8,666	**20,480**
Ketoketo	43	6,874	4,823	**11,740**
Tamaneke		2,646		**2,646**
Ramata			3,036	**3,036**
Mbili Passage			3,469	**3,469**
Total	**25,302**	**33,956**	**34,339**	**93,597**
Roviana Lagoon				
Sasavelle	6,529	3,368		**9,897**
Hapai		5,130		**5,130**
Nusahope		1,067		**1,067**
Total	**6,529**	**9,564**		**16,093**
Ontong Java				
Kemalu (base)			11,071	**11,071**
Sunset (near Pelau)			6,594	**6,594**
OJ (Luaniua)			2,461	**2,461**
Total			**20,125**	**20,125**
TOTAL	**31,831**	**43,520**	**54,464**	**129,815**

Source: Johannes (1999)

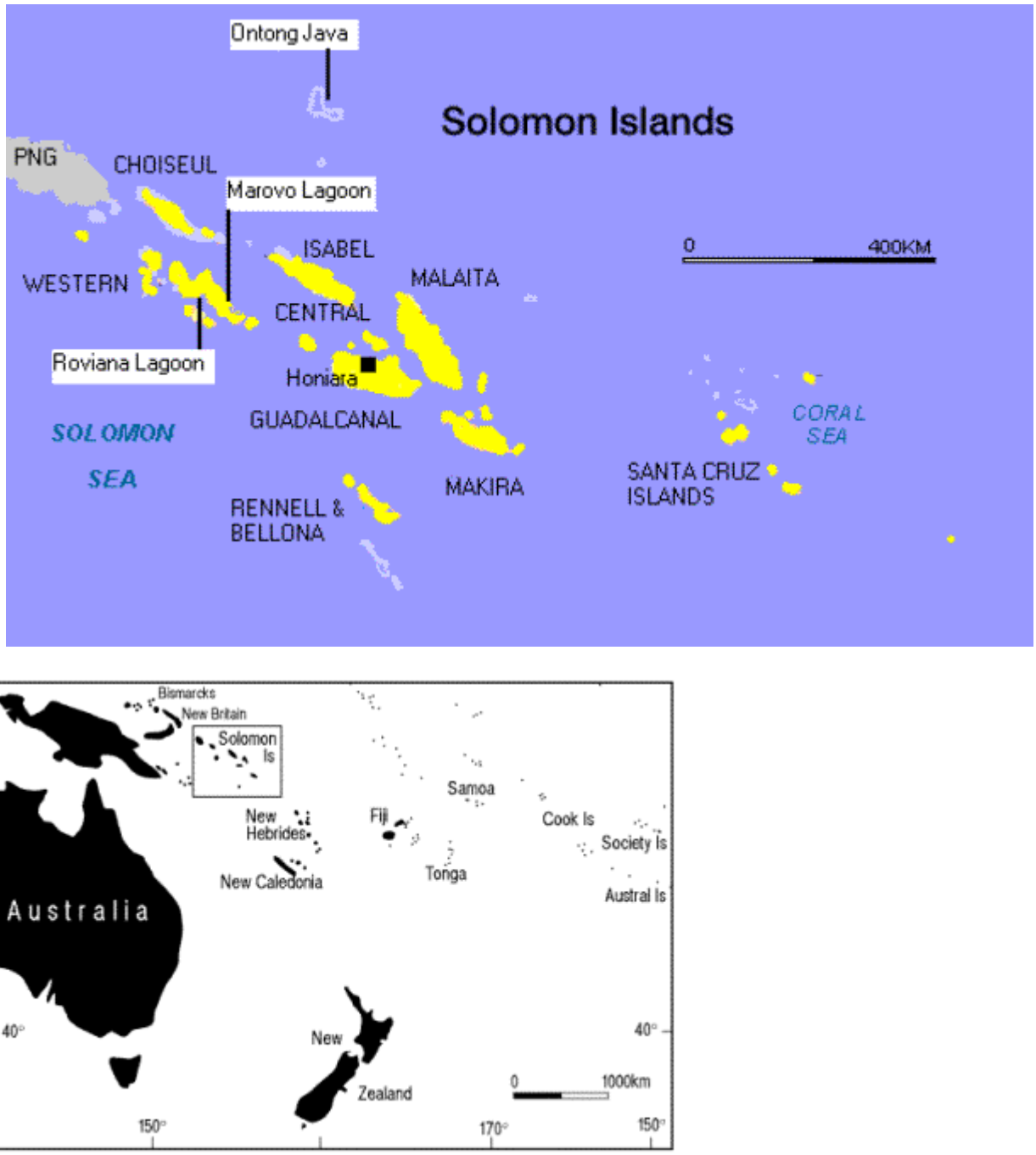

Figure 1. Location of the regions where the LRFFT was practiced

The important target species in Solomon Islands are the square-tailed coral trout (*Plectropomus areolatus*), camouflage grouper (*Epinephelus polyphekadion*) and the flowery grouper (*E. fuscoguttatus*). All three species aggregate to spawn in overlapping locations, seasons and moon phases, but the timing of these aggregations varies among the three regions where the trade was practiced. Another important species is the leopard coral trout (*P. leopardus*). Aggregations of these species, however, are smaller and more scattered (Zeller, 1998). The beginning and end of the spawning season varies by about a month from one year to another so fishers stored their live catch in holding pens prior to the arrival of the LRFFT company. Johannes (1999) pointed out that twice a month, during the fishing season, the company vessel would tour the lagoon to pick up the live fish. The seasons are distinct from region to region. In Marovo Lagoon, the peak spawning season is from February through June; in Ontong Java, the company operated from June until September; and in Roviana Lagoon, the season is roughly from October through January. In this regard, the company was able to operate all year and still able to target seasonal spawning aggregations.

Initially, live fish were caught by local fishers and then stored in floating holding pens, which were usually owned by the company, but overseen by a local villager. Twice a month, the company vessel, the *John Franklin*, collected the fish and transported them to the company facilities at Liapari in Vella La Vella. The fish were then held until a quantity was collected that was sufficient to justify ordering a large LFTV from Hong Kong to collect them (Johannes, 1999). Activities in the LRFFT, however, were not regularly monitored, principally because of a lack of resources in the SIFD. This has resulted in a poor understanding of the status of the fishery. This paucity of resources is exemplified by the fact that the LRFFT was in operation for two years before SIFD became aware of it. This serves also to highlight the unconnectedness that exists between government officials in Honiara and activities in remote villages in outlying provinces. The interim moratorium on the export of live fish is due to remain in force until such time as a Plan of Management, for the LRFFT, is completed in July 2001.

There are a number of other difficulties that hamper integrated and cohesive management of the LRFFT in Solomon Islands. There is poor communication between national and provincial governments and between Ministries. The Foreign Investment Board, for example, issued a fisheries-based investment license with no prior consultation with SIFD. During the moratorium, the Western Province government issued a business license to a company called *South Pacific Live Fish and Marine Export.* The company then bought live fish from fishers in Marovo and Roviana Lagoons. *South Pacific Live Fish and Marine Export* is the same group of people as *Ika Holdings* and *Asia Pacific Imports and Exports Company Ltd*. The company also changed the name of their vessel from *John Franklin* to *Western Star.* The company exploited administrative loopholes and government fragmentation to continue operating on a limited scale, in anticipation of the rumoured lifting of the moratorium. On the 18th December 1999, the *Western Star* sank when it struck a reef outside Monggo Passage in Marovo Lagoon. The vessel was transporting almost two tonnes of live fish from Sasavelle Village in Roviana Lagoon to holding pens at Vacambo Village in Marovo Lagoon (Smith & Johannes, 2000). The vessel has since been replaced. Reports also reached SIFD from Hong Kong that shipments of live fish had arrived from Solomon Islands. The precise origin of these shipments is unknown.

In Marovo and Roviana Lagoons, alternative income-generating opportunities from fishing are not as lucrative, in the short term, as the LRFFT. Aside from weekly shipments of fish on ice to Honiara, there is a fisheries centre in both Marovo and Roviana Lagoons. However, the centre in Marovo Lagoon, near the airport at Seghe, is a prohibitive distance for fishers to travel with their catch, given that most fishers have only a wooden paddle canoe. The fisheries centre in Roviana Lagoon is located centrally in Munda, a more populous and developed town than Seghe. Most Roviana villages are in close proximity to Munda. Fishers are able to sell their catch directly, and easily, to the centre. There is also a tourist resort that buys local catch and the Solomon Taiyo cannery at Noro, which employs people from Munda and the surrounding area. Johannes (1999) stated that fishers in Roviana Lagoon complained that the price difference between live and dead fish was not substantial given the level of post harvest mortality in the LRFFT. Even in Hapai, the Roviana village involved in the LRFFT situated furthest from Munda and its markets, villagers stated that unless the company offered higher prices, they would be unperturbed if the company did not return.

Many fishers in Marovo Lagoon are anxious to see the moratorium lifted. In interviews, conducted in February 2000, fishers expressed exasperation at the closure of the fishery. They pointed out that spawning aggregations had been fished for generations and that the money from the LRFFT alleviated the, sometimes prohibitive, cost of living in the villages. Villagers are sometimes suspicious of government representatives, particularly those from SIFD, because there is a customary system of fisheries management, and some villagers resent interference from Honiara. In other cases, villagers welcomed the closure because they resented the LRFFT company. Prices paid for live fish in Hong Kong restaurants are well known among village fishers as a result of an awareness campaign conducted by SIFD. This campaign generated a degree of angst, levelled at the LRFFT company, from village fishers. However, the issue of prices paid, in many cases in Marovo Lagoon, has overshadowed consideration for the destructive impacts of fishing spawning aggregations. Many fishers are prepossessed with the idea that the moratorium should be lifted and the company forced to pay more, per kilogram, for live fish.

In Ontong Java, village chiefs in Pelau Village confiscated the gear belonging to the LRFFT company as a result of reluctance, by the company, to pay the agreed royalty. There was also

concern from the Chiefs regarding the high level of post harvest mortality. Interviews with fishers, conducted in November 1999, indicated that fishers were eager for the moratorium to be lifted. However, there are lucrative alternatives for fishers through bêche-de-mer and trochus collection. Recent reports indicated that the Council of Chiefs in Ontong Java was not prepared to allow the LRFFT company to operate in their waters. Table 2 indicates the prices paid to fishers for the live fish catch.

Table 2. Price paid to fishers and villages for live fish since the LRFFT commenced

Year	Price paid to fishers	(AU$/US$) 26.05.2000	Price paid to village	(AU$/US$) 26.05.2000
1994	SBD$2.50 kg^{-1}	($0.88/$0.50)	0	(0)
1995	SBD$4.00 kg^{-1}	($1.40/$0.80)	0	(0)
1996	SBD$5.00 kg^{-1}	($1.75/$1.00)	0	(0)
1997	SBD$5.00 kg^{-1}	($1.75/$1.00)	SBD$0.50 kg^{-1}	($0.18/$0.10)
1998	SBD$5.00 kg^{-1}	($1.75/$1.00)	SBD$0.50 kg^{-1}	($0.18/$0.10)

Source: SIFD & TNC (1999).
NB: Any fish larger than 8kg fetched fishers the price of an 8kg fish only (Johannes, 1999).

The legislative framework, which management of the LRFFT must adhere to, is contained in the *Fisheries Act* (1998). The Act seeks to optimise utilisation of marine resources, but exploitation must be developed in a sustainable manner. Prior to the assent of this Act, legislative objectives were to ensure that fisheries resources were exploited to the maximum extent. Under the Act, current objectives are to ensure the long term conservation and sustainable utilisation of fisheries resources. The Act provides for an enhanced role of Provincial government and clear recognition of customary rights. Customary reef owners are now active participants in the licensing process. Permission from a customary reef owner is required in order to obtain Provincial government approval, which is, in turn, required before a National government license can be issued. There are currently no holders of live fish exporting licenses and the moratorium prevents the issuing of new licenses (SIFD & TNC, 1999).

It is necessary for the focus of management of the LRFFT to centre on empowerment of traditional clan groups. The first level of enforcement must be from the customary owners, who have a vested interest in maintaining their fisheries resources. Additional enforcement would need to come from Provincial and National government. SIFD resources are inadequate to properly enforce the live reef fish regulations in Solomon Islands. Provincial fisheries officers need to conduct workshops that inform customary owners of the management structure and legislative framework. Other information and training needs include:

- live fish handling, storage and transportation techniques;
- a broad description of the population dynamics of the key target species; and
- differentiation between the effects of targeting spawning aggregations for subsistence and that of doing so to meet the demand of an international market.

Data collection at village level, with a consistent format, and a program that monitors the occurrence and extent of spawning aggregations, needs to be undertaken. Currently, fisheries officers are not adequately trained, and resources to achieve adequate training and to facilitate workshops, are limited.

8. Biological implications of fishing for the key target species in Solomon Islands

The timing and location of spawning aggregations of the important target species is well known to local fishers. In Marovo Lagoon, for example, these aggregations have been targeted for subsistence

for generations. The problem of intensive targeting of spawning aggregations for the LRFFT in Solomon Islands is exacerbated by the nature of the consumer demand. Most groupers are protogynous hermaphrodites. Individuals begin their reproductive life as females but change to males as they age and grow (Randell *et al.,* 1997). Lau & Parry-Jones (1999) stated that plate-sized fish are preferred because they can be served whole to diners. These fish are usually females and are preferred for eating upon closing a business deal or as a mute declaration of status. Larger specimens (usually males) are served whole at banquets such as weddings and birthdays. As fishers target the aggregations in great number, the removal of large numbers of breeding-aged females may have disastrous ramifications for the availability of fish in future spawning aggregations at a particular site, and for the sex ratios that typically occur within the aggregations.

Female groupers characteristically outnumber males in aggregations (Zabala *et al.*, 1997). However, this is generally at the peak of the aggregation when the actual spawning activity is at the optimum level. Upon arrival at an aggregation site, male groupers aggressively establish territory (Zabala *et al.,* 1997; Johannes *et al*., 1999). Female groupers arrive several days after the males and typically, several females attend each male. In a heavily fished passage in Palau, however, Johannes *et al.* (1999) found that male *P. areolatus*, uncharacteristically, outnumbered females 5:1. The courting behaviour of males included harassment of females by several males at once, which sometimes resulted in females leaving the aggregation site without releasing gametes. This contrasts with the courting behaviour of males in a lightly fished passage in the same study, where females outnumbered males and there was no such harassment. Johannes (1989) recorded the same orderly behaviour of males within a spawning aggregation in Solomon Islands where the sex ratio was skewed in favour of females.

Heavily fished grouper spawning aggregation sites, resulting in a shortage of females, may alter the courtship behaviour of males and have a deleterious effect on the number of fertilised eggs released. Sadovy (1996) pointed out that there is a clear link between a reduction in the adult population from heavy fishing pressure and declines in subsequent recruitment if the adult biomass falls below critical levels. Local demographic conditions are believed to influence the stage of development at which sex change occurs. Shapiro *et al.* (1993) suggested that female *Epinephelus guttatus* evaluated future reproductive success, and the best time to change sex, from information that would only be available within an annual spawning aggregation. A decrease in males would result in some females changing sex to compensate for the shortfall of reproductive potential. Sadovy (1996) stated that factors that induce sex change, either behaviour, sex ratio or relative size (or a combination of these factors) have been implicated in the inducement of sex change, but never absolute size or age. These adaptive characteristics must be seen as a mechanism of homeostasis, whereby equilibrium is maintained against normal background variation in the sex ratio. The specific targeting of smaller groupers and coral trout for the LRFFT is a shock event and cannot be compensated for, in the short term, by such behavioural adaptation.

Spawning aggregations of *P. areolatus, E. polyphekadion* and *E. fuscoguttatus* tend to overlap in time and space. Intensive fishing pressure during spawning aggregations of these species risks serious depletion of current stocks, lower participation in subsequent spawning aggregations, and reduced egg output from aggregations, now and in the future. These fish display a high degree of fidelity to particular spawning aggregation sites. Females may return to spawn at a particular site more than once in a spawning season and males often return on numerous occasions. Female *P. areolatus* travel in schools for periods before reaching and after leaving spawning aggregations, possibly as a means of minimising predation (Johannes *et al.,* 1999). However, fishers exploit knowledge of behaviour and ecology, such as cyclical rhythms and migration behaviour, to maximise their catch and/or to minimise their effort (Parrish, 1999). Targeting of female schools heading to or from spawning aggregations could be an important source of mortality that contributes to a low female:male ratio, thereby disrupting reproduction of *P. areolatus* within the aggregation (Johannes *et al.*, 1999)

Spawning behaviour of *P. leopardus*, observed by Zeller (1998), indicated that the aggregations were small and comprised several sites within a small geographic range. Individual sites were found to be vulnerable to increased fishing pressure. Samoilys (1997) concurred but added that the spatial and temporal predictability made the sites amenable to specialised management such as spatial or temporal closures. Zeller (1998) found that males spent an average of eight times as long at aggregation sites as females and made several times as many trips to those sites. Consequently,

males were considered more vulnerable than females to fishing. Samoilys & Squire (1994) stated that *P. leopardus* spawned only in pairs and found that spawning in the aggregations occurred only for a short period at sunset. The greater vulnerability of males and the paired spawning behaviour may increase the potential for sperm limitation in the aggregations of this species.

9. Likely social and economic implications of the LRFFT in Solomon Islands

Social and economic implications of the LRFFT in Solomon Islands differ within the regions in which the trade has been pursued. The relative value of the resource, both in terms of current and potential financial return, and as an integral component of the diet of villagers, may determine the extent to which the resource is exploited or conserved. The presence of alternative income sources for villagers might also determine the relative value of the LRFFT target species; and proximity of villages to passages may determine the degree to which the LRFFT target species fulfil dietary requirements. Local tastes, or preferences, for particular species as a food source can also affect the value of the LRFFT target species. The extent to which disputes over access to fishing grounds and the payment of royalties may arise and escalate, could be dependent on either or both of these factors.

9.1 Marovo and Roviana Lagoons

In the Melanesian regions of Marovo and Roviana Lagoons, in Western Province, the close proximity of villages to passages has a profound effect upon the relative importance of the target species in the trade to the diet of villagers. Villagers have fished in passages and spawning aggregations for subsistence for generations. Consequently, a major component of the diet of these people is species of grouper and coral trout, known collectively as *pajara*. Villagers typically fish from dugout wooden paddle canoes and use a handline consisting of fishing line coiled around a glass bottle. Villagers who are situated further from a passage might fish in the lagoon and their catch is predominantly Carangids, known collectively as *mara.* There is a market for their finfish catch in the fish and produce markets of Honiara. Subsistence fishing is sometimes conducted by spearfishing in the nearshore environment. Varieties of *pajara* caught in this way include *Cephalopholis miniata,* small (female) *Plectropomus* spp. and some smaller *Epinephelus* spp. (*e.g. E. merra* and *E. areolatus*).

Many villagers in Marovo Lagoon welcomed the LRFFT. Lack of refrigeration dictates that fishers in Marovo Lagoon fish for the Honiara market for the two days before the weekly appearance of the transport vessel. The SBD$4.00kg^{-1} that fishers receive for their catch is only marginally less than that which the LRFFT company paid them during the operation of the trade (SBD$5.00kg^{-1}). However, the returns were much higher in the LRFFT due to the intensity and timing of the fishing effort. Fishers targeted the spawning aggregations in great number, often for two periods of six to eight hours, six days per week (unpublished field data). The company operated in the regions only during the period of peak spawning activity.

Depletion of *pajara* stocks in Marovo Lagoon might however, result in alteration of the diet of villagers. The human population growth rate in the area suggests that such depletion would result in greater pressure exerted on fish stocks, including recovering stocks of *pajara*, which could prolong or even prevent stock recovery, such as occurred in the Philippines and Indonesia. Spawning aggregation sites were verified by gonad inspection, and spawning fish quantified at three sites in Marovo Lagoon in February 2000. The sites were verified as spawning aggregation sites, but the number of spawning fish was so small that the sites were declared “heavily overfished” (Squire, *pers. comm*., 2000).

Villagers’ daily life during the LRFFT was focused heavily on maximising fishing effort. Tasks that were typically carried out by men and women in the household were left solely to women or they remained uncompleted as women also fished in the trade. Neglect of vegetable gardens and house

maintenance and reduced general family unity are, apparently, consequences of the LRFFT in Marovo Lagoon. Money earned from the trade helped villagers pay school fees and better provide for their families, but the returns were not so great that long term benefits such as solid roofing and drinking water retention could be seen as widespread. There is little to reflect the SBD$0.50kg^{-1} royalty paid to the village, and this is the subject of unrest among some fishers. Marovo Lagoon is characterised by traditional woodcarving. Carvers interviewed indicated that, during the LRFFT, they engaged in fishing only and ceased carving completely.

The exertion of extraordinary fishing effort during the LRFFT obtained relatively high returns but the benefit is likely to be short term, and is not reflective of the likely opportunity costs. External costs in the form of reduced future subsistence catches, neglect of important village activities, increased dependence on cash and, possibly, some degree of social dislocation need to be factored into the analysis of costs and benefits from participation in the LRFFT.

An associated matter is that of the distribution of economic rent (see Box 1 below) from the exploitation of resources for the LRFFT. As owners of the resources, the villagers in the areas in which the fishery operates should be entitled to a significant share of the economic rent appropriated from the fishery. However, it is quite likely, although not yet proven, that others appropriate the majority of the available rent in the marketing chain, including the exporting company and the wholesalers and retailers in the end markets. The chance to garner the available rent is a significant inducement to participate in the fishery, and there are strong arguments that the resource owners should be the principle recipients of the rent. Both economic theory, and experience elsewhere in fisheries, suggests also that the ability to appropriate rent results in overexploitation of the resources in question and, ultimately, to the dissipation of the rent. That is, the rent is competed away as more fishers enter the fishery and the resource becomes depleted.

A related important matter is that of post-harvest losses. The apparently high level of post-harvest losses in the Solomon Islands' LRFFT amount to significant economic losses, which equate to lost economic rent. So the waste that occurs through poor post-harvest handling, storage and transport systems, not only represents biological waste, but also significant economic losses.

Box 1: Economic Rent

Economic rent, according to the Pareto definition, is the payment to a factor in excess of what is necessary to keep it in its present employment. In sectors such as fisheries and forestry, rent is the economic surplus over and above normal profits earned from the exploitation of those resources. The opportunity to appropriate rents is a significant factor in attracting fishers and other resource users into various industries and activities.

Relate
to the
issue of economic rent and to overexploitation of fishery resources, are the important policy issues of equity and efficiency (Box 2). These represent two important guidelines in framing policy for the sustainable use of a nation's natural resources. Equity, or fairness, both amongst people in this generation, and between people in this generation and those to come, is a cornerstone of sustainable development. Overexploitation of a resource by one group in this generation will deny others, both now and in the future, a similar level of access to that resource. Economic efficiency in resource use must also be achieved if sustainability is the desired outcome.

Box 2: Equity and Efficiency

Equity, in relation to natural resource use, means that all people in this

generation have the same access to resources (intra-generational equity); it also means that future generations will have access to a stock of resources no less than that which is now available (inter-generational equity).

Efficiency means that the best possible use is made of scarce resources, and that the net social benefit from the use of those resources is maximised.

9.2 Onto Java

In Polynesian Ontong Java, the villages of Luaniua and Pelau are a considerable distance from passages that might host spawning aggregations. Fishers must travel to the passages in canoes powered by outboard motors at considerable expense due to the relative scarcity and high cost of petrol. This distance precludes most subsistence fishing in the passages. Consequently, LRFFT target species do not feature prominently in people's diet. There is no market for their finfish catch due to the isolation of the atoll from major markets. The primary fishing interests are the harvesting of bêche-de-mer and trochus, which are harvested in alternate years. These fisheries earn villagers a year round income. During the trochus-fishing year, the bêche-de-mer fishery is briefly opened from mid-November to mid-December to assist villagers with the payment of annual school fees. The LRFFT, conducted for just one year, was the cause of consternation for villagers due the company's reluctance to pay the SBD\$0.50kg^{-1} royalty to the communities.

Given the small population, the low usage of the LRFFT target species in the diet, and the relatively large size of the region, the impact of targeting spawning aggregations is unlikely to be as devastating as the impact on Marovo or Roviana Lagoon sites. However, these impacts are yet to be assessed. The distance between the villages and the passages often resulted in the men of the household setting up a camp on an island nearby to the fishing grounds, returning only on weekends, usually for the Sunday church service. Women in Ontong Java did not usually fish in the LRFFT. Disruption to family unity, the division of labour and the consequent disruption to vegetable production, reduced provision of food from subsistence fishing and the absence of a male role model for the many children are some of the potential social repercussions of the LRFFT. Houses are typically made from pandanus timber and leaf. They require relatively high maintenance, particularly after stormy weather. During the LRFFT, most of the men of the village were absent and these jobs were left until they returned. Some fishers who were interviewed in Pelau in November 1999 were still fishing for live fish in this way, in anticipation of the lifting of the moratorium on the export of live fish.

9.3 Property Rights

Customary rights to tenure of land and sea resources have evolved over generations and form an integral basis for the management of marine resources today. Hviding (1996) and Aswani (1997) described Melanesian kin-based groups as *butubutu*. These groups have access or use rights to certain areas of home reefs. Through intermarriage and other relationships, there has developed primary and secondary rights owners. Johannes (1999) noted that primary owners dictate who can exploit the resources within their area of land and sea resources. Secondary rights owners may exploit these resources freely for subsistence, but must seek permission to do so for commercial purposes. Such permission need not necessarily be granted. In this way, monitoring of resource exploitation can be effected. Primary resource owners have a vested interest in preserving the resources within their compounded land and sea territorial unit. Knowledge of fish behaviour and of moon, tide and seasons enables villagers to monitor and interpret changing ecological circumstances and adapt their relevant regulations accordingly.

In Marovo Lagoon, however, where there are many villages in a relatively small geographical area in the South-East of the lagoon, disputes arise over primary use rights in some circumstances. The

royalty of SBD$0.50kg^{-1} paid to participating villages by the LRFFT company has been the subject of a heightened dispute over ownership of Lumalihe Passage. Telina village was paid the royalty but the people of Rukutu village claim that the primary user right belongs to them and, therefore, the royalty should be paid to them. This is the subject of a protracted court battle, causing division within the lagoon as people side with one or other of the protagonists. What becomes of the royalty is also a matter of consternation among some fishers. Allegations of misappropriation of the royalty by village Chiefs serve to undermine the authority of the Chief and the system of protocol in general.

In Ontong Java, the two villages each have a Paramount Chief and a House of Chiefs. When discussion is warranted for matters concerning the atoll as a whole, a meeting of the Council of Chiefs - a combination of the House of Chiefs from each village - is called. Collaboration between the villages, well-known and well-regarded boundaries of tenure, and influential leadership mitigates the problems associated with marine tenure that have arisen in Marovo Lagoon.

10. The issue of bycatch and its use

The haul of non-target species has been identified as a major source of concern linked to the LRFFT. Fishers who participated in the LRFFT in Solomon Islands often incurred an incidental bycatch of non-target species. Based on interviews with fishers in Ontong Java in November 1999 and in Marovo Lagoon in February 2000, the amount of bycatch ranged between 50 and 80 per cent of the total catch. Johannes *et al.* (1999) found that at least 57 species of reef food fish spawned in or near the grouper aggregation sites in Palau. Fishers targeting grouper spawning aggregations in Solomon Islands stood to catch a variety of species as incidental bycatch.

The fate of the bycatch was largely dependent on the region in which the trade was practiced. In Ontong Java, where passages are typically a long distance from villages, fishers established temporary camps nearby to the passages. Men stayed away from the village during the week, during which time they fished intensively for live grouper and coral trout. The fishers consumed as much of the bycatch as they needed. However, as they did not return to the village until the weekend, they took back only the bycatch that was caught in the day or two before returning, because there was no way of keeping the fish fresh. For the remainder of the week, most of the bycatch was essentially wasted. There is no alternative market for finfish in Ontong Java. The LRFFT company bought some smaller fish, at a reduced price, to feed the captive fish.

In Marovo Lagoon, most fishers returned to the village to sleep. Some fishers, however, established camps on islands nearby to passages. In some instances, whole families inhabited the temporary dwelling. Men, women and occasionally children exerted varying levels of fishing effort in order to maximise the catch. Most of the bycatch in Marovo Lagoon was utilised. The transport vessel for the Honiara markets arrives, with eskies and ice, once per week. Bycatch that was caught in the day or two before the vessel arrived was sold to that market. For the remainder of the week, the bycatch fed the fishers in temporary camps or was taken back to the village and shared. In the final two years of the operation of the LRFFT, prior to the moratorium, one Marovo fisher explained that due to the intensity of the fishing effort – there was usually 30 or more fishers in close proximity to each other for up to 16 hours per day – the size of the catch was often less per individual than at other times of the year, particularly for the LRFFT target species.

Fish caught in passages are often hauled in from a depth of more than 20m. Johannes & Lam (1999) stated that fishers were instructed by the LRFFT company to pierce the swollen swim bladder where it protrudes from the mouth and anus. However, to do so allows bacteria to enter the gut cavity and this results in septicemia and the death of the fish, often infecting other fish within the holding pens (Squire, *pers. comm.,* 2000). Fishers interviewed, who were fishing for live fish in anticipation of the lifting of the moratorium, indicated that they did not know how to deflate the swim bladder of fish that had been caught at depth without causing it to die shortly thereafter. A recent fish-handling workshop, conducted in Marovo Lagoon for the benefit of Fisheries personnel, taught proper swim

bladder deflation techniques and emphasised that non-target species should be deflated and returned to the water. An inherent consequence of generations of subsistence fishing is that returning a caught fish to the water is an alien concept. However, due to lack of refrigeration and the fact that extraordinary fishing effort is exerted during the pulse fish of the LRFFT, consideration needs to be given to mitigation of the bycatch problem, particularly in Ontong Java. Village level fish-handling workshops are scheduled, primarily to reduce the level of post harvest mortality, but the opportunity also exists to address the bycatch issue at the grass roots level.

11. Management strategies for inshore marine fisheries[1]

Management of the various inshore fisheries, including the LRFFT fishery, involves a combination of customary and institutional management systems. Village decision-making systems in Solomon Islands underpin customary marine tenure, which deals with reefs, lagoons, coasts, open sea, and islands and islets contained within the overall seaspace. Importantly, the property rights that support customary marine tenure are mostly well-specified, meaning that village leaders have substantial control over their custom areas. This is particularly the case when commercial exploitation of inshore resources is desired or occurring. Conversely, subsistence fishing is less strictly controlled in most areas, with the approach often approaching a situation of open access to marine resources.

The new Solomon Islands *Fisheries Act* (1998), for the first time, recognises the need for government - the institutional sector - to give more power to traditional resource owners who can then take responsibility for the management of their own property. The focus has shifted towards management being based on property rights, rather than on centralised and institutional regulations.

Individual user-rights in most Pacific societies are over-ridden by community obligations, including participation in decisions about resource use and management. Resource users also agree to abide by communally imposed measures to protect scarce resources, agree to report infringements of agreed conservation and management measures, and participate in rituals designed to enhance resource productivity and longevity. In most areas, these communal obligations are administered and controlled by the village chiefs and or Councils of Chiefs. While there are some variations in approach between the Melanesian areas of Marovo and Roviana, and the Polynesian region of Ontong Java, the chiefs typically have considerable status and decision-making power.

While customary management systems, particularly when supported by institutional systems, have much to offer to the management of inshore fisheries such as the LRFFT, they tend to come under increased pressure when commercial considerations become significant. Pressure from outside entrepreneurs, coupled with the desire for increased cash incomes at the village level, have the potential to undermine customary marine tenure and management systems. It is for this reason that supporting government legislation is important to the management of the resources in question. Furthermore, the government has an important role in the education of village fishers who may not fully understand the medium and long-term impacts of certain fishing practices, such as the targeting of spawning aggregations. Again, education will support appropriate management, at the village level, of inshore marine resources.

12. Existing village-based monitoring systems

Monitoring of resource inventory and rates of exploitation is integrally linked to the system of customary marine tenure. Almost all Pacific Island societies traditionally apply some sort of marine tenure as the basis of management, whereby local communities manage local fisheries, particularly the non-commercial food fisheries that make up the majority of the catch (Adams, 1998). In Solomon Islands, customary marine tenure evolved from the lack of indigenous separation of land and sea spheres of ownership (Aswani, 1997). The guardianship of resources of specific areas of barrier reefs, lagoon and open sea form part of the territorial rights that are associated with ties to a particular kindred group or *butubutu.* Access rights to marine resources are dependent upon the strength of the kindred association. An important aspect of customary marine tenure is the

recognition that primary rights owners formulate and enforce management of their own marine territory (Fong, 1994).

Hviding (1996) described the Marovo *kastom* regarding mutual help and food giving as being a crucial link in the premise that everyone is allowed to fish anywhere for subsistence. Hviding qualified the premise by emphasising that *everyone* actually meant Marovo people only. People who are not from Marovo are not entitled to use Marovo fishing grounds for any purpose. Primary rights owners decide who can fish in the waters of the marine estate of a particular butubutu. In this way, the number of people removing fish from home reefs is generally known. Restrictions on the exploitation of the resources are based on the knowledge gained from generations of intimate association of fishers and the underwater environment. Hviding & Baines (1994 p.28) stated that "the practical, behaviour-oriented and observation-based nature of Marovo people's knowledge of the marine environment, focusing as it does on the fluctuating and changing abundance of important food species, is relevant to fisheries management in the sense that it provides an admirable basis for the monitoring of fish stocks".

Prohibitions on the types of fish that could be caught and on specific fishing grounds were practiced for many generations. There were closures in preparation for ceremonial feasts such as those connected with funerary rites and there were closures whereby areas of reef would be opened and closed on a rotational basis (Hviding, 1996). These closures are likely to be a response to localised overfishing. Johannes (1988) stated that marine resources have always existed in quantities surplus to the requirements of the local population. There was little conservation ethic due to little exploitative pressure exerted on the resources. Therefore, when an export market develops and places added pressure on resources, fishers are often unaware of the vulnerability of the resources to overexploitation. Gillett (1999) added that, in some cases, the authority of local traditional leaders has eroded. Johannes (1998a) noted that erosion of traditional authority was often the result of centralised fisheries management that was ignorant of pre-existing management structures. Such cases demand integration of modern and traditional management in order to reinstate a functional property rights structure, underwritten by appropriate legislation.

In other countries, where declining fish stocks have necessitated action on behalf of centralised fisheries management, compliance with management initiatives has relied heavily on integration with traditional management systems. In Samoa, King & Fa'asili (1999) found that village groups were willing to partition areas of their marine estate as fish reserves in key habitat areas in an effort to mitigate the decline. Villagers undertook monitoring and enforcement of management initiatives because the degree of benefit and detriment to their own resource base was their responsibility. Fa'asili & Kelekolo (1999) noted that cessation of destructive fishing techniques and overexploitation of marine resources in Samoa was best achieved by the inception of village fisheries by-laws, formulated mainly by the villagers themselves. The most important process was seen to be monitoring and enforcement. Breaches within the village were dealt with using traditional fines of pigs and taro *etc*. Breaches from outside the village community were dealt with through a court of law.

Johannes (1998a) detailed the complexity of traditional rights to marine tenure in Vanuatu. More than 100 language groups adopt differing resource tenure customs. However, exercising the right to exclude outsiders and to regulate activities on fishing grounds is intensifying. Declining fish stocks heightened the urgency with which traditional owners sought to protect marine resources within their estate. The emergence of a number of invertebrate species as important exportable resources challenged the traditional management system concerning sustainable exploitation. A process of cooperative management arose whereby the Fisheries Department of Vanuatu provided advice concerning life histories and population dynamics to resource owners who, in turn, monitored the resource inventory and regulated the level of exploitation within the boundaries of their own tenure.

Johannes (1998b) pointed out that traditional management systems were data-less and yet the prescribed management measures of seasonal closures, size restrictions and restricted entry were no different from that which is prescribed today. He added that the data needed for management were often not cost effective to generate especially when the coastline is of a prohibitive length. Traditional knowledge and long established management methods do not necessarily adapt readily to

the evolution of cash economies, rapid population growth, new export markets, commercial fishing and advances in fishing gear technology. However, the pressure that these changes exert on marine resources hastens demand for management measures to be implemented. The success of precautionary and adaptive management initiatives in Vanuatu (Johannes, 1998a) and Fiji (Fong, 1994), based on education and cooperation with traditional resource owners, emphasises the need to integrate centralised and community based management regimes.

13. Summary

The LRFFT in the Asia-Pacific region offers village fishers the opportunity to increase their income earning potential, a potential desired in communities typified by ever-growing cash dependence. Adoption of destructive techniques of fishing in some countries has, however, rendered unlikely the appropriation of long term benefits from participation in the trade. Use of cyanide in the capture of live fish for the LRFFT is, seemingly, not a widespread problem in Solomon Islands. Fishers seeking to maximise their catch have, instead, intensively targeted grouper spawning aggregations. The five years that the trade operated in Marovo Lagoon, for example, resulted in heavy depletion of stocks of targeted species.

Declining fish stocks have necessitated action on behalf of centralised fisheries management due to the reliance of some villages on the species targeted in the LRFFT for subsistence. Compliance with management initiatives, however, relies heavily on integration with traditional management systems. Enforcement of management measures in Solomon Islands is only possible through the empowerment of local communities who hold the property rights and have a vested interest in the sustainable management of their marine resources. It is important that resource owners are able to differentiate between the impacts on the fishery of meeting subsistence requirements and that of servicing the demand of an international market. Access to such information facilitates informed decision making and results in effective co-management of fisheries resources.

In Solomon Islands, local fishers largely adhere to customary tenure and access rights. Outside investors are obligated to obtain permission from traditional resource owners prior to the commencement of commercial resource exploitation. The basis for integrated co-management of fisheries resources is, therefore, well established. It is the goal of this project to integrate existing customary fisheries management with that of the centralised authority through empowerment of local communities, underpinned by appropriate legislation and clear definition of the property rights of traditional resource owners.

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[1] The manner in which customary marine tenure and village decision making systems are implemented in Marovo, Roviana and Ontong Java, is spelt out in greater detail in Discussion Paper No. 2 in this series: *Managing the live reef food fish trade in Solomon Islands: the role of village decision-making systems in Ontong Java, Roviana and Marovo Lagoons*