South Pacific Regional Environment Programme

SPREP Reports and Studies Series no. 93

Overview of Destructive Fishing Practices in the Pacific Islands Region

South Pacific Regional Environment Programme

Overview of Destructive Fishing Practices in the Pacific Islands Region

by

Joeli Veitayaki*
Vina Ram-Bidesi*
Elizabeth Matthews*
Lionel Gibson*
Veikila Vuki*

**University of the South Pacific, Suva, Fiji*

November 1995

SPREP Library Cataloguing-in-Publication Data

Overview of destructive fishing practices in the
Pacific Islands region / by Joeli Veitayaki ... [et.al.].
—[Apia, Western Samoa] : SPREP, 1995.

vi, 32p. ; 29 cm.—(SPREP Reports and
studies series : no.93)

ISBN 982-04-0124-0

1. Fishing—Oceania. I. Ram-Bidesi, Vina. II. Matthews,
Elizabeth. III. Gibson, Lionel. IV. Vuka, Veikila. V. South Pacific
Regional Environment Programme. VI. University of the
South Pacific. VII. Series.

639.0995

Prepared for publication by the South Pacific
Regional Environment Programme,
PO Box 240, Apia, Western Samoa

Original text: English

Editor
Suzanne Grano

Production
Peter Evans

Typeset in 10/12 New Century Schoolbook and Helvetica
Printed on 80 gsm Tudor R. P. (100% recycled)
by ABC Printing, Brisbane, Australia

P 44/95 – 2C

**Produced with financial assistance from the
Canadian International Development Agency (CIDA)**

Foreword

There have been only a few reports documenting destructive fishing and collecting methods in the Pacific islands region. These reports have tended to focus on the effects these methods have on the fisheries, and only consider environmental effects in terms of those fisheries. Environment and fisheries agencies in the region need reliable information concerning the environmental effects of coastal destructive fishing and collecting practices and suggestions on how to address this problem.

This report looks at the issue of destructive fishing and collecting practices from a broader perspective. Through a review of the current literature, both published and "grey", and via responses from government fisheries and environment staff, this report provides a preliminary assessment of the range, extent and effects of these practices within the region.

The interviews with a number of dynamite fishers in Fiji also provided some insights into the social and economic context in which destructive fishing and collecting are practised. This is an area which should receive more attention within the region, especially in light of population and economic pressures.

Owing to the time limits placed on the preparation of this report, it has only been possible to scratch the surface of the issue in the region. A number of recommendations for further study and action have been provided by the authors and these should receive due consideration for further work in this area.

Vili A. Fuavao

Director
South Pacific Regional
Environment Programme

Acknowledgements

We are grateful to the many people for the assistance they provided in the preparation of this report. To fisheries experts, researchers and officials who responded to our questionnaire and queries, we hope we have correctly related your views and ideas. To our students and postgraduate assistants our heartfelt thanks for the effort. To the police who assisted us and provided information and the fishers and their families who enlightened us with rare information, we thank you for your time, trust and the willingness to share part of your lives with us.

To the University of the South Pacific and other colleagues who in some way assisted in the work, we are grateful. Our *vinaka vakalevu* to SPREP for the opportunity to undertake this review. We are also indebted to the people at USP, SPREP and the external reviewers for their thoughtful comments on our drafts.

To all you good people, we extend our sincere thanks. We alone are responsible for the work and all its shortcomings.

This study was commissioned by the South Pacific Regional Environment Programme (SPREP) and was funded by the Canadian International Development Agency (CIDA).

Contents

Abbreviations and Acronyms

ASEAN	Association of South East Asian Nations
EVAAM	Etablissement pour la valorisation des activités aquacoles et maritime
FAO	Food and Agriculture Organization of the United Nations
FFA	Forum Fisheries Agency
ICLARM	International Center for Living Aquatic Resource Management
IUCN	The World Conservation Union
NGO	non-government organisation
scuba	self-contained underwater breathing apparatus
SPC	South Pacific Commission
SPREP	South Pacific Regional Environment Programme
UN	United Nations
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USP	University of the South Pacific

1. Introduction

1.1 The need

The use of the term "destructive" in regard to fishing practices is subjective because the resulting list could include nearly all of the fishing methods now used. Any fishing method can be destructive if improperly used or used to excess. However, in this study, the aim is to highlight only the methods that cause direct physical or ecological damage. These include the use of explosives, modern poisons, traditional plant and animal poisons, physically destructive practices and other fishing or collecting practices that cause damage to the environment.

Environment and fisheries agencies in the Pacific need both reliable information concerning the environmental effects of destructive coastal fishing and collecting practices, and suggestions on how to address the issues. Considerable information is available from the Asian region but this needs to be reviewed, and its value to the Pacific islands region assessed.

To devise appropriate policies that will minimise destructive fishing and collecting methods there is a need to know more about the people who undertake such practices, and the way in which resource allocation and resource destruction are interrelated. For example, is there a connection between resource depletion and economic impoverishment? If so, does it prevent the more vulnerable people from using long-term resources management practices?

Other important questions concern how benefits of improved resource management can accrue to resource users, and what are the opportunities for, and constraints on, effective community-level resources management and conservation.

The Terms of Reference for the team were to:

(1) review the extent of all destructive coastal fishing and collecting practices in the Pacific islands region;

(2) review the literature concerning these practices in the region and elsewhere;

(3) identify the environmental effects of these practices in the Pacific islands context;

(4) consider the social and economic contexts in which destructive fishing and collecting are practised, particularly in relation to the dynamics of resource allocation (that is, ownership and access) with reference to gender relations; and

(5) provide practical suggestions and guidelines on the actions required to control these practices within Pacific island countries.

1.2 Methods

The team started the project with a series of meetings. The team members, who comprised people from various disciplines and backgrounds, were allocated different tasks.

In compliance with the requirements of the Terms of Reference, a review of destructive fishing and collecting practices was conducted. Part of the review was done with the participation of on-campus and extension students from throughout the region, who were asked as part of the requirements of their University course, "Ocean Resource Management in the South Pacific", to write papers on destructive fishing methods and collecting practices in their countries.

In addition, two graduate students were employed as research assistants to conduct library searches and prepare annotated bibliographies. A literature review was conducted to find information about destructive fishing practices and their environmental effects. The Pacific Islands Marine Resources Information System (PIMRIS) provided a computer print-out of references to the materials listed in their databases. This print-out was then studied to ensure that only material relevant to destructive fishing and collecting practices was included in the References of this report.

Additional information was sought from government personnel from throughout the region (see Annexe 2). Faxes were sent to the directors of fisheries and conservation departments with the following questions:

(1) What types of destructive fishing methods, if any, are most common in your country? Please describe in as much detail as possible, including the compounds or gear used, the species caught, and any effects that have been seen.

(2) What is the trend in the use of destructive fishing practices over the last 10 years?

Increasing ____ Decreasing ____ Same ____

(3) How serious do you think these problems are?

(4) Are there any educational, enforcement, legislative or information programs in place dealing

specifically with destructive fishing practices? What are they?

(5) Have any studies been done in your country (either by government personnel or outside researchers) that assess the impacts of using any of these methods? If yes, please describe and briefly explain the results. Please also give the reference.

Only 13 replies to our queries were received (see Annexe 3). Those replies, however, proved to be very helpful in forming a picture of some of the destructive fishing practices currently used in the region. Several other people involved in fisheries work were also consulted about specific issues. A more comprehensive regional assessment would prove very useful in understanding the true nature of destructive fishing practices in the Pacific islands region.

Finally, interviews with fishers using dynamite for fishing in Fiji's Western Division were conducted to provide insights into the social and economic context in which destructive fishing and collecting are practised (Annexe 1). The Fiji Police were consulted to obtain information about fishers convicted of using explosives. Informal interviews were then conducted with some of these fishers in three villages in north-western Viti Levu; some mine workers at the gold-mine in Vatukoula; the Director of the Division of Mines; and some fishers in the Tavua Market.

1.3 Background

Pacific islanders, like people elsewhere, manipulated their physical environment to ensure their survival. The use of plants to stupefy and kill fish and the employment of destructive fishing practices have been part of traditional subsistence societies. However, although it is true that the use of destructive fishing methods is not new, nothing done before can compare with the intensity and magnitude of the impact of human fishing activity of recent times. With the emphasis on productivity and the large number of fishermen and women using the fisheries, the impacts of destructive fishing practices are much more severe.

The increasing monetisation of fisheries resources and the emphasis on increasing production to satisfy widening demand encourage the widespread use of efficient and often destructive fishing methods. Fisheries resources that are potentially renewable if they are exploited wisely are currently under threat due to over-efficient and destructive fishing practices by Pacific islanders.

By the early 1980s, three-quarters of the countries in the Pacific islands region had reported reef degradation (Dahl & Baumgart 1982). Nearly half of the cases were related to damage from illegal fishing with explosives and poison. Furthermore, in a brief overview of disturbances to reefs in Micronesia, Tsuda (1981) concluded that in the late 1970s using dynamite to catch fish was the most damaging activity found. In addition to the damage caused by destructive fishing, the region's reefs and fishing grounds are subject to a variety of other assaults (Brodie et al. 1990; Dahl 1984; Veitayaki 1994; Zann 1994). These include those that are due to human activities (dumping or leaching of contaminants, sewage disposal, sedimentation due to poor land use practices, dredging and mining, and increasing coastal development) as well as those due to naturally occurring events (storms, crown-of-thorns starfish predation and bleaching of corals). Reef and other habitat degradation can have serious consequences for the future of the region's inshore fisheries. Minimising the negative impacts of people can only help to protect marine resources for the future.

2. Destructive Fishing Methods

Many fishing methods are considered destructive because they are damaging to the environment; they are non-selective, so many species and all life stages of a population are captured; or they are potentially dangerous to the people who use them. Some of the methods are now illegal, such as using dynamite or cyanide to catch fish, but people still persist in their use. Destructive fishing methods can be categorised as follows (in decreasing order of impact on the environment):

- Explosives
- Modern poisons: cyanide, bleach, pesticides
- Physically destructive practices: fish drives, manual breakage of corals
- Traditional poisons: plant and animal compounds that stun or kill fish
- Other methods that lead to overharvest of one or more species

All of these methods have been used in the Pacific islands. Most are used in inshore marine areas, but there are a few reports of their use in rivers and bays. Unfortunately, the magnitude of their use has not been adequately documented throughout the region, although there is a general acknowledgement of their existence and, in some cases, persistence (see Table 2.1).

In general, there is little information on the details of how many of these methods are practised; under what conditions they are in use; of the effects of these practices at the levels that they are in use; or of the extent of their use in relation to other less destructive fishing practices.

Only a few reports specifically document destructive fishing and collecting methods in the Pacific islands region (Cox 1979; Eldredge 1987; Gatty 1947; Paxton & Lewis 1988). Most of these reports focus on the effects of these destructive methods on fisheries; they consider environmental effects only if they are related to fisheries.

Table 2.1 Summary of destructive fishing methods used in the Pacific islands region*

	Plant poisons	Animal poisons	Cyanide	Bleach	Pesticides	Explosives	Fish drives	Manual breakage	Other
American Samoa	X			X		X		X	
Cook Islands	X					X			
Fiji	X	X	X	X	X	X	X		
French Polynesia	X								
Guam	X	X		X					
Hawaii	X			X					
Kiribati							X		X
Marshall Islands						X			
Micronesia	X	X		X	X	X			
Nauru									
New Caledonia	X						X		X
Niue	X							X	
Northern Mariana Is.									
Palau	X	X	X			X		X	
Papua New Guinea	X				X	X		X	
Pitcairn Islands									
Solomon Islands	X				X	X			
Tokelau									
Tonga	X					X		X	X
Tuvalu									X
Vanuatu	X					X		X	
Wallis and Futuna	X								
Western Samoa	X				X	X		X	

* This table summarises information obtained from the literature search and responses from regional fisheries and conservation departments. Specific references can be found in the text.

The illegal and clandestine nature of modern destructive fishing practices complicate a research project of this type. One of the principal reasons that little research has been done regarding many of these practices and their effects in the region is that it is very difficult to find people who are willing to talk about practices they know are illegal. As a result, even fisheries and conservation personnel may not know the true extent and nature of the destructive fishing practices they are supposed to regulate. The responses from throughout the region to our queries revealed a wide range of interpretations of what constitutes a "destructive" fishing practice. They included use of explosives, plant and animal poisons, especially effective types of nets, spearfishing at night with scuba gear, or other practices that caused the localised depletion of some species. Interestingly, although almost every respondent noted some form of destructive fishing in their jurisdiction, only two reported any related studies (in Vanuatu a resource survey mentioned the issue and in New Caledonia researchers tested water from bêche-de-mer processing for its effects on fish).

One exception to this general lack of information, from outside the region, is the outcry and strong public information network that has emerged over the use of sodium cyanide and dynamite in the Philippines. These destructive fishing methods have been used so extensively that many of the once productive fishing grounds, including many coral reefs, are completely ravaged.

Such extreme cases of destruction are useful as examples of the devastating possibilities inherent in many of these fishing practices. Since Asian (or African or Latin American) models are not completely representative of situations in the Pacific, especially in regard to social and economic factors, local examples are used in the following discussion whenever possible.

2.1 Explosives

Unfortunately, although dynamite or blast fishing is illegal almost everywhere in the region, it is a very common means of catching fish. It has been used in American Samoa (Craig, pers. comm. 1995), Chuuk Lagoon (Johannes 1975; Cornelius, pers. comm. 1994), Fiji (see Annexe 1; and Zann 1994), Marshall Islands (SPREP 1992), Micronesia (SPREP 1992), Palau (Johannes 1975), Papua New Guinea (Anon. 1986; Raga, pers. comm. 1995), Vanuatu (David 1994), and Western Samoa (SPREP 1992). According to a survey conducted by SPREP (1988), dynamite is used also in Pohnpei's outer atolls and Tonga's outer islands. Other areas where dynamite use has been documented are Indonesia (Yap & Gomez 1985), Kenya (Saimolys 1988), Malaysia (Johannes 1975; Yap & Gomez 1985), the Philippines (Galvez & Sadorra 1988; Rubec 1988), Sierra Leone (Vakily 1993), and Thailand (Yap & Gomez 1985).

Most explosives are used in shallow water near reefs or near the water's surface (Rubec 1988). Blast fishing began in earnest in the Pacific islands with the explosives made available by World War II. In Palau, for instance, during the war, Japanese troops gave fishermen hand grenades and other explosives to use while fishing (Naughton 1985). There are several reports from around this time (1940s and early 1950s) in *Pacific Islands Monthly* about dynamite fishing in Fiji, New Caledonia and Western Samoa. Dynamite is now obtained in several Pacific island countries through various means. In Fiji, it is sold clandestinely after it has been taken from mining operations. In American Samoa, fishers have obtained small explosives from commercial purse seine operations (Craig, pers. comm. 1995). Construction sites, public works departments, and unexploded World War II materials continue to provide supplies of dynamite (SPREP 1988). Several fishers in Papua New Guinea have lost their lives while attempting to take explosives from old abandoned war bombs (Raga, pers. comm. 1995). In American Samoa (Craig, pers. comm. 1995), Papua New Guinea (Anon. 1986), and Vanuatu (David 1994), at least, the use of dynamite may be declining, partly due to a lack of supplies. However, the Conservation Division in Papua New Guinea noted that dynamite use may be increasing around urban areas as the demand for fish increases (Raga, pers. comm. 1995).

2.2 Modern poisons

Modern poisons kill or physically maim their aquatic targets. In addition, they can be very harmful to the environment, to the people who use the methods, or even to those who eat the poisoned fish. It appears that the shift from natural to man-made poisons was easy. In Palau, for instance, the same term is used for both types of poisons (Johannes 1981). It is not known if the use of modern poisons is more common in places where traditional poisons were commonly used; in some areas such as Solomon Islands and Papua New Guinea, modern poisons do not appear to be as much of a problem, despite the fact that there is a history of use of plant poisons (Diake, pers. comm. 1994; Raga, pers. comm. 1995).

There may be a trend towards a greater use of the more potent, and often readily available, modern chemicals as traditional plant and animal poisons are seen as less effective (Cornelius, pers. comm. 1994). Regardless, these poisons are only used when there is access to them. In Fiji, for instance,

cyanide-soaked rags that are discarded from the gold-mine near Vatukoula are smuggled away from the site for use in fishing. Fertilisers and pesticides can be obtained from sugar cane farms or from local garden suppliers. Lime was obtained by people from nearby quarries. Bleach is readily available in most supermarkets. Once these compounds are obtained, they are used much like traditional poisons. They are sprinkled in the water, or squirted into crevices in the corals and rocks. The stunned or dead fish are then easily collected.

Bleach
Chlorine bleach stuns fish and has been used in American Samoa (Craig, pers. comm. 1995), the Bahamas (Campbell 1977), in Fiji for the capture of freshwater prawns (Veitayaki, pers. obs.), Guam (Lujan, pers. comm. 1995), Hawaii (Johannes 1975), and Tonga (UNESCAP 1990). Bleach was also identified in a brief survey as one of the most commonly used poisons (second only to *Derris* roots) in the Pacific (SPREP 1988). Johannes (1975) observed the effects of bleach fishing in a cave in Hawaii:

> It contained dense schools of 3 species of fishes, populations of palinurid and homarid lobsters, and a rich, colorful encrusting fauna of sponges and tunicates. After the cave was exposed to bleach almost no visible macrofauna remained. Recolonization was far from complete a year later.

Unfortunately, Johannes does not describe in more detail what the fishers captured when they used the bleach. (For example: were fish and lobsters equally sensitive to the effects of the bleach? How much bleach was used? How often was the bleach used? What specific physical effects did the bleach have on the various organisms in the cave?) This is, however, a good illustration of how the use of one poison can alter an entire marine community.

Sodium cyanide
The use of sodium cyanide to poison fish, both for the live aquarium fish trade and for the capture of food fish, has seriously damaged reef systems in the Philippines and Indonesia (Pajaro 1994). Pajaro (1994) noted that it was second only to the use of dynamite in its destructiveness to a coral reef. Cyanide is currently used in the Philippines to collect aquarium fish and in Fiji to catch food fish. It has been reported to have been used by some fishers near Palau and Indonesia collecting fish for Hong Kong's live grouper trade (Rubec, pers. comm. 1994). However, government personnel in Palau have found no evidence for its current use in the grouper fishery (Graham, pers. comm. 1995). Many of the studies on sodium cyanide fishing were done in the Philippines, especially through the efforts of the International Marinelife Alliance, an NGO that initiated a public education and retraining campaign to stop the use of cyanide for the collection of reef fish for the aquarium market. Use of sodium cyanide to catch fish is illegal in most countries in the region.

Pesticides / Fertilisers
Various fertilisers and pesticides have been used successfully to stun or kill fish, often with disastrous results. Temephos was reported to have been used to catch fish in Solomon Islands, paraquat in Western Samoa, and permethrin in Apia's reservoir to catch freshwater prawns (Watts 1993). BHC (gamma — HCH, Lindane), a persistent organochlorin that has been banned in some countries, may be used at times in Fiji to catch fish (Watts 1993), and a timber treatment chemical was used in Papua New Guinea for fishing (Mowbray 1988). Fertilisers and pesticides, such as paraquat and ammonium sulfate from sugar cane farms, are also used occasionally on Fiji's west and north coasts to catch fish. In Kosrae, an unspecified agricultural chemical was used in a stream to catch eels. This killed not only the eels; a few days after the application, the stream was filled with dead eels and fish (Cornelius, pers. comm. 1994).

Other compounds
In New Caledonia, copper sulfate is squirted into the coral crevices where octopus hide. The copper sulfate irritates the octopus's eyes, forcing it to flee from its hole. It is then very easy to capture. Unfortunately, the copper sulfate remains in the corals, making the area inhospitable for another octopus (Farman, pers. comm. 1995).

2.3 Physically destructive practices

Fish drives
A traditional fish drive is a communal activity generally used only when a large amount of fish is needed by a community (for example, for funerals or other events). In Fiji, a fish drive (**yavi rau**) will involve at least a whole village. Plant and animal poisons are often used during fish drives. Veitayaki (1990) described a fish drive that was held in order to catch **tikawa**, a small reef fish. The drive began in deep water at the edge of the reef and proceeded towards the shore where a leafsweep was held. The villagers used long sticks and boat anchors to pound the water and corals as they moved towards the barrier of the leafsweep. The leafsweep was encircled about the fish enclosing them. Before the startled fish were able to escape, a net was used to scoop them into awaiting punts. This whole process may be repeated until as many of the fish as possible are collected.

In New Caledonia, some people use sticks to scare rabbitfish into nets. In addition to the destructive action taken to scare the fish, both large and small

individuals are collected (Farman, pers. comm. 1995).

The following two methods used in the Philippines are included as a warning to Pacific island countries.

A more commercialised fish drive was introduced into the Philippines by Okinawan fishermen in the 1930s. Muro-ami is similar to a traditional fish drive in many respects. However, it is a great deal more destructive because of the scale on which it is used. At depths of 13 to 30 metres, a large bagnet, held open by the current, is set with two detachable wings on either side (100 m long). Two to three hundred boys work as "swimmers" to chase the fish into the net. These boys each hold a scareline, a rope with plastic strips tied to it with a stone weight tied to the end. The boys bounce the scarelines up and down on the corals in order to scare the fish into the net. In 1982, two companies employed about 7000 people to use this method. A study found that, simply by changing the shape of the weight on the end of the scareline, reef damage could be reduced by 50 per cent (Corpuz et al. 1985).

Kayakas is another fish driving method used in the Philippines. Groups of fishers smash corals with sticks to chase fish into awaiting nets. This method is often used in conjunction with muro-ami and dynamite fishing to "squeeze" fish from already overfished reefs (McManus & Arida 1993).

Manual breakage

Small-scale collecting activities that result in the overturning, breaking, or rearrangement of corals also have a local damaging impact. Reef gleaning or other activities that involve large numbers of people walking around on the reefs at low tide, in limited areas can lead to similar damage. In American Samoa this is a problem in areas where people search for fish and octopuses at low tide (Craig, pers. comm. 1995). Some women in Niue collect clams and polychaete worms by smashing open their burrows with iron bars (SPC 1993). In Papua New Guinea, coral heads and boulders are moved to collect fish, echinoids, and other invertebrates (Anon. 1986). Axes, hammers and other metal objects are used to break corals in some areas in Vanuatu (Bani, pers. comm. 1995). In Palau, one of the authors observed women breaking rocks and coral heads to remove the giant clam *Tridacna crocea*. And in Tonga, women and children use bush knives, crow bars, iron poles or hammers when they are reef gleaning. They overturn rocks and corals without replacing them, so the smaller encrusting organisms are exposed. Octopuses that once were caught with lures or by hand are now often broken out of their nests. Men deliberately break coral while collecting giant clams (Chesher 1995).

2.4 Traditional poisons

Information about the use of plant and animal poisons (that is, traditional or "natural" compounds) comes from a variety of sources. Ethnographical and botanical studies of different Pacific island societies that examine fishing practices generally include descriptions of the uses of plant poisons to catch fish (Tueting 1940; Neal 1948). Some papers specifically addressed plants used to poison fish (Buck 1928; Gatty 1947; Gold 1955; and Hornell 1941). In the 1940s and 1950s, several anecdotal pieces were written about the use of plants and animals to poison fish (Barrau 1955; Frey 1951). In addition, at least one fairly wide-ranging analysis was done at that time on the poisons found in sea cucumbers (Yamanouchi 1955). Eldredge's 1987 review of fish poisoning methods includes descriptions of both traditional and commercial poisons and discusses the known effects of many of the compounds used.

Plants

Poisons from plants are used in tropical areas worldwide to catch fish and poison animals. On most islands in the Pacific, using plant poisons was a traditional form of fishing (Table 2.2).

The following examples illustrate how some of these plants were used in Fiji. This list is based on information collected about fishing methods that were in use in 1940. Some of these methods (for example, use of *Derris*) are still practised in many areas in Fiji, although their use in certain areas may be declining (Veitayaki 1990).

(1) **sumalaki**, **tuva**, or **duva**: men or women splash bundles of pounded **duva** stems (*Derris trifoliata* and *D. malaccensis*) in the water near coral heads. Alternatively, girls place bundles of beaten *Derris* bark in holes in the coral. The stunned fish rise to the surface where they are easily picked up or speared. These methods were documented in Kabara and Fulaga, Lau (Tueting 1940; Hornell 1940), but were also widespread throughout the islands.

(2) **tuva ni nikini**: On Kabara, people used the powdered root of New Guinea **tuva** to catch fish. People dive near the reef to chase fish into holes. Women then dive and squeeze handfuls of powder nearby. The fish float to the surface in about 15 minutes. New Guinea **tuva** appears to be quite potent, as "most fish caught this way die after about 5 minutes of play" (Tueting 1940).

(3) **tuva kalou**: A basket of steamed fruit (*Neubergia collina*) is placed in water in the bottom of a boat so the juice mixes with the water. A few cups of this liquid are poured around a "rock" in the water. The drugged fish float to the surface

Table 2.2 Plants used as fish poisons in the Pacific islands region

Scientific name	Parts used	Description / Notes	Areas used
Barringtonia asiatica *B. speciosa*	seed	Tree; active compound is saponin.	American Samoa, Fiji, Futuna, French Polynesia, Guam, Vanuatu
Cerbera manghas	seed	Tree. The seeds of a related species (*C. tanghin*), native to east Africa and Madagascar, were used for a deadly arrow poison (Neal 1948). Cerberine is the active ingredient.	New Caledonia
Colubrina asiatica		Shrub (Gatty 1947)	Hawaii
Curcurbita maxima		(Gatty 1947)	Hawaii
Derris elliptica *D. ferruginea* *D. malaccensis* *D. trifoliata (uliginosa)*	root, bark, stems	High-climbing woody liana. Roots contain rotenoids, the most potent of which are rotenone and tephrosin. *D. elliptica* is the species most often cultivated and was introduced (to Fiji from Malaya) and exported from Asia and the Pacific for rotenone production.	American Samoa, Cook Islands, Fiji, Guam, Kosrae, New Caledonia, Tahiti, Tonga, Papua New Guinea, Palau, Vanuatu, Western Samoa
Diospyros ebenaster *D. samoensis*	green fruit	Persimmon	Niue
Entada scandens		Cooked before use (Gatty 1947; Barrau 1955)	New Caledonia
Euphorbia cotinifolia *E. kanalensis* *E. tannensis*	stems, leaves		Fiji, New Caledonia
Excoecaria bicolor *E. agallocha*	sap	Picara; contains glucosides (cerberine-like)	New Caledonia
Neubergia collina	fruit	Steamed fruit is mixed with water (Tueting 1940; Veitayaki 1990).	Fiji
Pittosporum arborescens	fruit	Cooked first (Barrau 1955)	Fiji, Tonga
Plumeria		(Gatty 1947)	Hawaii
Rhynchosia minima	all but roots		Marquesas, Austral Islands
Sapindus saponaria	fruits	Endemic to Marquesas; contains saponin	Marquesas
Tephrosia piscatoria (purpurea)	leaves	Perennial herb	Cook Islands, Hawaii, Fiji, Tahiti, Moorea
Wikstroemia sp.	roots, bark, leaves	Pounded, placed in porous container, and sunk in saltwater pools (Gatty 1947; Neal 1948)	Hawaii

where they are caught or speared. This method was used in Namuka, Lau (Tueting 1940).

(4) **tuvatu**: A short leaf rope is placed around rocks or coral at high tide, the trapped fish are poisoned with plant extracts when the tide falls and then collected. This method was used in Moce, Lau (Tueting 1940).

(5) **soto**: Leaves or bark of *Euphorbia tannensis* are crushed and placed in coral holes at low tide at night in calm water (Tueting 1940).

Throughout the Pacific, *Derris* is one of the most commonly used plant poisons (SPREP 1988). The Japanese imported *Derris elliptica* into Palau, since it is stronger than the indigenous *D. trifoliata* (Johannes 1981: 12n). *D. elliptica* was raised commercially for the manufacture of insecticides. *Derris trifoliata* was probably introduced into the Cook Islands from New Guinea by Anglican missionaries and then by migrating fishermen into Tahiti (Pétard 1986). In Kosrae, *Derris* is still used to catch fish. Fish as small as a half inch are killed

(Cornelius, pers. comm. 1994). The active ingredient of *Derris*, rotenone, is still used as a pesticide and as a fisheries management tool to kill unwanted fish species (Frey 1951; Leonard 1939; Gutreuter, pers. comm. 1994; Rimmer, pers. comm. 1994).

The leaves, fruits, seeds, or bark of other plants have also been used to collect fish. This form of fish collection is still practised in American Samoa (Craig, pers. comm. 1995), Fiji (Veitayaki 1990), Futuna (Galzin & Mauge 1981), Guam (Lujan, pers. comm. 1995), Kosrae (Cornelius, pers. comm. 1994), Marquesas (Pétard 1986), Northern Mariana Islands (Johannes 1975), Palau (Johannes 1975), Papua New Guinea (Raga, pers. comm. 1995), Pohnpei (Johannes 1975), Solomon Islands (Diake, pers. comm. 1994), Tahiti (Pétard 1986), Vanuatu (David 1994), and Western Samoa (Johannes 1975).

Sea cucumber (*Holothuria atra*)
Some sea cucumbers also contain compounds that can stun fish. Frey (1951) described a scene he witnessed in Guam where men cut open the "common black sea cucumber" (probably *Holothuria atra*) and squeezed the guts of the animal into crevices in a pool in the coral. Fish soon floated to the surface "exhibiting much the same type of behaviour as in rotenone poisoning" (Frey 1951). The fish were immobilised, but not killed. They were then very easy to spear and collect. Frey also noted the use of sea cucumbers to poison fish in the Marshall Islands.

In Fiji, **sosolo**, **soli**, or **loloni** is a sea cucumber (*Holothuria atra*) that was used in Namuka, Lau to poison fish (Tueting 1940). In Qoma, people still commonly use this sea cucumber to stun fish (Veitayaki 1990). Johannes (1981) also noted that poisons from sea cucumbers were used for fishing in Palau.

2.5 Other destructive practices

Some fishing methods take advantage of species at times when they are vulnerable, such as during the juvenile stage or at night when they are sleeping. Other methods make it easier for collectors to overharvest species, especially the easily collected sedentary invertebrates. These methods can be particularly damaging to fish stocks if used continually or to catch large numbers of fish, thereby fishing out an area. As a result, they can be overly efficient and hence devastating to the species. These methods include the use of scuba gear while spearfishing at night, small mesh nets, purse seining, and hookah.[1] Other activities, especially the overharvest of reef building corals, modify the habitat so that the marine species become misplaced.

The use of breathing apparatuses (such as hookah gear and scuba) while collecting invertebrates or while spearfishing has been banned in a few countries in the region, but the practice continues. The use of scuba while fishing is a problem in New Caledonia (Farman, pers. comm. 1995). In Fiji, the use of underwater breathing gear for the harvest of sedentary resources has been blamed for their rapid depletion. In the early 1990s, some people in Fiji's outer islands resorted to the use of scuba gear close to the end of the boom period of harvesting of bêche-de-mer, trochus and giant clams (Veitayaki, pers. obs.). There is, however, no written evidence about the use of the gear. The fact that hookah gear is still in use in Fiji to collect bêche-de-mer is evidenced by an increase of hookah divers who have been treated in the Fiji Recompression Chamber Facility since 1991 (Manueli, pers. comm. 1995). In Tonga, giant clams were overharvested, in part due to the use of hookah and scuba gear (Chesher 1995).

Several countries in the region reported that some nets are destructive to local stocks of fish. In Kiribati, some fishers, including those working for the local tuna company, use a bouki-ami net to catch bait fish. This net is used with fluorescent lights to concentrate schools of bait fish. The use of this very efficient net over the years has led to declines in stocks of rainbow sardine (*Dussumieria* sp.) and goldspot herring (*Herklotsichthys quadrimaculatus*) (Tioti, pers. comm. 1995). Also in Kiribati, bone fish (*Albula vulpes*) are chased into gill nets with iron bars (Tioti, pers. comm. 1995). The Kiribati Fisheries Division reports that this is particularly damaging to the stocks of bone fish around South Tarawa because of its effectiveness. Stocks of mullet have declined in Tonga, partly because of the use of chicken-wire fish fences and net fishing in shallow areas (Matoto, pers. comm. 1995). In Tuvalu, the use of gill nets has decimated the stocks of *Selar crumenphthalmus* (Saloa, pers. comm. 1994).

Overharvest of coral
The harvest of corals for a variety of purposes appears to be a growing industry in some areas of the Pacific. Precious corals (that is, black and red corals that are used in jewellery-making and sculpture) are collected in large amounts from deep waters near the Philippines (Carleton & Philipson 1989). Black coral is processed on a small scale in Hawaii, Papua New Guinea, Fiji and Tonga. More serious is the growing harvest of ornamental

1 A hookah apparatus allows divers to stay underwater for a long time. The divers breathe through hoses attached to an air compressor that is on a boat at the surface.

corals.[2] In Fiji, two businesses have been issued permits to harvest and export large amounts of ornamental corals (one company removes approximately a tonne per week). The corals are used to make artificial bones and eyeballs, table lamps, and ornaments (Ryan 1994). From 1985 to 1988, more than 250,000 pieces of 56 species of corals were exported from Fiji for the ornamental coral trade. Collectors have been "advised to move their operations to fringing reefs and inner lagoon reefs, rather than inshore reefs, as the latter are affected by freshwater runoff and are likely to be slow to regenerate" (Richards et al. 1994).

Corals are also harvested for building material, road construction, and/or betelnut lime production in Federated States of Micronesia, Fiji, Palau, Papua New Guinea, and throughout Asia.

Live corals are harvested and exported for the aquarium market in the United States and elsewhere. In 1991, approximately 250,000 pieces of live coral were imported into the US alone for this market (Norse 1993). Overharvest of corals is a problem in the South China Sea (Anon. 1986) and in the Philippines (Rubec 1988). In Palau, 1200 pieces of live hard corals, 400–600 lb of "live rock" and 8000 pieces of soft corals were exported for aquarium use in 1994. This trade has since been banned as there was a concern that the trade could be damaging to Palau's unique marine environment (Graham, pers. comm. 1995). Exporters in Vanuatu send corals to New Zealand, Japan and the United States. In 1992, more than 800 pieces were sent out with shipments of aquarium fish. It is often difficult to assess exactly how much coral is leaving Vanuatu because exporters usually describe the shipments of coral as "rock" (Bell & Amos 1993). While no country in the region reports the overharvest of corals to date, care should be taken to monitor this fishery before such a stage is reached.

2 Ornamental corals, the major component of coral reefs, are abundant in shallow waters, whereas the semiprecious black corals and the precious red and pink corals are deep-water species.

3. Environmental Effects of Destructive Fishing Methods

There is general agreement among fisheries and resource managers that the practices discussed in this report are destructive. Blasting and the use of poisons to catch fish, together with pollution and siltation, have been called the major causes of reef degradation in the Pacific (Dahl & Baumgart 1982). However, it is very difficult to find hard evidence of the damage they do. Very few studies have specifically addressed the environmental impacts of destructive fishing methods. In fact, few studies can be found on the effects of the compounds used in these practices. However, studies on the effects of other events that are devastating to coral reef environments (that is, storms, crown-of-thorns starfish and bleaching) provide some clues to the ways reefs respond to damage. Obviously, when a fisher throws dynamite into the water, there will be an effect on whatever gets in its way. If the dynamite is thrown near a reef, not only are the fish killed, the coral and other associated organisms may be damaged as well. If cyanide is used to catch aquarium fish or if bleach is used to catch food fish, the immediate environmental effect is on the target species. However, since many species coexist in tropical reef and mangrove areas, other effects to non-target species can be expected. The environment itself may be altered by the use of these methods. Physical harm to the fisher may result from the use of explosives or some of the poisons. Some consumers may be sensitive to some of these compounds if they persist in the tissues of the fish or shellfish, causing allergic reactions. Finally, most destructive fishing methods are indiscriminate rather than selective in their targets. As a result, their use can lead to overfishing of stocks.

3.1 Explosives

Explosives cause physical damage to nearby fish. If a fish has an air bladder, the bladder is almost always ruptured and filled with blood. The vertebral column may be fractured and localised haemorrhages can be found both inside and out (Johannes 1975; Paxton & Lewis 1988). This applies both to those species that the fishers are able to collect because they float to the surface after a blast, as well as to those that sink to the bottom with ruptured air bladders.

Explosives used near reefs devastate nearby coral heads. Marine officers in Papua New Guinea made the following observations in areas where explosives had gone off along reef flats and slopes: "Coral heads were tipped over, branching, foliose and soft corals were reduced to fragments, and all sizes of fish were killed". However, at other reefs where dynamite was reported to have been used, there was no visible damage to the corals (Raga, pers. comm. 1995). It is not known if other organisms are severely affected, or if there are long-term effects when explosives are used in open water areas. There is some evidence that predators of all stages of the crown-of-thorns starfish (*Acanthaster planci*) may be eliminated by blasts of explosives, creating an environment particularly suited to uncontrolled outbreaks of this destructive organism (Owens 1971). Demersal plankton production has been shown to decrease, diminishing the supply of food to the fish that could recolonise a blasted area. Alcala and Gomez (1987) predict that it could take 38 years for a reef to recover 50 per cent of its coral cover after it has been blasted. Reef recovery will be discussed in more detail in Section 3.4.

Fishers who use explosives often suffer physical harm. All of the men interviewed in Fiji were hurt by the explosives they use to catch fish: one man lost a finger, one lost his lower arm, and another man was blind. The dangers are well known to such men, but they are willing to take the risks in order to catch large amounts of fish relatively easily.

3.2 Modern poisons

Modern poisons can have serious and long-lasting effects in the marine environment. Many of the compounds can persist in the environment long after the fishers have gone away. There is the possibility that they can persist in the tissues of the catch, making the fish or shellfish unsuitable for consumption by sensitive people, causing allergic reactions. However, although the team heard this was a possibility, no evidence could be found.

Sodium cyanide affects the internal organs of fish. The effects on invertebrate organisms appear to be variable, some species are highly susceptible while others are relatively resistant to acute damaging effects (Eldredge 1987). Cyanide also has a "bleaching" effect on coral (presumably, this means the coral polyps that are dosed with cyanide are killed,

leaving the coral skeleton bare in those places) (Golden 1991). Repeated doses of cyanide may kill coral polyps, but there is no conclusive evidence (Rubec 1986).

The effects of using chlorine bleach in the marine environment are not well studied. Many studies have been done on the effects of chlorine in freshwater environments because of concern over the effects of chlorine-containing effluent from pulp and paper mills. While most of the research focuses on the effects of bleach on freshwater fish species, one study was done at the University of Guam documenting the effects of chlorine bleach on some tropical marine phytoplankton and larvae of an urchin and a mollusc (opisthobranch) (Best et al. 1981). The phytoplankton were more sensitive to lower concentrations of chlorine bleach than were the urchin and mollusc larvae, respectively. However, higher temperatures (33°C) increased the toxicity of the bleach.

In an analysis of bleach fishing in the Bahamas, Campbell (1977) summarised the long-term effects: fish are lost from the community; populations of crustaceans, annelids, and molluscs are greatly reduced; urchins increase in number to feed on the new algal growths in areas on the coral heads that were affected by the bleach.

Studies on pesticides have shown a variety of responses in aquatic species.[3] For instance, in a review of the effects of pesticides, Eisler (1972) listed the following as some of the research findings of the mid to late 1960s:

> ... concentrations which are not sufficient to control many species of salt-marsh mosquitoes, nevertheless can inhibit the productivity of phytoplankton populations; kill or immobilise crustaceans, fishes, and molluscs; kill eggs and larvae of bivalve molluscs; induce deleterious changes in tissue composition of molluscs and teleosts; disrupt the schooling and feeding behaviour of fishes; and interfere with ovary development in molluscs and teleosts. (See Eisler for the references to these studies.)

Studies of the toxicity of the pesticides reported to have been used to collect fish in the region show that gamma BHC is a persistent chemical, and its repeated use could be detrimental to both the environment and wildlife; paraquat is lethal if swallowed in sufficient amounts (Firman 1981). However, there is no information on whether fish collected with paraquat (or with any other pesticides) are tainted enough to cause harm to consumers.

In addition, many pesticides have been shown to have sublethal effects on fish. These include alterations in behaviour, feeding habits and reproductive success, and morphological changes, making them more susceptible to predation (Murty 1984). Often, aquatic invertebrates are more sensitive to the effects of pesticides than are fish (Murty 1984).

Changes can occur to community structure over the long term due to the use of pesticides. Murty cites a report by Swingle (1954):

> . . . aquatic environments may appear to have recovered from the effects of pollutants, especially if judged by the physicochemical conditions, and such environments may support a good standing crop of fish, but the actual population analysis often shows a reduction in desirable and harvestable species and an increase in the number of species that cannot be exploited (Murty 1984, p.85).

3.3 Traditional poisons

Compounds from plants and animals used as fish poisons usually act by stunning rather than killing fish. However, if used in large amounts, they too can kill. Rotenone is the most active compound in *Derris*, the most commonly used plant poison. Rotenone narcotises fish, but appears not to harm invertebrates. However, Eldredge (1987) could find no studies of the effects of rotenone on corals or associated organisms. Rotenone has been widely used in the United States since the 1930s to remove "undesirable fish populations" from lakes and streams (Leonard 1939). It is still used in the US (Gutreuter, pers. comm. 1995) and in Australia (Rimmer, pers. comm. 1995) to control unwanted and competitive species, such as tilapia, in ponds. Most of the rotenone that is used in the US today is made from South American Cube that is then synergised to increase its potency (Gutreuter, pers. comm. 1995). Experiments on freshwater fish species showed that *Derris* itself (not the more powerful commercial variety of rotenone) was lethal to certain species (Leonard 1939). Johannes (1981) noted that young fishermen in Palau used to be taught not to place *Derris* bundles under coral heads because too much of the poison in an area would kill coral.

Rotenone kills fish by disrupting the exchange of oxygen (Eldredge 1987). Its effectiveness declines with exposure to sunlight (Gutreuter, pers. comm. 1995), so it does not persist for very long in the environment.

Other plants (such as *Barringtonia*) contain saponins that paralyse the gills of fish. Eldredge (1987) mentions only one study of the effects of this plant on fish. All guppies that were treated with juice from the ripe fruits were killed in this experiment (Eldridge 1987).

---

3 Note that many of these studies focus on long-term exposures from agricultural run-off or other sources, and not to the highly localised and infrequent doses that result from fishing practices.

Sea cucumbers also contain saponin-like compounds. Although *Holothuria atra* was the species widely used by Pacific islanders to stun fish, Yamanouchi was able to extract a saponin-like compound from all but three of the 27 tested sea cucumbers. Marine fish died when exposed to this compound (called holothurin) in concentrations of 1:250,000. Selected marine crustaceans and a gastropod showed no reaction, while sea anemones contracted in response (Yamanouchi 1955).

Perhaps the most serious problem associated with the use of plant or animal poisons is their non-selectivity. The poisons make it very easy to collect many species, in many different stages of life simultaneously. For instance, in Futuna, women use **futu**, a toxin obtained from *Barringtonia speciosa* seeds, to collect fish. Galzin and Mauge (1981) poisoned fish in three sites with this compound and found that 40 species belonging to 20 families of fish were affected. More than 50 per cent of these fish were juveniles. They concluded that the method could "endanger the balance of the ichthyological fauna of [the] island". The fish community is attacked in a way from which it cannot easily recover. When all age classes of a population are removed from an area, depletion of the stocks can easily result. There are no young fish left to replace the fish caught by fishermen and women.

If used in a controlled manner, these compounds are probably not extremely harmful to the environment. The active compounds tend to break down after a few hours, so they become less and less effective over time (Leonard 1939). If used in large amounts, repeatedly in the same area, or indiscriminately, however, they could contribute to the over-exploitation of fish and shellfish resources.

3.4 Additional consequences

Finally, undesirable situations can result from the use of any of the methods mentioned above. Increased incidences of ciguatera, habitat loss and overfishing can occur when the marine environment is subjected to stresses, particularly the relatively major stresses inherent in some of these destructive fishing practices. Often, areas are hit by several of these practices at once. Combined with the increasing threats from sedimentation and pollution, and from the damage caused by storms, crown-of-thorns starfish and bleaching events, the effects can be severe.

Increased incidence of ciguatera

One possible effect of environmental disturbances, including those caused by destructive fishing, is the increased incidence of ciguatera, a form of ichthyosarcotoxism (poisoning by the flesh of fishes). The probable cause of ciguatera is a toxin from the dinoflagellate *Gambierdiscus toxicus*. There is some evidence connecting the incidence of ciguatera to disturbances in the coral reef environment such as dredging, blasting to create channels, and sewage outfalls (Bagnis 1973; Bagnis et al. 1988; and Kaly & Jones 1994). In addition, Tebano (1991a) noted that ciguatera poisoning was unknown in Nauru until a boat channel had been made by blasting through the coral reef. Outbreaks of ciguatera in the Marshall Islands and Tuvalu also have been associated with major disturbances to the reef (Tebano 1991b, 1991c). "It is believed that new faces created by damaged coral reef provide new habitat for algae and seagrass which in turn provide more habitat for *G. toxicus*" (Tebano & Lewis 1991, p.4). Much more rigorous research needs to be done before a definite link can be made between ciguatera and reef disturbance, since often there is no such outbreak of ciguatera after a disturbance. Some circumstances seem to favour outbreaks of ciguatera, while others do not. It is not known why outbreaks will occur in some places where there is a disturbance to the reef, and do not occur in other areas where there are similar disturbances. To complicate the situation further, the causative factor has never been definitively identified. Most researchers are careful to call *G. toxicus* a "probable cause".

If indeed reef disturbance and poisonous fish occurrences are linked, then fishing in ways that destroy or damage coral, such as using dynamite, dragging nets that snag on coral colonies, or pounding on fragile branching corals as part of a fish drive, could increase the incidence of poisoning. There are, however, no conclusive studies to date.

Habitat destruction

In assessing the impacts of destructive fishing practices on the tropical marine environment, it helps to know how serious the damage to coral reefs is and how long the environment will (if left undisturbed) take to recover. Massive destruction has occurred to corals and coral reefs through the effects of storms, crown-of-thorns starfish (*Acanthaster planci*) predation, and bleaching events. Storms physically destroy corals, much like explosives, though on a much larger scale. Crown-of-thorns predation and bleaching events cause impacts very similar to the effects of some of the chemical poisons used for fishing because these events kill coral polyps, leaving the physical structure relatively intact. The effects of these phenomena have been much more extensively analysed than the effects of destructive fishing techniques. Hence, they offer valuable clues to the effects of physically damaging events on coral reefs.

Storms, especially cyclones and hurricanes, result in serious, widespread damage to the marine environment. The continual pounding of reefs by cyclone-induced wave action, and large amounts of freshwater run-off due to heavy rains have

destroyed large areas of reef in the region. For instance, the reef slopes on three atolls in French Polynesia were severely damaged by six hurricanes in the summer of 1982–1983 (Harmelin-Vivien & Laboute 1986). The deeper outer reef zones were more seriously affected than the shallower areas owing to avalanches of broken coral colonies raining down from above. "The outer slope was transformed to a scree zone covered with coarse sand and dead coral rubble." Harmelin-Vivien and Laboute (1986) speculated that based on their observations and other estimates, recovery periods of at least 50 years for totally destroyed reefs and from 2 to 10 years for areas with limited damage were within reason.

Acanthaster planci, the crown-of-thorns starfish, eats corals, and as a result can be devastating to the coral reef community. Following a population explosion of this starfish in 1969 on Guam's reefs, Colgan (1987) found less than one per cent of the coral cover remaining in two of three study sites. However, by 1981, the percentage of coral cover had risen to 65 per cent. In the space of 12 years, the reef had reached species richness and composition levels at or greater than those of the pre-starfish days. However, since *Acanthaster* selectively ate the fast-growing coral species and not those that form the skeletal basis of the reef, the damaged reef still had its structural integrity on which to grow. It is not known whether poisons have such selectivity.

Bleaching of corals is believed to occur for a variety of reasons, including long stretches of unusually warm water temperatures, torrential rains or river discharges that lower nearshore salinities, extreme low tidal exposures, and sudden temperature drops due to upwelling or atmospheric chilling (Glynn 1993). Bleaching kills coral polyps since it results from the loss of the photosynthesising zooxanthellae on which the polyps depend for nutrients. How other species are affected by the bleaching of corals is not known. Glynn (1993) estimates that full community restoration (replacement of 100 to 300 year-old framework of the reefs) of severely affected reefs will take several hundred years.

Reef recovery from such massive destructive events varies. The recovery rates seem to be dependent on both the extent of the damage as well as the location (Glynn 1993). Recovery of the tropical marine environment after being damaged can be very slow. If corals are killed, it may take decades before the reef is once again productive.[4] While the damage due to destructive fishing practices is thankfully not on the major scale of these global catastrophic events, any structural damage to the coral reef is worth concern. Habitat loss will have effects on the fisheries in the affected area as fish find other places to inhabit (Kaufman 1983). Loss of much of the coral reef habitat, as is happening in the Philippines, must be avoided for the health and welfare of the Pacific's inshore fisheries. Zann (1994) noted that coral cover in the south-west Pacific islands has "significantly declined in the past 20 years".

In fact, habitat loss may be more damaging to fisheries stocks than overfishing (Rubec 1988). These two problems are very closely interrelated, and habitat destruction can lead to overfishing, just as overfishing can lead to habitat destruction. Saila et al. (1993) estimate that it may take as long as 25 years for a reef to begin to recover if the present level of destructive practices is maintained. The human-induced destructive practices compound the naturally occurring catastrophic events. Some effects of destructive fishing may actually increase the impacts of naturally occurring events. For instance, *Acanthaster planci* outbreaks may increase due to the use of explosives either because their prey is killed (Owens 1971) or because broken corals attract predation (Chesher 1986). Chesher (1986) also postulates that coral broken by collectors may be susceptible to damaging infection by blue-green algae (Cyanobacteria). Reefs that are continually subjected to physical assault are not given the opportunity to heal themselves when there is a natural destructive event.

At present, the impacts of coral harvesting activities on the region's reefs are not known. The harvest of coral, although considered a fishery, is in fact quite different from other fisheries. In addition to being another living marine resource, corals are the building blocks of reefs. They also protect small islands from excessive cyclone damage and storm surge (Brodie et al. 1990). Coral *is* the reef, and removal of corals is equivalent to the removal of the reef habitat. Indiscriminate removal of large amounts of coral is comparable to steadily removing all trees from a forest. The critical habitat, once gone, can no longer sustain other life in the ecosystem, and the area effectively dies. Large-scale reef destruction can have serious consequences on the future productivity of the inshore fisheries in the Pacific islands region. If practised at the current levels and with the proper regard for conservation and careful collecting practices, the small-scale operations will not become destructive. However, removing too much will cause "at the very least, local depletions . . . as the number and distribution of remaining colonies fall below levels needed to maintain successful recruitment through sexual reproduction" (Carleton & Philipson 1989). In other words, if there are too few corals in an area, the reef will be unable to sustain the harvest for very long.

4 Interestingly, Glynn (1993) notes that a recovery rate of decades is considered "rapid" in terms of coral growth rates. In human terms, decades are a long time.

Careful monitoring of this fishery is necessary in order to avoid large-scale destruction of the region's reefs.

Overfishing

Overfishing may result from the use of many of the destructive fishing practices mentioned above because they tend to be used during times of scarcity, so the fish populations are already low. For instance, in Fiji, dynamite is believed to be used to catch **salala** (chub mackerel, *Rastrelliger brachysoma*) when it is least abundant and the market prices are at their highest. Also, some methods are innocuous enough when used on a small scale, but when used extensively they become destructive. Population pressures in the region are increasing; this increases the likelihood of overfishing, especially in populated areas near towns and cities, as was noted earlier for Papua New Guinea (Raga, pers. comm. 1995). Pauly (1988) defines Malthusian overfishing as the problem of too many fishers chasing too few fish. This leads fishers to further damage the stocks by destroying the habitat in order to scour every last fish from the waters.

3.5 Conclusion

Sensitive areas such as mangroves, estuaries and coral reefs may be adversely affected by destructive fishing practices, especially if these practices are sustained continuously over a long time in the same area. While traditional poisons tend to act by stunning fish and otherwise making them easier to catch, modern chemicals and explosives act by killing the target species or by affecting them so severely that they do not recover. A shift from the use of traditional plant and animal poisons to the widespread use of chemicals and explosives could have a serious impact on the marine and freshwater environments of the Pacific islands. The continued use of such destructive fishing practices in the Pacific islands region, especially as population grows, could lead to a situation similar to that in the Philippines, where these destructive practices have caused massive devastation to local coral reef communities and fishing grounds. Some of these practices have localised impacts. However, in combination with other assaults on the marine environment, especially siltation, pollution, and naturally occurring destructive events, irreversible damage could be caused.

4. Legislation

The use of destructive fishing methods such as explosives, poisons and other noxious substances is ecologically harmful and is prohibited by law in nearly all of the countries of the Pacific islands region. As shown in Table 4.1 the use of dynamite and other destructive methods has been identified as important and has been the subject of concern in the region. With the exception of Australia, Nauru, Papua New Guinea, Pitcairn Island and Tokelau, all of the islands in the region have put in place legislation banning the use of dynamite, poison and other noxious substances to catch fish. The fact that the legislation is in place, however, is no indication at all of observance and adherence by the people. Indeed, the continued use of explosives and other destructive methods may mean that the legislation is not adequate and that more stringent and effective measures are required.

It is evident from Table 4.1 that legislation relating to destructive fishing practices for the present moment is limited to the use of explosives, poisons and other noxious substances. There is little reference to other destructive fishing practices, in particular the use of hookah gear, fish drives and reef gleaning practices that are destructive to the marine habitat. For instance, while some of the countries have conservation legislation that restricts the taking of special specified species, there is nothing specifically related to habitat destruction. This is a concern because the destruction of habitat associated with coral extraction and other related fisheries is, in our view, more destructive to the marine environment than the local decline of certain species. These are the types of legislation that will be seen more in the future when the destructiveness of these practices becomes more evident.

Fines for the use of destructive fishing practices vary from country to country but all seem to show the seriousness of the offence throughout the Pacific. The range is between $SI 200 in Solomon Islands (approximately $US 60) and $NZ 250,000 in New Zealand (approximately $US 169,100). In the Marshall Islands the fine stands at $US 50,000 for criminal penalty and $US 100,000 for civil penalty. Within this range are the different fines that are imposed on the offenders in the different countries.

In spite of the impressive legislation that attempts to prohibit the use of destructive fishing practices in the region, the widespread use of these fishing methods is an indication of either the ineffective nature of the legislation or the attraction of the method. In both cases more work is required. Perhaps the legislation alone is not effective and more effort should be directed at the enforcement of these laws. There may even be the need for more innovative methods such as the empowering of coastal communities so that they can take a more proactive role in the proper and effective management of their marine resources. The involvement of coastal communities will make the people feel part of the management system, which should then enhance adherence and conformity. In addition, the empowering of local communities will give people the right and freedom to organise their management systems in ways they know best.

The existing legislation relating to the use of destructive fishing methods is expected to be reviewed, revised and added to in the near future as people become more aware of other destructive methods that are used in their fishing ground, but which are, as yet, not covered under current legislation. For the moment, however, destructive methods as defined by these laws are largely restricted to the use of explosives, poisons and other noxious substances.

Table 4.1 Penalties for use of destructive fishing practices in the Pacific Islands region

Country	Offence	Fine	US$
Cook Islands	Prohibited fishing methods (explosives/poisons). *Marine Resources Act 1989* s.26	NZ$10,000	6,760
Federated States of Micronesia	Use of explosives, poison or chemicals to kill marine life. *Title 23 of the Code of the FSM* §101 and 104	US$2,000 (US$100 min)	2,000 (100)
Fiji	Taking or attempting to take fish by the use of dynamite or explosives. *Fisheries Act* Cap. 158 s.10(4)	1st offence: F$1,000 min 2nd offence: F$2,000 min 3rd and subsequent offences: F$5,000 min	720 1,430 3,590
Kiribati	Fishing with explosives, poison, etc. *Fisheries Act* Cap. 33, s.14(1)	A$200	320
Marshall Islands	Use of explosives, poison or other noxious substance. *Marshall Islands Marine Resources Authority Act 1988* s.38	Criminal Penalty: US$50,000 Civil Penalty: US$100,000	50,000 100,000
New Zealand	Use of explosives, electricity or noxious substance. *Fisheries Act 1983* ss.65, 98 and 107	NZ$250,000; NZ$1,000 per day for continuing offence	169,100 680
Niue	Use of explosives, firearms, poisons or underwater breathing apparatus for fishing. *Fish Protection Ordinance 1965* s.5(3)	NZ$1,000	680
Palau	• Fishing with explosives, poison, or chemicals, *Chapter 13 of Title 24 of the Palau National Code* (Environmental Protection) § 1301–1305 • Placing explosives or poisons in waters; taking of marine life affected by explosives or poison. *Chapter 13 of Title 24 of the Palau National Code* (Environmental Protection) § 1321–1326	Min fine: US$100 Max fine: US$2,000 US$100	100 2,000 100
Solomon Islands	Use of explosives, poison or other noxious substances for fishing. *Fisheries Act 1972* s.8(1)	SI$200	60
Tonga	Fishing with explosives, poisons, noxious substances, etc. *Fisheries Act 1989* s.21(1)	TS$1,000	810
Tuvalu	Fishing with explosives, poison, and noxious substances. *Fisheries Act* Cap. 45, s.14(1)	A$200	320
Vanuatu	Fishing with explosives, poisons, etc. *Fisheries Act* Cap. 158 s.19	1,000,000 vatu	9,030
Western Samoa	Fishing with explosives, poisons, noxious substances, etc. *Fisheries Act 1988* s.4[1] and s.21[5]	WS$1,000	420

Source: FAO 1993

5. Conclusion / Summary

The following points summarise the current situation relating to destructive fishing practices in the Pacific islands region.

5.1 Extent of destructive coastal fishing

While there is fairly widespread use of destructive fishing methods, both traditional and modern, in the Pacific islands, the information available from island governments is very general, with very few details on the nature, extent and effects of destructive coastal fishing. Further, the few detailed studies available tend to be microstudies that focus on a particular destructive method (for example, Yamanouchi 1955) or on a specific geographic location (for example, Eldredge 1987).

In order to have fully met the requirements of the first term of reference (see Section 1.1), the present study would have required considerably more time and resources. What the study has displayed is the need for a comprehensive research programme into destructive fishing in the region. Without such a research effort it would be very difficult to even begin to assess the nature of destructive fishing in the Pacific and would severely compromise any attempt to formulate effective and relevant ameliorative policies.

5.2 Literature on destructive coastal fishing

The literature available on destructive coastal fishing practices in the Pacific is limited. It does, however, suggest that the use of potentially more damaging modern poisons, as well as physically and biologically damaging fishing practices, is becoming more frequent. Unfortunately, the available evidence is patchy, suggesting on the one hand that these examples of fishing malpractice occur, yet on the other offering very little in the way of details as to how they occur and with what results.

More optimistically, though, the literature survey does reveal that research and researchers from the Pacific Rim countries, especially from South-East Asia, could prove to be very useful for future research work and even for policy formulation in the Pacific region.

5.3 Environmental impact of destructive fishing

While detailed evidence is lacking about the effects of explosives, poisons and physical destruction in the marine environment, the available information strongly suggests that the environmental implications of continued destructive coastal fishing may be dire for the Pacific. The continued use of physically, biologically and chemically damaging fishing methods in coastal fisheries is likely to degrade reef and coastal ecosystems, produce unsustainable levels of fishing and even endanger the health of fishers and fish consumers. Destructive fishing can exacerbate the impacts of other events (such as storms, crown-of-thorns starfish predation, and bleaching) that cause extensive physical damage to the coral reef community. As studies of these catastrophic events have shown, reef recovery can be anywhere from a few years for minor localised damage to several decades for extensive structural damage of the reef itself. Such damage to the reef will create a less healthy environment for the fish and invertebrates inhabiting the area. By increasing assaults on the reef community through the use of destructive fishing practices, people are creating a situation where the natural recovery processes are unable to keep pace with the damage.

5.4 Economic and social context of destructive fishing

Consideration of the social and economic impacts of destructive fishing at the level of the region was not possible because of the lack of research which looks at the relationship between ownership, access and destructive fishing. It was also not possible because of the time and resource constraints of the present study. What the present study was able to do, however, was to produce a set of case histories on dynamite fishing in north-western Viti Levu, Fiji (Annexe 1). These accounts produced some interesting insights into the socio-economic context in which destructive fishing takes place. They suggest that economic imperatives (specifically the desire for cash income) in areas where there are limited cash- earning opportunities and inadequate ecological knowledge, may override any cultural and moral obligations that fishermen and women may have for the protection of the coastal environment. This may, with more detailed research efforts, have an

important bearing on decisions that are made about how best to provide people with the tools and the incentives to manage coastal fisheries sustainably.

Within the confines of this study it was not possible to consider gender relations and destructive fishing practices. It is suggested that a study of this type should be undertaken as a separate piece of research rather than as an add-on to a more general and preliminary overview.

6. Recommendations

The recommendations of this study, which are listed below, are put forward only as general suggestions and guidelines. Only after more comprehensive research work will a more detailed plan of action be possible. What the recommendations do strongly suggest, though, is that if the region is to control these practices effectively, widespread cooperation is necessary. Only with the real participation of regional, national and local bodies, as well as that of the coastal peoples themselves, will the countries of the Pacific region be in a position to effectively reduce destructive coastal fishing and collecting practices.

(1) Community participation in conservation and resource management programmes is a way to increase local residents' involvement in the protection and stewardship of the environment. In conjunction with educational campaigns, community participation can lead to an effective means of stemming destructive fishing and harvesting practices. Since many of these fishing practices have roots in traditional culture or are used on a small-scale or subsistence basis, involving local people regularly and fully in management programmes enforces any lessons learned through schooling, workshops, or extension.

(2) Job alternatives and income-generating schemes at the local community level are extremely important in areas where dynamite or other destructive practices are used in order to catch more fish because of financial concerns at home.

(3) Education, training and extension at all levels (in schools, in villages, as radio programmes) to instil appreciation of the destructiveness of these practices and their effects on the resources and the environment are crucial. Local workshops designed to promote sustainable and non-destructive fishing methods are one way of increasing community awareness of the problems.

(4) Research is needed to increase understanding of the situation in the region and should include studies of the effects of these practices on the environment, levels of residues in fish and shellfish, allergic reactions linked to poisons used in fishing, estimation of magnitude of the problem in each country in the region, and socio-economic analyses in different areas.

(5) Collaboration within the region is necessary to increase awareness of the extent of the problem. A more comprehensive and in-depth survey of destructive fishing in the Pacific is needed in order to determine country-specific needs for education, training and planning. The International Marinelife Alliance in the Philippines has expressed interest in collaborative research or training projects. Several of the respondents from regional government offices expressed their interest in involvement in future educational programmes.

(6) One of the most important needs in the region is for increased and effective enforcement of existing laws. In addition, further legislation may be needed in some places where dynamite fishing continues despite the existence of laws. Especially important are measures to lessen the availability of explosives and cyanide. For instance, the gold-mine in Vatukoula, Fiji could be held more responsible for the leakage of explosives and cyanide off the property.

References

Alcala, A. C. & Gomez. E. D. 1979. "Recolonisation and growth of hermatypic corals in dynamite-blasted and coral reefs in the Central Visayas, Philippines", in Proceedings of the Symposium on Ecological Biogeography of the Southern Hemisphere. pp. 645–661.

Alcala, A. C. & Gomez, E. D. 1987. "Dynamiting coral reefs for fish: A resource-destructive fishing method", in Human Impacts on Coral Reefs: Facts and Recommendations, ed. B. Salvat. Antenne Museum — E.P.H.E., Moorea, French Polynesia, pp. 51–60.

Alino, P. M., Viva Banzon, P., Yap, H. T., Gomez, E. D., Morales, V. J. T. & Bayoneto, R. P. 1985. "Recovery and recolonisation on a damaged back reef area at Cangaluyan Island (Northern Philippines)", in Proceedings of the Fifth International Coral Reef Congress. Antenne Museum — E.P.H.E., Moorea, French Polynesia, vol. 4, pp. 279–284.

Anon. 1984. "Fisheries men act on an explosive problem". Fiji Times, Suva, Fiji, 5 April, p. 9.

Anon. 1986. "Background to reef damage in South East Asian waters and bordering Indo-Pacific regions", in Human Induced Damage to Coral Reefs, ed. B. E. Brown. UNESCO Coastal Marine Project and National Institute of Oceanology, Jakarta, Indonesia, pp. 3–11.

Bagnis, R. 1973. Fish Poisoning in the South Pacific. South Pacific Commission, Noumea, New Caledonia.

Bagnis, R., Bennett, J., Barsinas, M., Drollet, J. H., Jacquet, G., Legrand, A. M., Cruchet, P. H. & Pascal, H. 1988. "Correlation between ciguateric fish and damage to reefs in the Gambier Islands (French Polynesia)", in Proceedings of the Sixth International Coral Reef Symposium. The Symposium Executive Committee, Townsville, Australia, vol. 2, pp. 195–200.

Baquie, B. 1977. Fishing in Rarotonga. MA Thesis, University of Auckland, New Zealand.

Barrau, J. 1955. "Fishing poisons of the South Pacific". SPC Quarterly Bulletin, July, pp. 7–8.

Bell, L. A. J. 1985. "Coastal zone management in Western Samoa", in Report of the Third South Pacific National Parks and Reserves Conference, Vol 2: Collected Key Issues and Case Study Papers, ed. P. E. J. Thomas. South Pacific Regional Environment Programme, Noumea, New Caledonia, pp. 57–73.

Bell, L. A. J. & Amos, M. J. 1993. Republic of Vanuatu Fisheries Resources Profiles. FFA Report No. 93/49. Forum Fisheries Agency, Honiara, Solomon Islands.

Best, B. R., Braley, R. D., Marsh, Jr., J. A. & Matlock, D. B. 1981. "Effect of chlorine on some coral reef phytoplankters and invertebrate larvae", in Proceedings of the Fourth International Coral Reef Symposium. Marine Sciences Center, University of the Philippines, Quezon City, Philippines, vol. 1, pp. 169–172.

Brodie, J. E., Arnould, C., Eldredge, L., Hammond, L., Holthus, P., Mowbray, D. & Tortell, P. 1990. State of the Marine Environment in the South Pacific Region. UNEP Regional Seas Reports and Studies No. 127, SPREP Topic Review No. 40. South Pacific Commission, Noumea, New Caledonia.

Buck, P. H. 1928. "Fish poisoning in Rarotonga, Hora". Journal of the Polynesian Society, vol. 37, no. 145, pp. 57–66.

Campbell, D. G. 1977. "Bahamian chlorine bleach fishing: A survey", in Proceedings of the Third International Coral Reef Symposium, Miami, USA. vol. 2, pp. 594–595.

Carleton, C. & Philipson, P. W. 1989. "The marketing and processing of precious coral products in Japan, Taiwan and Hawaii", in The Marketing of Marine Products from the South Pacific, ed. P. W. Philipson. Institute of Pacific Studies, University of the South Pacific, Suva, Fiji, pp. 164–195.

Chesher, R. H. 1986. Pollution Sources Survey of the Kingdom of Tonga. SPREP Topic Review 19. South Pacific Commission, Noumea, New Caledonia.

Chesher, R. H. 1995. Giant Clam Sanctuaries in the Kingdom of Tonga. Marine Studies Programme Technical Report No. 95/2. University of the South Pacific, Suva, Fiji.

Colgan, M. W. 1987. "Coral reef recovery on Guam (Micronesia) after catastrophic predation by *Acanthaster planci*". Ecology, vol. 68, no. 6, pp. 1592–1605.

Corpuz, V. T., Casteñeda, P. & Sy, J. C. 1985. "Traditional muro-ami, an effective but destructive

coral reef fishing gear". ICLARM Newsletter, January, pp. 12–13.

Cox, P. A. 1979. "The use of indigenous plants as fish poisons in Samoa". Economic Botany, vol. 33, no. 4, pp. 397–399.

Dahl, A. L. 1984. "Oceania's most pressing environmental concerns". Ambio, vol. 13, no. 5, pp. 296–301.

Dahl, A. L. & Baumgart, I. L. 1982. "The state of the environment in the South Pacific", in Report of the Conference on the Human Environment in the South Pacific, Rarotonga, Cook Islands, 8–11 March 1982. South Pacific Commission, Noumea, New Caledonia, pp. 47–71.

Dalzell, P. & Preston, G. 1990. Fishing Activities and Natural Resources in the Tropical South Pacific. ISRS Congress, Noumea, New Caledonia.

David, G. 1994. "Traditional village fishing in fisheries development planning in Vanuatu", in Science of Pacific Island Peoples, Vol. 1, eds J. Morrison, P. Geraghty & L. Crowl. Institute of Pacific Studies, University of the South Pacific, Suva, Fiji, pp. 11–40.

Eisler, R. 1972. "Pesticide-induced stress profiles", in Marine Pollution and Sea Life, ed. M. Ruivo. FAO, Fishing News Ltd, London, pp. 229–232.

Eldredge, L. G. 1987. "Poisons for fishing on coral reefs", in Human Impacts on Coral Reefs: Facts and Recommendations, ed. B. Salvat. Antenne Museum — E.P.H.E., Moorea, French Polynesia, pp. 61–66.

FAO. 1993. Regional Compendium of Fisheries Legislation (Western Pacific Region), Vol. 1, eds B. Campell & M. Lodge. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands; Food and Agriculture Organization, Rome, Italy.

Firman, I. D. 1981. Pesticide Handbook. South Pacific Commission, Noumea, New Caledonia.

Frey, D. G. 1951. "The use of sea cucumbers in poisoning fish". Copeia, no. 2, pp. 175–176.

Galvez, R. & Sadorra, M. S. M. 1988. "Blast fishing: A Philippine case study". Tropical Coastal Area Management Newsletter, vol. 3, no. 1, pp. 9–10.

Galvez, R., Hingco, T. G., Bautista, C. & Tungpalan, M. T. 1989. "Sociocultural dynamics of blast fishing and sodium cyanide fishing in two fishing villages in the Lingayen Gulf, Philippines", in Proceedings of an ASEAN–UN Coastal Resources Management Project Workshop, Bauang, La Union, Philippines, 25–27 May 1988, eds G. Silvestre, E. Miclat & T. E. Chua. no. 17, pp. 43–62.

Galzin, R. & Mauge, A. 1981. "Traditional fishery in Futuna and its dangers—Horn Archipelago, Polynesia", in Proceedings of the Fourth International Coral Reef Symposium. Marine Sciences Center, University of the Philippines, Quezon City, Philippines, vol. 1, p. 111.

Gatty, H. 1947. "The use of fish poison plants in the Pacific". Transactions and Proceedings of the Fiji Society 1938–1954, vol. 3, no. 145/47, pp. 152–159.

Glynn, P. W. 1993. "Coral reef bleaching: Ecological perspectives". Coral Reefs, no. 12, pp. 1–17.

Gold, E. 1955. "Fish poisons at Mangaia". Journal of the Polynesian Society, vol. 64, no. 2, pp. 237–239.

Golden, F. 1991. "Reef raiders". Sea Frontiers, February, pp. 22–29.

Gomez, E. D., Alcala, A. C. & Yap, H. T. 1987. "Other fishing methods destructive to coral", in Human Impacts on Coral Reefs: Facts and Recommendations, ed. B. Salvat. Antenne Museum — E.P.H.E., Moorea, French Polynesia, pp. 67–75.

Harmelin-Vivien, M. L. & Laboute, P. 1986. "Catastrophic impact of hurricanes on atoll outer reef slopes in the Tuamotu (French Polynesia)". Coral Reefs, no. 5, pp. 55–62.

Holthus, P. F., Maragos, J. E. & Evans, C. W. 1989. "Coral reef recovery subsequent to the freshwater kill of 1965 in Kaneohe Bay, Oahu, Hawaii". Pacific Science, vol. 43, no. 2, pp. 122–134.

Hornell, J. 1940. Report on the Fisheries of Fiji. Government Printer, Suva, Fiji.

Hornell, J. 1941. "Fishing poisons". Man, no. 41, pp. 121–128.

Itano, D. 1980. Illegal Fishing Practices in Samoa. Department of Marine and Wildlife Resources, Pago Pago, American Samoa.

Johannes, R. E. 1975. "Pollution and degradation of coral reef communities", in Tropical Marine Pollution, eds E. J. Ferguson Wood & R. E. Johannes. Elsevier Scientific Publishing Co., New York, pp. 13–51.

Johannes, R. E. 1981. Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. University of California Press, Berkeley, CA.

Kaly, U. L. & Jones, G. P. 1994. "Long-term effects of blasted boat passages on intertidal organisms in Tuvalu: A meso-scale human disturbance". Bulletin of Marine Science, vol. 54, no. 1, pp. 164–179.

Kaufman, L. S. 1983. "Effects of Hurricane Allen on reef fish assemblages near Discovery Bay, Jamaica". Coral Reefs, no. 2, pp. 43–47.

Leonard, J. W. 1939. "Notes on the use of Derris as a fish poison". Transactions of the American Fisheries Society, no. 68, pp. 269–280.

McManus, J. W. 1980. "Philippine coral exports: The coral drain". ICLARM Newsletter, vol. 3, no. 1, pp. 18–20.

McManus, J. W. & Arida, C. 1993. "Philippine Coral Reef Fisheries Management". Working Paper No. 39. University of the Philippines, Los Barros, Philippines.

McManus, J. W., Nanola, C. L. & Reyes, R. P. 1991. Destructive Coral Reef Fishing: Seeking Perspectives. Rhode Island University, International Center for Marine Resource Development, Kingston, RI.

Mowbray, D. L. 1988. Pesticide Use in the South Pacific. UNEP Regional Seas Reports and Studies No. 89, SPREP Topic Review No. 26. South Pacific Commission, Noumea, New Caledonia.

Murty, A. S. 1984. Toxicity of Pesticides to Fish, Vol. II. CRC Press, Boca Raton, FL.

Naughton, J. 1985. "Blast fishing in the Pacific". SPC Fisheries Newsletter, no. 33.

Neal, M. C. 1948. In Gardens of Hawaii. Bernice P. Bishop Museum, Special Publication 40. Honolulu, Hawaii.

Norse, E. 1993. Global Marine Biological Biodiversity. Island Press, Washington, DC.

Öhman, M. C., Rajasuriya, A. & Lindén, O. 1993. "Human disturbances on coral reefs in Sri Lanka: A case study". Ambio, vol. 22, no. 7, pp. 474–480.

Owens, D. 1971. "*Acanthaster planci* starfish in Fiji: Survey of incidence and biological studies". Fiji Agricultural Journal, no. 33, pp. 15–23.

Pajaro, M. G. 1994. "Using education to stop destructive fishing practices: A partial success in several communities", in Collaborative and Community-based Management of Coral Reefs: Lessons from Experience, eds A. T. White, L. Z. Hale, Y. Renard & L. Cortesi. Kumarian Press, West Hartford, CT, pp. 51–58.

Pauly, D. 1988. "Some definitions of overfishing relevant to coastal zone management in Southeast Asia". Tropical Coastal Area Management, vol. 3, no. 1, pp. 14–15.

Paxton, J. R. & Lewis, A. D. 1988. Manual for the Identification of Fishes Caught by Explosives in Fijian Waters. Fisheries Division, Suva, Fiji.

Pearson, R. G. 1981. "Recovery and recolonization of coral reefs". Marine Ecology Progress Series, no. 4, pp. 105–122.

Pétard, P. 1986. Quelques Plantes Utiles de Polynésie Française et Raau Tahiti. Éditions Haere Po No Tahiti, French Polynesia.

Purseglove, J. W. 1968. Tropical Crops: Dicotyledons, Vols 1 and 2. Longmans, Green and Co. Ltd, London.

Richards, A., Lagibalavu, M., Sharma, S. & Swamy, K. 1994. Fiji Fisheries Resource Profiles. FFA Report No. 94/4. Forum Fisheries Agency, Honiara, Solomon Islands.

Rickard, P. & Cox, P. A. 1986. "Use of *Derris* as a fish poison in Guadalcanal, Solomon Islands". Economic Botany, vol. 40, no. 4, pp. 479–484.

Rubec, P. J. 1986. "The effects of sodium cyanide on coral reefs and marine fish in the Philippines", in The First Asian Fisheries Forum, eds J. L. Maclean, L. B. Dizon & L. T. Hosillos. Asian Fisheries Society, Manila, Philippines, pp. 297–302.

Rubec, P. J. 1988. "The need for conservation and management of Philippine coral reefs". Environmental Biology of Fishes, vol. 23, nos 1–2, pp. 141–154.

Ryan, P. 1994. "Potential disasters: The trouble on our coral reefs". Fiji Times, Suva, Fiji, 17 December, p. 6.

Saeger, J. 1993. "The Samar Sea, Philippines: A decade of devastation". Naga: The ICLARM Quarterly, October, pp. 4–6.

Saila, S. B., Kocic, V. L. & McManus, J. W. 1993. "Modelling the effects of destructive fishing practices on tropical coral reefs". Marine Ecology Progress Series, vol. 94, no. 1, pp. 51–60.

Saimolys, M. A. 1988. "Abundance and species richness of coral reef fish on the Kenyan Coast: The effects of protective management and fishing", in Proceedings of the Sixth International Coral Reef Symposium, Australia. vol. 2, pp. 261–266.

Sesepasara, H. 1980. "Illegal fishing — on increase". Samoa News, Pago Pago, American Samoa.

SPC. 1993. Survey of the island of Niue. Inshore Fisheries Research Project, Technical Document No. 3. South Pacific Commission, Noumea, New Caledonia.

SPREP. 1988. "SPREP Questionnaire on Destructive Fishing Methods: Summary of Results". SPC Workshop on Pacific Fishery Resources, 14–25 March 1988. Working Paper 19. South Pacific Commission, Noumea, New Caledonia.

SPREP. 1992. Environment and Development: A Pacific Island Perspective. Asian Development Bank, Manila, Philippines.

Swingle, H. S. 1954. "Fish populations in Alabama rivers and impoundments". Transactions of the American Fisheries Society, no. 83, p. 47.

Tebano, T. 1991a. A Preliminary Survey on Ciguatera Fish Poisoning on Nauru Island, Central Pacific. Marine Studies Programme Technical Report No. 7. University of the South Pacific, Suva, Fiji.

Tebano, T. 1991b. A Preliminary Survey on Ciguatera Fish Poisoning in the Marshall Islands. Marine Studies Programme Technical Report No. 10. University of the South Pacific, Suva, Fiji.

Tebano, T. 1991c. A Preliminary Survey on Ciguatera Fish Poisoning in Tuvalu. Marine Studies Programme Technical Report No. 11. University of the South Pacific, Suva, Fiji.

Tebano, T. & Lewis, R. 1991. Ciguatera Fish Poisoning and Reef Disturbance. Marine Studies Programme Technical Report No. 6. University of the South Pacific, Suva, Fiji.

Tebano, T. & MacCarthy, D. 1991. Ciguatera Fish Poisoning and the Presumed Causative Organism in the Gilbert Islands, Kiribati. Marine Studies Programme Technical Report No. 9. University of the South Pacific, Suva, Fiji.

Tsuda, R. T. 1981. "Coral reefs in Micronesia". Coral Reef Newsletter, no. 3, pp. 25–27.

Tueting, B. 1940. "Subsistence", in Southern Lau: An Ethnography, ed. L. Thompson. Bernice P. Bishop Museum Bulletin 162, Honolulu, Hawaii, pp. 127–143.

UNESCAP. 1990. Environmental Management Plan for the Kingdom of Tonga. United Nations, Bangkok, Thailand.

Vakily, J. M. 1993. "Dynamite fishing in Sierra Leone". Naga: The ICLARM Quarterly, October, pp. 7–9.

Veitayaki, J. 1990. Village level fishing in Fiji: A case study of Qoma Island. MA Thesis, University of the South Pacific, Suva, Fiji.

Veitayaki, J. 1994. "Land-based pollution in the Pacific: A major threat to the sustainability of ocean resources", in La Terre: Actes du Sixième Colloque CORAIL, 27–29 October 1993, Noumea, New Caledonia. pp. 257–270.

Virot, R. 1950. "Plantes ichtyotoxiques utilisées en Nouvelle Caledonie". Revue Internationale de Botanique Appliquée et d'Agriculture Tropicale, no. 327–328, pp. 86–88.

Waqa, I. 1994. "Explosives worry a chief". Daily Post, Suva, Fiji, vol. 6, no. 201, p. 6.

Watts, M. 1993. Poisons in Paradise: Pesticides in the Pacific. Greenpeace, Auckland, New Zealand.

Wells, S. 1988. Coral Reefs of the World, Vol. 3, Central and Western Pacific. UNEP, Nairobi, Kenya; IUCN, Gland, Switzerland.

Wells, S., Holthus, P. & Maragos, J. 1994. Environmental Guidelines for Coral Harvesting Operations. SPREP, Apia, Western Samoa.

Wilson, J. W. 1967. "Faka kona ika: A note on the use of poisons in Niue". South Pacific Bulletin, vol. 17, no. 2, pp. 35–36.

Yamanouchi, T. 1955. "On the poisonous substances contained in Lolothurians". Pabl. Set. Mar. Biol. Lab., vol. 4, nos 2–3, pp. 183–203.

Yap, H. T. & Gomez, E. D. 1985. "Coral reef degradation and pollution in the East Asian seas region", in Environment and Resources in the Pacific. UNEP Regional Seas Reports and Studies No. 69. UNEP, Nairobi, Kenya, pp. 185–207.

Zann, L. P. 1994. "The status of coral reefs in south western Pacific islands". Marine Pollution Bulletin, vol. 29, nos 1–3, pp. 52–61.

Annexe 1 Dynamite fishing in the Ba and Tavua area, Viti Levu, Fiji

Introduction

Blast fishing using dynamite is more prevalent in the Western Division than anywhere else in Fiji (SPREP 1988). More specifically, cases have been reported in areas extending from Lautoka to Rakiraki. The gold-mining industry, construction of the hydroelectric dam, and more recently the King's Road construction project are the main sites from which dynamite is stolen and supplied to fishers. Some fishers are said to be able to devise home-made explosives. Such a case was reported to police in the Ba area last year when a fisher used firecrackers to make explosives.

According to police records, fishers continue to use dynamite despite the fact that the activity is banned by law. In the context of dynamite fishing, there are three kinds of fishers in the area: those who never use explosives for fishing, those who use explosives only rarely, and those who use explosives quite often. There are, however, no full-time dynamite users, as is the case in the Philippines. The following accounts provide an insight into the situation surrounding the use of dynamite in Ba, Tavua and Vatukoula in the last five years (Tables 1–3). The fishers are based in Ba and Tavua while Vatukoula is the gold-mine from where dynamite thefts are reported.

Table 1 Cases of killing fish with explosives in Tavua

Year	Cases
1989	5
1990	1
1991	3
1992	1
1993	5
1994	4

Table 2 Cases of using and possessing explosives in Ba

Year	Killing and selling dynamited fish	Illegal possession of explosives
1989	3	0
1990	6	0
1991	3	11
1992	6	0
1993	3	1
1994	10	3

Table 3 Cases of missing explosives in Vatukoula

Year	Cases	No. of detonators missing	No. of gelignite sticks missing
1989	1	3	0
1990	1	6	0
1991	0	0	0
1992	1	3	11
1993	5	23	49
1994	8	92	106

Case histories

The following are the result of seven interviews carried out with fishers who have either been convicted or questioned by police for using dynamite. The names of the fishers were changed in order to protect their identity. The fishers are from three villages in Tavua and individual settlements in the nearby cane areas.

1. Mr Ram Singh

Mr Singh was a part-time farmer and fisher but is now retired. He moved to his present location about 30 years ago when his father-in-law allocated 12 acres of land to his daughter (Mrs Singh). The 58-year-old Mr Singh suffers from diabetes and has problems with his eyesight as a result of a heart attack. He stays home most of the time as he no longer is able to work. At the moment he is making arrangements to go abroad for medical treatment.

The Singhs have three sons and one daughter. The eldest son manages the farm and the youngest son is an apprentice electrician. None of the three sons is involved in fishing. The daughter is now married and lives abroad.

Mr Singh recalled his fishing days as a time when he was looked upon as a strong, influential person. According to the other fishers, Mr Singh was well known for fishing with dynamite. He was also known to have hired crew who could use the

explosives. He admitted fishing with dynamite and showed his hands which today bear the result of an earlier accident. Mr Singh lost most of his fingers when a detonator cap exploded in his hand.

Mr Singh was confronted by the naval patrol twice. He was questioned and investigated. He has also been questioned by police on several occasions.

According to Mr Singh, cane farming on a 12-acre plot did not generate sufficient income to meet the family expenses. Besides, Mr Singh's brothers-in-law did not legally transfer the land allocated to his wife by her father. This created insecurity as Mr Singh had to rely on the goodwill of his brothers-in-law. According to the Fiji Sugar Corporation, Mr Singh was a tenant on the land and therefore needed the approval of his brothers-in-law for any major activity or development on the property. The relationship was not so cordial.

Mr Singh wanted to educate his children and that was difficult as he was the only breadwinner. He further added that he had needed money to build his house which is now one of the better houses in the area, and get his children married. The need for cash tempted him to fish with dynamite as it was not difficult for him to obtain explosives from the illegal sources at the Vatukoula gold-mine. According to Mr Singh, the miners or the "middlemen" always know their target customers.

Mr Singh sold his engine and boat in 1987 after losing most of his fingers in the accident. He was well aware that the use of explosives is not only prohibited but dangerous. He indicated that it was a risky business but he was prepared to take the risk to meet his immediate cash needs. He added that as a result of these risks and the loss of his fingers, he has a well-constructed concrete house and does not have any outstanding loan.

According to Mr Singh, the use of explosives is a very efficient method of fishing which requires less time and costs. He claimed that if he had used nets or carried out line fishing he would have remained a poor man who failed to meet his economic obligations.

Mr Singh is contented that his children are now grown up and are able to manage the household. He said that even if he had not had the accident, he would have stopped using dynamite because his children no longer needed financial support.

2. Mr Sairusi Waqa

Mr Waqa is 60 years old and lives with his family in one of the villages. He started commercial fishing when he was 18 years old and stopped in 1960 when, at the age of 26, he was involved in a serious accident when a stick of gelignite exploded prematurely in his hand. Mr Waqa lost both of his eyes and half of his right arm. Since the accident, he has not been able to work. He spends most of his time resting and attending village functions and meetings. Mr and Mrs Waqa have eight children—six sons and two daughters. Three of their sons are now working. One manages the sugar cane farm, one is a carrier operator and the third is a fisher who owns an outboard punt. The three of them now support the family.

Mr Waqa used dynamite for eight years, his entire time as a fisher. Explosives which were widely used in large amounts for open-cast and underground mining were readily available from the miners as the security checks were not very tight.

According to Mr Waqa, it was difficult for him to bring up his children with a normal fishing income. During the 1950s and 1960s, fish prices were very low so one needed a large volume of fish to achieve the targeted income. Using dynamite was an easy way to catch large schools of mullet, emperors, mackerel and other fish aggregation.

Income from farming was periodic whereas fishing provided instant cash. However, after the accident, Mr Waqa's family relied on income from land rent. Mrs Waqa assisted by selling crabs collected from the nearby mangrove areas and sold them along the roadside. Village members and relatives also assisted in providing the basic necessities.

Mr Waqa felt his experience was not going to deter others (including his children) from using explosives. According to him the choice is up to the individual fisher. There is no guarantee that people will stop using dynamite as it is efficient and provides economic returns.

The other victim of dynamite fishing in this village disappeared into the nearby cane farms when word got around that the team was interested in talking to him. Mr Waqa's son, a fisher, mentioned that there are other fishers in the village who still use dynamite.

3. Mr Peni Nadruku

Mr Nadruku is 52 years old and has eleven children — seven sons and four daughters. For Mr Nadruku, fishing has been the main source of income for over thirty years. Five years ago he sold his boat and now fishes only occasionally. He now raises goats for his living. Only one of his sons works at the gold-mine in Vatukoula. The rest of his children now live and work in Suva.

Mr Nadruku recalled his fishing days when he used to go out fishing three or four times a week. He used gill nets, line and dynamite. During a night fishing trip, dynamite, if it was employed, would be used in the early hours between 5 and 7 a.m. before returning. During the day, dynamite would be used in the afternoon between 2 and 4 p.m. These were considered "safe" times when boat traffic in the surrounding fishing grounds was low. However, if a large school of fish was sighted and if there were no

"strange" (unknown) fishers around, dynamite would be used at any time.

As a fisher, he usually targeted schools of small fish (mackerel, sardine or mullet) near a reef area because bigger fish will aggregate to feed on the smaller fish. The bigger fish, including a variety of groupers, cod and sharks, are then caught using lines. Fish that are killed or directly affected by the explosion are collected quickly by diving.

Describing the illegal trade in stolen explosives from the mines, Mr Nadruku explained that miners either sell directly to fishers or to fixed clients who operated as middlemen. He claimed that most fishers knew whom to approach if they needed explosives.

Mr Nadruku admitted that he had used explosives for several years. He lost part of his left thumb and his left fingertips when a detonator cap prematurely exploded. He related how Mr Singh (case study 1) would pay to get him to use dynamite for him. On such trips Mr Nadruku would receive an average income of $F 100 to $F 150. In addition, Mr Singh also provided all educational expenses for two of Mr Nadruku's sons.

Mr Nadruku's main reason for taking such a high risk was for economic gain. He had to support his large family who needed education and food. He also had other social obligations, such as helping his extended family and participating in community activities. He explained that if he fished using nets and line, he would have had to work four or five times longer and harder to achieve the same size catch.

4. Mr Mata Prasad

Mr Prasad is a part-time fisher and farmer. He sold his boat in 1990 after he was convicted of fishing with dynamite. He now goes out fishing with other fishers from his area.

Mr Prasad has three sons and one daughter. Although he has a cane farm, his land has been earmarked for native reserve by the Native Land Trust Board. His house is next to a village where the people already have limited land to do their own planting as most of the village land has been leased to cane farmers. Like many other farmers in the area, Mr Prasad is worried about losing his rights to the land in the near future. Because of the insecurity surrounding the future of his land, he has not made any attempt to improve it. At the time of the study, the place was one of the worst hit drought areas, which resulted in poor cane plantations. As a result, fishing has been regarded as a better option.

Mr Prasad had to seek permission from the Tui Tavua and Tui Navitilevu to have access to fishing grounds. According to him, the relationship with the fishing rights owners is good because he does not have to pay large monetary sums as in other areas.

Mr Prasad complained about being harassed by naval patrols at sea. According to him, he escaped gunshots three times, as the naval patrols suspected that he was using explosives. He stated that his catch was confiscated twice and once he was beaten by army officers. Mr Prasad had lost three fingers from his left hand in one explosion at sea.

Mr Prasad explained that the use of explosives was for economic reasons to support his family as farming income was not sufficient. Explosives which are available from the miners and other sources are very effective. According to Mr Prasad, there was no commercial fisher in the Tavua area who had not used explosives for fishing. He gave a list of names of known dynamite fishers.

Mr Prasad argued that using explosives only destroyed a small area in the vast ocean space. He did not consider it a major environmental threat. He said that fishers of both races, Indian and Fijian, were alike in that they faced similar economic problems such as educating children and meeting basic needs.

5. Mr Toma Lakula

Mr Lakula is a part-time fisher and farmer. He has nine children—seven sons and two daughters.

In 1979, under the Fisheries Assistance Aid Programme, he obtained a 28-foot half-cabin launch and in 1987 he replaced it with a wooden punt. With his 28-foot boat, Mr Lakula fished for deep-sea snapper. For this type of fishing, he needed bait, such as mackerel, which he said he caught close to the coast using gill nets. Occasionally he bought from other fishers who had caught the mackerel using explosives. He denied ever using dynamite himself. Mr Lakula said that these days he prefers to concentrate on his cane farm and goes out on short fishing trips once or twice a week. However, farming itself is a part-time activity and he therefore needs to rely on the little fishing he does. He sells his fish along the roadside or to middlemen at the market.

According to police records, Mr Lakula was convicted for using dynamite. However, he had no visible injury, and when asked about the use of dynamite, had denied it outright. Mr Lakula explained in detail the process other fishers used to catch fish with dynamite. He said that living close to a coastal area, occasionally he hears a loud bang in the sea when all else is quiet.

6. Mr Jone Tamani

Mr Tamani is 45 years old and lives in the village. He has five children — two sons and three daughters. One is a baby, two are at school, and two are working and living in Suva.

Mr Tamani works as a cane cutter during the harvesting season and is a part-time fisher with an outboard punt. He was convicted for using dynamite but he did not show any signs of physical injury. He admitted his conviction and said that he had used dynamite for economic reasons. He explained that with dynamite he could save a lot of time and fuel. In addition, the level of catch was much greater than that of ordinary line and net fishing. He said that one has to take great care when using dynamite but it is a risk that people are prepared to take because of the need for immediate cash. Mr Tamani has also worked as crew on other fishing vessels which also used explosives.

Mr Tamani noted that when fish are caught using dynamite, those that are physically damaged or undersized are separated out and sold from a carrier in the mining settlements in Vatukoula. Those fish that show no signs of damage and those that are attracted to the blasted fish and caught by lines are sold at the market.

Mr Tamani added that since dynamite is readily available, there is always a temptation to use it.

7. Mr Ashok Kumar

Mr Kumar lives with his brother in the cane area not far from the town. He has a full-time fishing operation with three crew members from the nearby settlement. (The crew members were also present during this interview.) Mr Kumar has a half-cabin launch, a motorised punt and a carrier. His brother manages the farm and sometimes he joins the crew. Likewise, Mr Kumar may help his brother on the farm. The farm land is small and hilly with poor soil and does not generate adequate income. Fishing is a more stable source of income for the Kumar family. Mr Kumar supports a family of eight.

During fine weather, Mr Kumar goes out fishing at least three times a week. For most of the trips, he leaves in the afternoon and returns by the morning tide. He has obtained permits from the Tui Tavua and Tui Ra. Permits were obtained simply by a presentation of *yaqona* (kava). On several occasions the crew has gone deep-sea fishing off the Yasawas (an area outside their permitted fishing ground). However, they now stay within their allocated area because of increased patrols.

Mr Kumar has been questioned by the police on a number of occasions and is known by other fishers to be using dynamite. Police have not charged him so far because of lack of evidence. Mr Kumar denied using dynamite. Crew members indicated that they have witnessed other fishers using explosives but that they have never resorted to such practices. Mr Kumar and his crew gave a vivid explanation of the process used to catch fish with dynamite. They said it was the main method of catching bait in the area. One of the crew members added that they usually catch their own bait using nets but sometimes they have no choice but to buy bait from others who had used dynamite.

Mr Kumar complained about the naval patrols who occasionally harassed him and his crew, twice confiscating their catch. The crew said they were beaten because the owner was not on board. Mr Kumar indicated that he and his crew have acquired good fishing skills and the patrols and police eye them with suspicion because they simply have a good catch.

He admitted that many times he has been approached by people selling dynamite but he has never bought it. However, at the Tavua Market, a group of fishers mentioned Mr Kumar as a dynamite user.

Discussion

Security problems at Vatukoula gold-mine

Although the Vatukoula gold-mine is not the only source of supply of explosives, it has been the major source for a long time.

According to the Director of Mines at the Mineral Resources Department, there is a strict security system and supervisors are employed wherever explosives are handled. Explosives are unloaded and brought to the magazine for storage until they are used. Only authorised staff are permitted to handle the explosives ordered from various sites of the mine. Every package of explosives must be accounted for.

Interviews with the mineworkers indicated that explosives are occasionally stolen by the underground miners who blast rocks. The miners use several avenues to obtain and smuggle explosives out of the mine.

Miners generally bore holes in underground tunnels to implant the explosives in order to blast the rocks that contain gold ores. They are required to record the number of explosives used. However, sometimes they sign for the required amount, but put less into the bore holes, hiding the rest. A supervisor is supposed to cross-check that the number of explosives signed is actually implanted into the bore holes before the blast. However, in practice, the supervisors only make random checks if they are suspicious of any wrongdoing.

Miners who steal explosives may hide these items in their pockets, underwear, or boots; stick them inside their hair; or put them in bags, coffee thermoses, or food parcels. One police officer said that he dealt with a case where a miner had hidden explosives inside a hollowed-out loaf of bread. Discussions also revealed that there may be cooperation between underground miners and people on the ground. For example, explosives may be

hidden inside trucks that bring ore to be processed to the surface. The workers who handle these trucks can then remove and hide the explosives before the truck moves to the processing area. The above-ground workers are not subject to security checks.

Underground miners are checked randomly if there is some suspicion. The mining company does not hire full-time security guards. Explosives are not expensive items and some loss does not seem to matter economically to the company. In addition, there is no legal responsibility for the mine to install stricter security measures.

Miners who steal explosives either sell directly to the fishers or to a "middleman" who then supplies the fishers. One fisher said that currently a stick of explosive may cost $F 0.20 – $F 0.50 and it could be retailed on the black market for $F 6.00 – $F 10.00.

Finally, discussions with miners indicated that some people who work at the mine steal scrap cloths used to wipe drums containing cyanide. These cloths are then rinsed in mangrove areas in order to catch fish and invertebrates.

Why fishers use explosives

Both Indian and Fijian fishers were interviewed for this study. A number of fishing operations had mixed crew while some were all Fijian or all Indian. When asked about the heavy use of explosives in the area, Indian fishers indicated that they were encouraged by the Fijian crew to use explosives because the practice would result in a good catch and therefore a higher share for the crew. The Fijian fishers explained that they use explosives because they would otherwise become relatively poor and would face price discrimination at the market because those who use explosives are able to sell fish very cheaply. Everyone indicated that taking the risk was necessary because of the need to improve their personal economic position and because explosives are readily available.

From the interviews it was obvious that the use of explosives in western Fiji is not based upon ethnic or resource ownership lines. Both groups—resource owners (Fijians) and those who lease access rights (Indians)—are using explosives to catch fish. Neither group appears to be concerned about the environmental impacts of their actions on their fishing grounds. The Fijian fishers who are the customary owners of these inshore areas are directly involved in the act of using explosives and they also approve and renew permits of those Indian fishers who are known to be using explosives. Ownership does not appear to automatically engender responsible use of the resources. Accessibility, ease of use, effectiveness, and monetary reward of dynamite fishing are strong incentives for its use.

Fishers who use dynamite are able to bring their catch to market within four to six hours of fishing. Depending upon the extent of damage to the fish or if they were afraid of being caught, they would sell their fish at a much lower price. This competitive market situation forces other fishers who do not use dynamite to resort to use of such methods when the need for income is urgent.

According to the fishers, surveillance by naval patrol boats has increased recently in the area. However, patrol vessels are only seen occasionally over certain periods. If a patrol boat is sighted, the word gets around quickly among the rest of the fishers.

Socio-economic issues

From the interviews and discussions carried out, it appears that dynamite fishing is a more serious problem than is immediately apparent. It is difficult to catch those fishers and miners involved in the network that has evolved to support this form of fishing in Fiji. The use of explosives in the area has been going on for some time as indicated by interview 2 where the fisher admitted using explosives for eight years prior to his accident in 1960. Other fishers interviewed also revealed years of practice before being caught.

The major problem at Vatukoula is the lack of adequate security checks at the gold-mine. It may not be economically feasible for the mine to hire full-time security officers who diligently check that dynamite is not leaving the mining area, but it is becoming an extremely important environmental concern. Interviews revealed that most fishers operate on a part-time basis because the farm income is not sufficient to meet their basic needs. Others rely heavily on fishing income because of limited access to land for farming. Fishing in the area has been an important and stable source of income for both full-time and part-time operators.

If current practices continue, the reefs and fish stocks will start to show serious signs of damage. According to the interviewed fishers, reef damage was limited. Much of the blasting activities took place in the lagoonal waters and in estuaries. However, large oversupplies of some reef fish (red bass, paddletail, yellow-tailed emperors, spangled emperors and rock cod) are occasionally found in the Ba and Tavua fish markets. Some of the consumers in the Tavua area said that at times some of the fish they bought from the market had very soft flesh and broken bones. This correlates well to the evidence from Fiji Fisheries on the state of fish caught with explosives (Paxton & Lewis 1988). The sudden large oversupply by certain fishers and the consumers' concerns suggest that explosives may be used closer to the reefs than the fishers are willing to say.

If the dynamite is not readily available, fishers would, it is hoped, be forced to use more responsible and acceptable fishing gear, such as nets and lines. Many fishers use explosives because of their

availability. This use is based on the attitude that if others are using it, then "why shouldn't I?".

Fishers who fish using acceptable or recommended gear face the problem of high operation and capital costs (for example, purchase of nets) relative to those who use explosives. Thus, when explosives are used, resulting in large volumes of catch, oversupply results. Prices are forced downwards for all fishers. In addition, fish that have been damaged by the explosion of dynamite deteriorate quickly, therefore cannot be kept very long and need to be sold quickly. There are also limited storage facilities, especially at the Tavua market. Because of the situation, fishers who do not usually use explosives may resort to such practices when they face periods of depressed income. This is how most fishers in the area get involved in the use of dynamite.

The use of explosives not only damages the marine life but it is also a risky operation as indicated by the various accidents in the case studies. Several fishers in the Ba and Tavua area have lost their arms and fingers. Cases of blindness and deformed faces also exist. Some fishers get injured to the extent that they become disabled and cannot continue to earn a living (interviews 1 and 2). This eventually leads to increased hardships and a further burden on other family members. For example, in interview 2, the fisherman's wife had to sell crabs by the roadside to support her family until the children grew up.

Ownership of customary rights over the fishing grounds, and the implied obligation to protect the resources and the marine environment, seems to be an ineffective measure in the area. The need for easy cash without much capital input is the overriding goal of many fishers. This indicates that economic forces can easily override customary and traditional practices and the moral obligation to exploit the resources wisely. Other factors include the lack of adequate knowledge on stock dynamics and environmental ecology.

The penalties imposed on fishers in Fiji who used dynamite to catch fish prior to 1991 were quite lenient. For example, a penalty of $F 100 or $F 200 was easily raised by fishers from one blast-fishing trip. These penalties, however, have been increased since 1991 as indicated in the *Fiji Fisheries Act*, but there is no evidence of a decline in the use of explosives since then. Penalties for persons found in illegal possession of explosives, however, still remain low. It was not possible to determine the number of fishers imprisoned, but the interviews indicated that such a practice was minimal.

An opposite extreme occurs in the Philippines, where the use of dynamite for fishing has destroyed extensive reef areas and marine habitats. Penalties for fishers are much stiffer than in Fiji. For example, Galvez (1988) writes:

> Under the laws, mere possession of explosives intended for blast fishing is punishable by 12 to 25 years of imprisonment, and if such explosives are actually used and resulted in injury, the penalty is 20 years to life imprisonment. When caught, the usual amount for "bail" ranges from P1000 to P5000.

According to Galvez (1988), these penalties are too harsh and therefore not widely implemented by police. This leads to corrupt practices by fishers, such as bribing police officers, in order to avoid imprisonment. A system somewhere between these two extremes, that acts as a real deterrent, must be devised.

The *Fiji Fisheries Act* Cap. 158 Ed. 1992, Section 10 (4), states the following:

> Any person who takes or destroys or attempts to take or destroy any fish by the use of dynamite, gelignite or other explosive substance, or who, being the holder of a licence under this Act, is found in possession of dynamite, gelignite or other explosive in such circumstances as to satisfy the court before which he is being tried that he intended to use the substance for the purpose of taking or destroying fish, or any person possessing, transporting or selling or exposing for sale or hawking fish which has been taken by the use of one of the aforesaid explosives, shall be liable for a first offence to imprisonment for six months and to a fine of one thousand dollars, for a second offence to imprisonment for twelve months and a fine of two thousand dollars, and if he is the holder of a licence to take fish it shall be cancelled and may not be renewed for a period of three years from the date of the second conviction; for a third and any subsequent offence to imprisonment for two years and to a fine of five thousand dollars, and if he is the holder of a licence to take fish it shall be cancelled and may not be renewed for a period of six years from the date of such conviction.
>
> In all cases where dynamited fish is seized, it shall be confiscated and destroyed.

The *Fiji Explosives Act* Cap. 189 Rev. 1985, concerning illegal possession and sale of explosives, states the following:

> Any person who has in his possession any explosives contrary to the provisions of regulation 61 or sells any explosive contrary to the provisions of regulation 61 or 62 shall be liable to a fine not exceeding $400 or to imprisonment for any term not exceeding one year.

Conclusion

These interviews were conducted in order to make a preliminary assessment of the socio-economic aspect of dynamite fishing in north-western Viti Levu, Fiji where this practice has existed for some time. Although the Fiji Government has increased naval patrols in the area, it seems that this is done only periodically and thus provides only a temporary solution. Some standard guidelines on how these patrols should operate or handle cases at sea should be devised. Several fishers interviewed in this study complained about physical abuse from naval personnel. Physical violence against offenders or suspected cases is a difficult and sensitive issue that may cause unnecessary retaliation.

According to a survey conducted by SPREP (1988), one of the effective informal measures of enforcement of laws against destructive fishing practices in Fiji was "physical violence against offenders by villagers". This may not always hold true, because some of the offenders in western Viti Levu are themselves villagers who own resource rights. Even if the Indian permit-holders who lease fishing rights were stopped from fishing or using dynamite, there would be no guarantee that the legal right-holders would also stop. The damage to the marine environment will probably continue. It is therefore important to find ways to stop the use of explosives by both groups at the same time.

The need for regulations and proper enforcement to ensure strict security systems at places where explosives are utilised, such as the mine or public works sites, will do a lot to prevent leakage of explosives in the first place. This may not only generate revenue for the government but also ensure that such operations take more care in handling such dangerous substances. There is also a need for a more integrated approach in order to find an effective solution to the problem outlined in this study, for example devising a system whereby an action plan could be formulated that would involve the fishers, police, the Navy, consumer affairs, chiefs, religious leaders, teachers, fisheries personnel, institutions that utilise explosives, and other people in the communities.

These interviews, although limited, provide a useful picture of the conditions associated with blast fishing, their human impacts, and suggest possible remedies. More detailed research leading to comprehensive case studies in Fiji and elsewhere in the region are necessary before effective policy changes and management plans can be formulated.

Annexe 2 Offices where requests for information were sent

AMERICAN SAMOA
- Department of Marine and Wildlife Resources, Pago Pago

COOK ISLANDS
- Secretary of Marine Resources, Rarotonga

FEDERATED STATES OF MICRONESIA
- Chuuk Marine Resources Department, Weno, Chuuk
- Department of Conservation and Development, Kosrae
- Marine Resources Division, Lelu, Kosrae
- Division of Marine Resources, Palikir, Pohnpei
- Marine Resources & Management Division, Colonia, Yap

FIJI
- Fisheries Division, Suva

FRENCH POLYNESIA
- EVAAM, Papeete, Tahiti

GUAM
- Division of Aquatic and Wildlife Resources, Agana

KIRIBATI
- Fisheries Division, Tarawa
- Ministry of Environment and Natural Resources Development, Tarawa

MARSHALL ISLANDS
- Environmental Protection Agency, Majuro
- Marshall Islands Marine Resources Authority, Majuro

NAURU
- Department of Island Development & Industry

NEW CALEDONIA
- Department of the Sea, Noumea
- Service Territorial de la Marine Marchande, Noumea

NIUE
- Director of Agriculture, Forestry and Fisheries, Alofi
- Community Affairs Office, Alofi

PALAU
- Bureau of Natural Resources and Development, Koror

PAPUA NEW GUINEA
- Department of Fisheries and Marine Resources, Konedobu
- Department of Environment and Conservation, Boroko

SOLOMON ISLANDS
- Ministry of Natural Resources, Honiara
- Fisheries Division, Honiara

TOKELAU
- Office for Tokelau Affairs, Apia, Western Samoa

TONGA
- Ministry of Lands, Survey and Natural Resources, Nuku'alofa
- Ministry of Fisheries, Nuku'alofa

TUVALU
- Fisheries Department, Funafuti
- Office of the Prime Minister, Funafuti

VANUATU
- Fisheries Department, Port Vila
- Ministry of Lands and Natural Resources, Port Vila

WALLIS AND FUTUNA
- Service de l'Economie et de la Pêche, Mata'utu, Wallis

WESTERN SAMOA
- Fisheries Division, Apia
- Department of Lands, Surveys and Environment, Apia

Annexe 3 Personal correspondents

Ernest Bani
Environment Unit
Port Vila, VANUATU

P. Cadeau
Service des Affaires Maritimes
Noumea, NEW CALEDONIA

Glasstine Cornelius
Department of Conservation and Development
Kosrae
FEDERATED STATES OF MICRONESIA

Peter Craig
Department of Marine and Wildlife Resources
Pago Pago, AMERICAN SAMOA

Sylvester Diake
Fisheries Division
Honiara, SOLOMON ISLANDS

Richard Farman
Service de la Mer
NEW CALEDONIA

Tom Graham
Division of Marine Resources
Koror, PALAU

Steve Gutreuter*
National Biological Survey
Wisconsin, USA

Rufo J. Lujan
Aquatic and Wildlife Resources
Agana, GUAM

Fiu Manueli*
Marine Studies Programme
University of the South Pacific
Suva, FIJI

Sione Vailala Matoto
Ministry of Fisheries
TONGA

Vaughan Pratt*
International Marinelife Alliance
Manila, PHILIPPINES

Mick Raga
Nature Conservation Division
Boroko, PAPUA NEW GUINEA

Mike Rimmer*
Northern Fisheries Centre
Queensland, AUSTRALIA

Peter Rubec*
International Marinelife Alliance
USA

Kelesoma Saloa
Fisheries Department
Funafuti, TUVALU

Louis Savoie
EVAAM
Papeete, FRENCH POLYNESIA

Beero Tioti
Fisheries Division
Tarawa, KIRIBATI

---

* These personal correspondents were not sent the faxed questionnaire.