

Status of reef and lagoon resources in the South Pacific – the influence of socioeconomic factors

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Abstract Poor knowledge on status of reef fisheries, as well as extent and impact of subsistence fisheries challenges design and implementation of effective fisheries management aiming at sustainable resource use in the South Pacific. This paper presents experiences and results made in the framework of the multi- and interdisciplinary PROCFish/C project that is funded by the European Union. The project aims at establishing a regional database on status and use of coastal marine resources and the identification of indicators that will help to better monitor the interactions between both. The two major components of the project, resource and socioeconomic surveys, collect both data according to a fisheries classification system to permit joint data analysis. The socioeconomic component does not only furnishes data that is compliant with ecological and resource data but also uncovers site specific mechanisms, in particular interrelations between market-resource- and sociocultural attitudes. Case studies are presented from fisheries communities in Tonga, Fiji and French Polynesia to highlight that appropriate and thus effective policies and fisheries management projects require not only knowledge on the resource, but also on fishing and marketing systems.

Fisheries in all three case studies are affected by the dualisms of modern, cash based economic and traditional, non-monetary valorization mechanisms. The Tongan case study illuminates the interplay between sociocultural attitudes and market as improved income incentives provided by urban markets trigger adoption of more efficient fishing strategies. The live rock study from Fiji shows that creating awareness and moral barriers may be a more effective tool in fisheries management than providing facts from research only. The combination of traditional value systems, resource availability and marketing mechanisms that determine not only exploitation but also commercialisation of certain coastal resources is demonstrated by the case study from French Polynesia.

Results show that the better understanding of socioeconomic mechanisms will help fisheries managers further understand the manipulative forces of sociocultural attitudinal factors in specific situations to

foster or to reduce pressure of specific reef and lagoon fisheries.

Keywords sociocultural mechanisms, subsistence fisheries, South Pacific, fisheries management

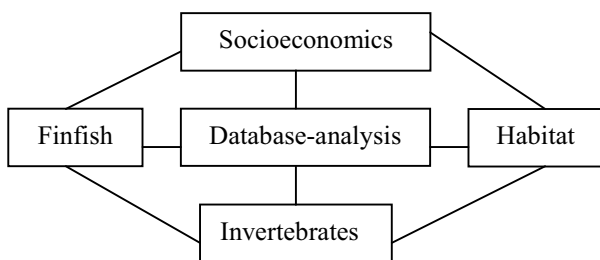
Introduction

Reef and lagoon resources have always provided basic needs to coastal communities in the South Pacific region. To ensure sustainable use of resources, effective fisheries management strategies are needed to prevent further deterioration of the region's coastal resources. However, coastal fisheries management is challenged by several shortcomings. As opposed to oceanic fisheries, little baseline, and even less historical timeline data are available on both, status and use of the resource. Taking into account that generally we have not sufficient knowledge of the dynamics of coastal fisheries (Hilborn and Walters 1992), and that nature is too complex and too variable, a precautionary marine resource management approach (Munro 1996), data-less or data-poor management (Johannes 1978) have been proposed not only as being appropriate but imperative (Johannes 1998) to address detectable problem with no delay. While we do not contest this principle, reliable and detailed information on the status and use of coastal resources may increase efficiency of management interventions, as it does not only reveal the not so obvious though undesired developments but also allows to assess the dimension of fisheries problems (Visser 2003). In most cases, information gathering capacity has been severely limited in most fisheries departments in the South Pacific. Thus there is an urgent need for research geared towards the assessment and management of fisheries that are already exploited at levels exceeding maximum productivity (Adams and Wata, 1995). Unfortunately, the knowledge base on the status of reef fisheries stocks (FAO 1995), the extent and impact of subsistence fisheries (Mac Manus 1996) continues to be poor.

The ongoing regional coastal fisheries project, PROCFish/C, which is implemented by the Secretariat of the Pacific Community and funded by the European Union (2002-2007) addresses the need for a regional

database on coastal marine resources. The multidisciplinary team aims at working hand in hand towards the interdisciplinary analysis of finfish, invertebrate, environmental and socioeconomic parameters to better understand the dynamics between resource status and user level. The interdisciplinary analysis of complementary data from each discipline aims at identification of indicators or proxies that will help to better monitor the status of selected marine coastal resources (Fig. 1). The project's major objective is to contribute to improved fisheries management in the Pacific region.

Fig. 1: Interdisciplinary data collection and analysis of PROCfish/C project



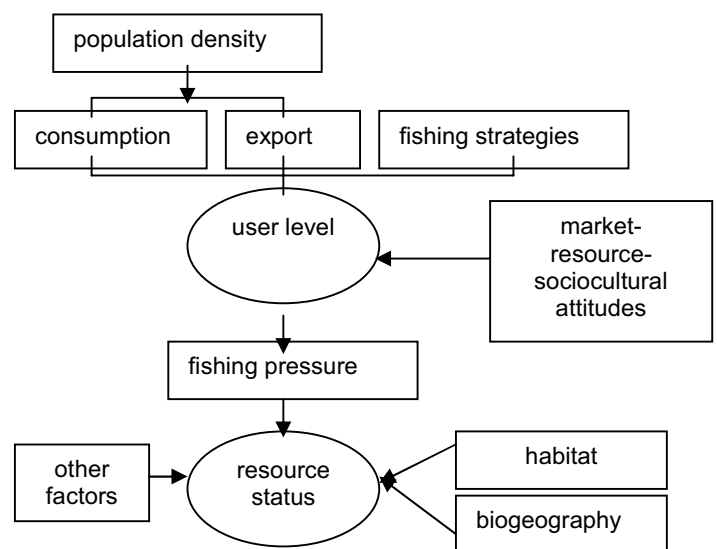
Reference units classified as “fisheries” are defined using predominantly ecological parameters. Generally, fisheries considered by PROCfish/C deal with coastal, i.e. reef and lagoon, finfish or invertebrate resources only. Pelagic species are excluded. Userwise, emphasis is placed on subsistence and small-scale artisanal fisheries that may include the occasional selling for generating cash income up to commercial fisheries targeting the international market (such as beche-de-mer, trochus, lobster) but still performed at small-scale economic level.

The different categories of fisheries defined depend on the discipline. Invertebrate resource and exploitation parameters distinguish two major types of invertebrate fisheries, i.e. those based on collection of resources in different habitats, and dive fisheries that are distinguished by the particular resource(s) targeted. Permitting exceptions, the first type describes the more subsistence while the second type of dive fisheries the more commercial oriented activities. For finfish resources, fisheries are mainly determined by the habitat fished, ranging from coastal reefs to lagoon, back reef and outer barrier reef sites. The selection and definition of socioeconomic parameters complies with both fisheries classification systems concerning use (consumption) and fisheries information. Socioeconomic parameters that are assumed decisive in explaining commonalities and differences between fishing communities surveyed, are collected on the basis of household units. The link between fishers and consumers by household and fisheries pursued makes possible combined data analysis.

The approach taken by the PROCfish/C project does not restrict socioeconomic data to its compliancy with ecological and resource data but puts emphasis on

its necessity to provide answers to many management, policy and planning questions that biological data alone cannot appropriately address. Thus, socioeconomic field surveys also aim at uncovering community specific mechanisms, in particular targeting interrelations between market-resource-sociocultural attitudes that determine selection and exploitation level of a specific or several fisheries. The combined analysis of both, standardized and site-specific mechanisms in view of explaining fishing pressure and ultimately resource status, is depicted in Fig. 2.

Fig. 2: Contribution of socioeconomic survey components to explain resource status



We use case studies from Tonga, Fiji and French Polynesia (Fig. 3) to illuminate how such site-specific mechanisms resulting from the combined effects of market-resource and sociocultural attitudes can drive – or discontinue – specific fisheries.

Case Studies

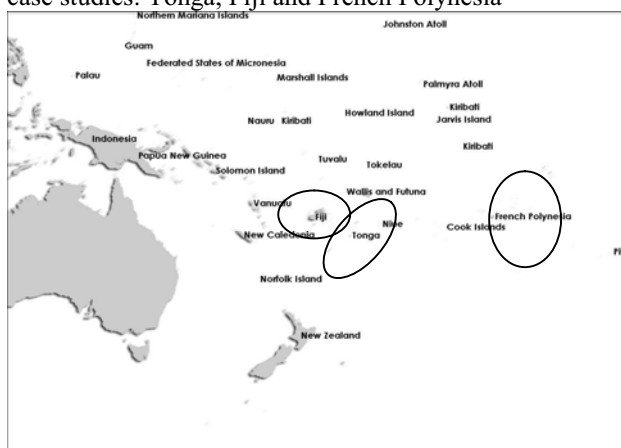
When Do Tongan Fishers Fish More Efficiently?

From an economic point of view, the small-scale characteristic of coastal fisheries makes difficult the determination of the driving factors and conditions that decide whether or not artisanal coastal fisheries and its marketing are viable. Knowledge of these driving factors and conditions, as analysed in the here presented Tongan case study, is considered as an essential foundation on which to argue for or against future economic investments in this sector.

In general, Tonga's reef and lagoon subsistence and small scale artisanal fisheries is best characterised as hand-operated, multi-gearred, and multi-species targeting. Fishing is mostly restricted to nearby coastal areas and, like in other South Pacific island communities, involves little entrepreneurial skills, small informal groups, small

fishing vessels, low capital investment, and correspondingly low productivity (Sabri 1977, Veitayaki 1993, Tu'avao et al. 1994, Passfield 2001). However, within this overall picture, various fisher groups can be distinguished.

Fig. 3: Locations of Pacific Island countries selected for case studies: Tonga, Fiji and French Polynesia



Results presented here are based on field data collected between end of 2001 and mid 2002 from 412 fishers representing between 50-90% of the adult population (≥ 15 years) in each of the six Tongan coastal communities surveyed (Kronen 2004) (Fig. 4). Quantitative and complementary qualitative data on fishing and marketing activities was collected by employing a snapshot approach and by using closed, fully-structured questionnaires.

Economic viability of four different finfisher groups (Table 1) was done using net present value (NPV) analysis. Net present value calculates the present net value of an investment, using a discount rate (interest rate), and a series of future payments (cost) and incomes (revenues) over a given time period. Viability was assessed by comparing net incomes typically achieved by each of the four fisher groups to net incomes of unskilled to medium skilled labour.

As shown in Table 1, group I represents the fisher group with the lowest investment costs but also with lowest productivity, and they serve subsistence or village demand only. Fishers from group II have medium investment costs resulting in a variable productivity level. Spearfishers in group III operate with high input cost but low productivity. Fishers from both groups, II and III, sell at village and rural markets only. The last group (IV) represents medium to high investment and moderate to high productivity. These are the only fishers that have a choice to sell their catch at village or urban markets.

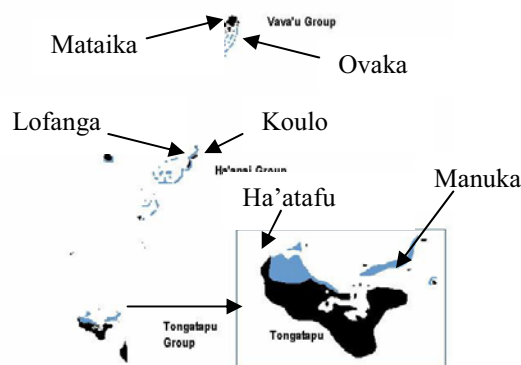
In Table 2 we have compared NPV of income obtained by all of the four fisher groups selected to lowest and highest possible NPV earnings from unskilled to medium-skilled labour. Taking into account that unskilled labour is the lowest possible wage and thus NPV level, it becomes obvious that most Tongan fishers do not operate viable from a mere economic viewpoint. This is particularly true for low investment and low productivity fisheries as represented by group I. It further

applies for the highly specialised spearfishers who are dependent on high cost input as they have to always rent

Table 1: Characteristics of four fisher groups with a commercial interest compared

Group No	Boat transport	Fishing gear	Productivity CPUE kg
I: simple	No, rarely, only non-motorised	restricted, mainly handline	Low ≤ 3
II: variable	owner and/or regular user of motorised	exclusive handline or multi-gear	variable $\geq 3 - 6+$
III: specialised	always using rented motorised	exclusive night time spear diving	low 2.8
IV: market choice	Owner and/or regular user of motorised	single to multi-gear	moderate to high ≥ 3

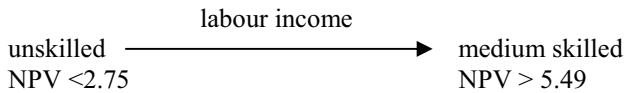
Fig. 4: Location of 6 Tongan communities in which fishers were interviewed



motorised boat transport, while productivity is relatively low. Competing and economically more interesting NPV are reached by fishers from groups II that operate at high productivity level and in particularly those of group IV who have choice of markets. These results suggest that choice and access to lucrative markets is related to the adoption of catch-maximising fishing strategies. Indeed, choice and access to urban markets in Tonga offer about double the price of reef fish (~ 2.50 USD/kg at Nuku'alofa market, capital of Tonga) as compared to village levels ($\sim 1-1.4$ USD/kg). The explanation of this bias lays in the fact that at village level traditionally fish has been exchanged on a non-monetary basis. Today, cash-based economic systems have also advanced in rural areas creating a social dualism between modern and traditional valorisation mechanisms. The traditional system enforcing social resilience and institutions through non-monetary sharing and caring is challenged by the recognition that cash income must be generated to survive. Thus, reef fish prices at village level take into account cash needs but not production cost, while prices asked for at the capital's market are more determined by

supply and demand, fees for transportation and marketing facilities.

Table 2: NPV analysis of four Tongan fisher groups as compared to lowest and highest income obtained from unskilled to medium-skilled labour income



- Group I simple
- Group III spear fishers
- Group II variable fishers
- Group IV urban market access

In conclusion and in view of fisheries management, the Tongan case study demonstrates that the valorisation of reef fish is a decisive parameter for the adoption of catch maximising strategies, and thus fisheries exploitation level.

What Stops Live Rock Collection In Muaivuso-Fiji?

Like other products in the marine aquarium trade, live rock collection continues as a growing, lucrative and licensed industry in Fiji. This fishery is regarded by local people as an unique opportunity to earn income (Sauni et al., in press). However, there is also an increasing awareness that live rock harvesting is not only unsustainable, but leading to long-term reduction of fishing grounds's productivity. Muaivuso, like other Fijian fishing communities, was therefore exposed to an awareness raising workshop performed by the national network for marine protection (FLMMA).

In this case study we used underwater census and socioeconomic data to establish which factor(s) may have triggered the decision taken by the Muaivuso fishing community to ban their live rock extraction operations by the end of 2003, just three years after commencement of this industry. Possible factors considered in this paper include resource depletion, lack of market and ecological awareness.

The Muaivuso community is located on the island of Viti Levu, in close proximity (~20 km) from Fiji's capital city Suva. Resource assessment was done by comparing underwater census data of extracted and non-extracted back reef sites by live rock collectors in the Muaivuso qoliqoli (traditional fishing ground). The socioeconomic, questionnaire based survey aimed at assessing the amount extracted, and to compare economic benefits of live rock collectors to those of the community's commercial fishers. Detailed information on case study site, location and research methodologies used is found in Sauni et al. (in press).

Socioeconomic investigations revealed that village fishers perceive their accessible live rock resource as exhausted and thus as major reason to ban further exploitation. However, our results showed similarities in the potential income generated from traditional finfisheries and live rock extraction. Considering average

household income based on reef fisheries only, daily revenues per fisher amounts to USD 10 on the basis of achieving an average catch during four fishing trips per week (Table 3). And in fact, provided good weather conditions, similar daily revenues for live rock fishers were reported.

Based on information provided by fishers at Muaivuso we estimated that total annual extraction of live rock amounted between 4.5 to 12 t depending on weather and marketing conditions. Assessing the effects from a socioeconomic viewpoint reveals four major issues. Firstly, revenues from live rock coral as opposed to finfish are based on the use and destruction of commonly owned fishing grounds but for the benefit of a few (10% of all households) families only. Secondly, the few families involved may have not increased their daily income but achieved a guaranteed cash payment upon delivery. However, live rock fishers do no longer pursue finfisheries. Thus reef fish for household consumption has to be purchased, or live rock earning families depend on the traditional sharing and caring system to obtain their seafood. Thirdly, reduction of total finfish extraction due to live rock fisheries is marginal ecologically and also in terms of local market value (Table 3). Fourthly, families involved in live rock fisheries used the fourth day that was no longer dedicated to finfishers for gardening.

We also found consistent similarity in major habitat compositions between extracted and non-extracted areas. However, there are indications that live coral species richness, evenness, diversity and dominance are slightly higher in non-extracted areas (Table 4) The trend towards such higher values in non-extracted areas suggests a measurable negative impact of live coral extraction. This tendency is supported by significantly higher fish abundance found in the non-extracted sites (Table 5). There was particular high abundance recorded among three fish families, i.e. Acanthuridae, Nemipteridae and Chaetodonidae. The majority of species in these families are herbivorous and coralline algae feeders. Thus, occurrence of their higher abundance in non-extracted sites may have been triggered by the dominant cover of algae associated with a physically undisturbed environment (Sauni et al. in press).

Bringing together socioeconomic and ecological results, our study did not show any significant socioeconomic or ecological impacts. The relatively short-lived nature (3 years) of live rock extraction in the case of Muaivuso's fishing grounds may be a reasonable explanation. On the other hand, our study also did not confirm either the ecological nor the economic perception of fishers, i.e. resource exhaustion and lucrativeness of the activity. We therefore conclude that awareness raising though the mentioned FLMMA workshop was the decisive factor that prompted the community's decision to ban this fisheries from their communal fishing grounds.

Table 3: Estimation of changes in total annual catch and local market value with and without live rock extraction fisheries in Muaivuso

Variable	details	Value
Total number of households		123
Total number of fishers		172
Total annual catch of fishers (kg/year)	30% women fisher ¹⁾ 70% fishermen ¹⁾	358 267
Total annual consumption (kg/year) ²⁾		134 556
Balance sold (kg/year)		223 711
Annual value of balance sold (USD) ³⁾		335 567
Total annual reduction in finfish if 10% of all households pursue live rock fisheries (kg/year)	30% women fisher 70% fishermen	35 410
Annual value of loss due to live rock fisheries (USD)		53 115

¹⁾ average catch of women fisher = 1030.5 kg/fisher/year;
average catch of fishermen =

2534 kg/fisher/year

²⁾ average annual per capita consumption = 105.7 kg

³⁾ average price for 1 kg of reef and lagoon fish = ~1.5 USD

Table 4: Composition of major benthic categories recorded in live coral extracted and non-extracted sites across Muaivuso's fishing ground

Benthos category	Extracted sites for live coral		Non-extracted sites	
	Mean (n=22)	Std	Mean (n=22)	Std
Abiotics	71.1	±4.7	67.8	±4.9
Dead corals	10.7	±2.7	8.2	±2.9
Bleached corals	0.1	±0.1	0.1	±0.1
Live corals	17.9	±4.1	21.6	±3.0
live macroalgae & sponges	0.3	±0.2	2.3	±0.9

Table 5: Summary of 2-way nested ANOSIM analysis comparing selected parameters of live coral extracted and non-extracted sites in the Muaivuso fishing ground

	Statistic value (R)	% Significance level
Coral species diversity	0.02	> 0.05
Fish species diversity	0.05	> 0.05
Habitat variables	0.06	> 0.05
Fish species abundance	0.19	<0.001

What Determines Commercial Export of Fresh Fish or Frozen Giant Clam in French Polynesia?

Abundance and demand are regarded as the main determinants of the commercial potential of a resource. Focusing on reef fish and giant clams fisheries in two island communities of French Polynesia we highlight that factors other than resource abundance and demand may determine commercialisation and thus exploitation level.

Generally, lifestyle and cost of living in French Polynesia are high as compared to other, mostly non-francophone countries in the Pacific Islands. Also, the French Polynesian society is considered as one of the highest seafood consumers worldwide (Labrosse et al. 2000, Lagadec 2003). Although production costs (gear, transport, labour) are high, local prices for reef and lagoon fish vary significantly.

Field research was carried out between January and February 2004 in the two island communities of Tikeau, a community of 350 people and Raivavae with a total of 1000 inhabitants (Fig. 5). A fully-structured closed questionnaire survey was used to collect data from households and fishers on seafood consumption, seafood catches and the proportion used for subsistence, exchanged on a non-monetary basis and sold (locally and externally). Information on costs was obtained from fishers, agents and transport companies.

Results obtained confirmed that both communities are high reef and lagoon fish consumers reaching annual per capita figures of 80.5 kg and 65.1 kg in Tikehau and Raivavae respectively. However, results also showed that while reef finfish is not only commercialised but also exported at a rate exceeding four times local consumption in Tikehau, finfish remains a non-monetary commodity amongst community members in Raivavae (Table 6). As opposed, giant clams are exclusively commercialised and exported by fishers from Raivavae (Table 7).

Fig. 5: Location and distance of Tikehau and Raivavae islands to Papeete, Tahiti, French Polynesia

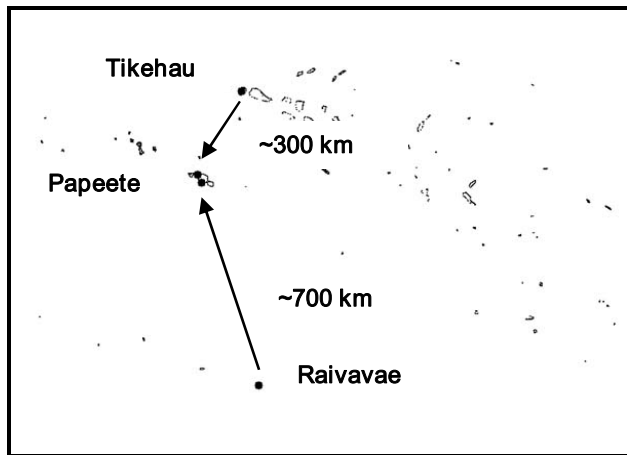


Table 6: Annual fish catch per community and habitat

Community	Total annual finfish catch (t)	Annual catch per habitat (t)		
		lagoon	passages/outer reef	
Tikehau	152.7	128.1	24.6	
Raivavae	65.8	47.9	17.9	
Use of total annual catch (t)				
		consump-tion	export	balanc-e
Tikehau	152.7	28.2	119.2	5.3
Raivavae	65.8	65.1	0.0	0.7

Table 7: Annual giant clam catch and use per community

Community	Total annual giant clam catch (total weight in t)	Proportion of total annual giant clam catch (total weight in t)	
		consumption	export
Tikehau	2.0	2.0	0.0
Raivavae	38.8	31.0	7.8

We also found that a suite of factors explain the two different commercialisation systems in both communities. As summarised in Fig. 6, geomorphology of both islands vary. While Tikehau is an atoll with little alternative food sources than seafood, Raivavae is a high island with varied agricultural production. This difference shows if comparing first sources of income between both communities (Fig. 7). Geomorphological difference alone may explain that the per capita consumption of reef finfish in Tikehau is substantially higher than in Raivavae.

Fig. 6: Comparison of finfish and giant clam exportation of two island communities in French Polynesia

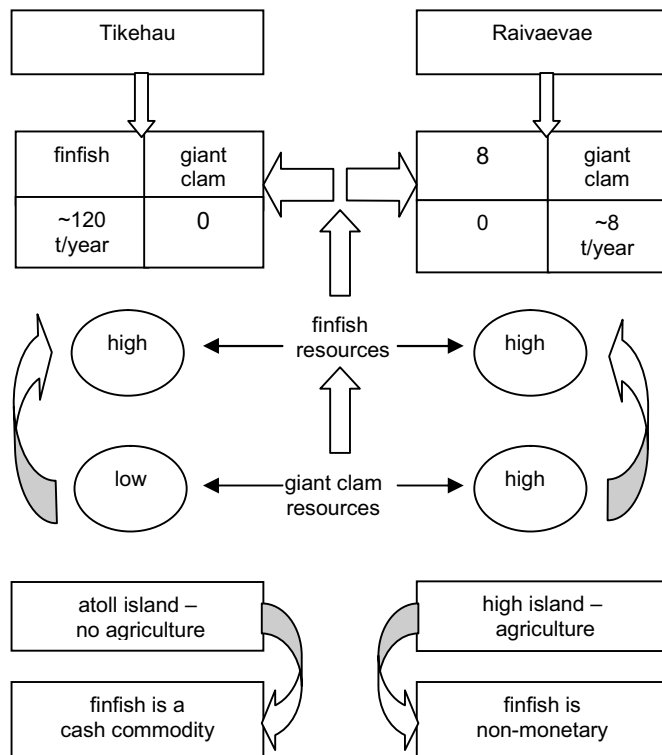
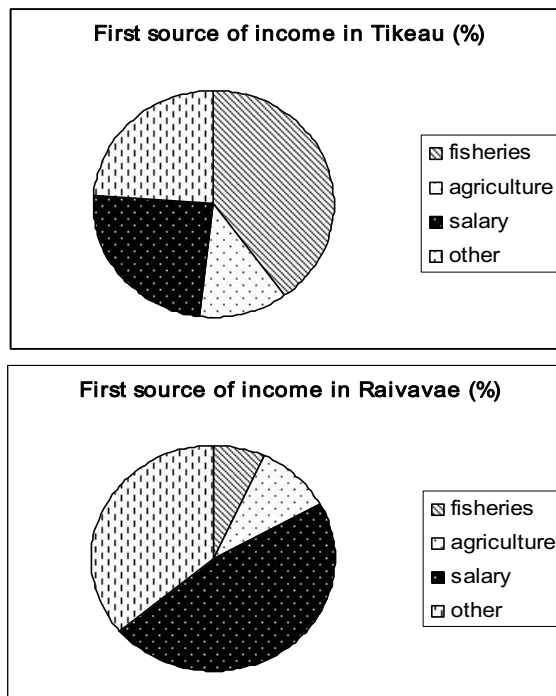


Fig. 7: First income sources (%) of households surveyed in Tikehau and Raivavae



Tikehau is located some 300 km away from Papeete, the capital city and major urban market of French Polynesia. The island is connected by daily air transport that includes a guaranteed weight allowances and price for fresh seafood. Thus, we conclude that lack of alternative

food sources, lack of alternative income options except for the few salary based public service positions, the available airfreight infrastructure, ample reef finfish resources and absence of ciguatera poisoning explain the high exploitation and export level for Tikehau.

As compared, distance between Raivavae and Papeete is approximately 700 km. Since three years, air connection is established twice to three times a week. However, freight volume is very limited and does not allow commercial marketing. Boat transport is regular but travel time requires seafood to be frozen. More recently, ciguatera poisoning has also appeared in certain areas of the island's lagoon system, and in response local fishers chose to fish more frequently in the passages and at the outer reef. Although reef finfish resources are ample, lack of transport for fresh reef finfish that is demanded by urban consumers of the Papeete market, the traditional system to exchange finfish on a non-monetary basis continues to be valid amongst Raivavae people. However, similar to Tikehau, alternative income sources are rare and cost of living is high. Hence, marine resources that are acceptable for marketing elsewhere in a frozen state are exploited and exported, such as giant clams and pelagic fish species.

In both communities export goods are partly marketed, although at a lower price, within the local community and partly still exchanged on the traditional, non-commercial basis.

The French Polynesian case study thus highlights that although exploitable resources and market demand may be available, quality demanded by the consumer (here taste for fresh rather than frozen reef finfish, risk of ciguatera poisoning) in combination with traditional attitudes may restrict (here finfish), as well as foster (here giant clam) exploitation level of certain resources.

Discussion

Our case studies support the argument that the development of appropriate and thus effective policies and fisheries management projects requires not only knowledge on the resource, but also on fishing and marketing systems, both of which, however, are in most cases not sufficiently known (Gillet and Lightfoot, 2001). Results further stipulate to take into account relationships between both, resource and market and sociocultural attitudes to better understand mechanisms that may drive or discontinue particular fisheries. Knowledge of economic, sociocultural structures and conditions associated with artisanal fisheries is therefore essential before appropriate management instruments can be implemented (Gustavson, 2002).

Fisheries in all three case studies are affected by the dualism of modern, cash based economic and traditional, non-monetary valorization mechanisms. The degree to which one or the other mechanisms prevails has consequences on the mode and level of coastal marine resource exploitation. These mechanisms are difficult to quantify and therefore hardly to be included into standardized fisheries surveys. However, as demonstrated in each of the three case studies,

knowledge of any of these site specific dynamics is paramount to successful fisheries management.

The Tongan case study illuminates the interplay between sociocultural attitudes and market as improved income incentives provided by access to the urbanized price-market system at the country's capital city triggers adoption of more efficient fishing strategies. If this access is not given, the traditional system will dominate that is determined by non-economic social and cultural values, opposing income maximizing but strengthening social status and support (Bender et al. 2002, Chakraborty 2002). Traditionally, a Tongan small-scale fisher does not associate cash with profit but with need and as a substitute for social obligations, subsistence requirements and occasional wants. Hence, coastal fisheries operate on a self-regulating basis that limits market participation of fishers to the allocation of catch, the proportion of catch sold and used for other purposes (Halapua, 1982, Iwariki and Ram, 1984). Such a self-regulating production system is short-term and does not consider medium- to long-term investment planning.

The live rock case study from the Fijian fishery community in Muaivuso shows that creating awareness and moral barriers may be a more effective tool in fisheries management than research results. This conclusion is based on the fact that results did not supported the perception of fishers that live rock extraction is financially more lucrative than finfisheries, and that only trends of dissimilarity between extracted and non-extracted sites were found in the ecological survey. Thus, the village people's perception that the depleted live rock resources may not permit further extraction activities could indeed not be confirmed at this stage. This example also highlights the advantage of a traditional system with high social resilience that still supports the "share-and-care" networking amongst its members. The fishing grounds (qoliqoli) are owned, shared and to a great extent managed by the community. This system allowed to inflict social and moral barriers on fishers targeting live corals as they not only use but extract a common basis of the community's livelihood for their personal benefit only. Furthermore, live coral fishers impose an additional burden on the community's welfare institution as others are now obliged to provide them with seafood that they no longer catch.

The French Polynesian case study illuminates how the combination of traditional value systems, resource availability and marketing mechanisms determine not only exploitation but also commercialisation of certain coastal resources. The decisive factors identified also show that even though some are quantitatively measurable (transport facilities), others are of a rather qualitative nature (cultural valorisation system, food preferences). Taking into account that differences in resource endowment are likely to continue, taste preferences (fresh versus frozen) may be a simple tool to manipulate the development of certain fisheries. The comparison between the two island of Tikehau and Raivavae also pinpoints that the provision of transport and freight volume are self-

regulatory mechanisms to determine the marine resource exploitation level for export on isolated islands given a situation where market demand at an urban centre exceeds supply.

Conclusions

Results show that interdisciplinary data analysis based on standardized data collection as performed by PROCFish/C must also take into account site specific mechanisms of market-resource-sociocultural attitude interrelations to explain user-resource dynamics. Our study also suggests that knowledge on the resource status alone may fail to identify not only causes for their demise but also adequate instruments for improving sustainability of their use.

The better understanding of these socioeconomic mechanisms, some of which have been demonstrated by case studies provided here, will help fisheries managers further understand the manipulative forces of sociocultural attitudinal factors in specific situations to foster or to reduce pressure on specific reef and lagoon fisheries.

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