REEF FISHERIES OBSERVATORY

Staff of the coastal component of the EU-funded Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) and the Coastal Fisheries Development Programme (CoFish) completed all substantive fieldwork in the 17 participating countries and territories in late 2007. Project staff began focusing on writing site reports and conducting some data analysis during the first quarter of 2008

CoFish loses another staff member

Ribanataake (Rib) Awira (Fig. 1) has left the CoFish project after spending almost three years with SPC as a Reef Fisheries Officer (finfish). Rib was an integral member of the finfish team and conducted survey work and training in 12 of the 17 participating countries and territories. His input during the rest of the project time will be sorely missed by the team. The good news is that Rib left SPC to take up his new position as the Director of Fisheries in Kiribati. So it is not goodbye to Rib; staff from SPC's fisheries programmes will continue to work with Rib and his staff in the future. The PROCFish/C and CoFish team wish Rib all the best in his new position.

Figure 1: Ribanataake Awira, ex-CoFish employee and now Director of Fisheries in Kiribati.

Update on country and territory site reports

With the substantive fieldwork completed, the focus has changed to writing site reports. Everything is on track to meet the June 2008 deadline agreed upon at the last Advisory Committee meeting. Considerable progress was made in the first quarter of 2008. All site reports (finfish, invertebrate and socioeconomic) have now been completed for Kiribati, French Polynesia, Nauru, Niue, New Caledonia, Papua New Guinea, Tuvalu, Vanuatu, Wallis and Futuna, and Samoa. Around half of the site reports for the remaining seven countries are now completed. All site reports are placed on the PROCFish/C website, in a restricted capacity, as soon as they are completed so that those in-country fisheries staff with permission can access them.

The next stage is to compile the site reports into country reports, and two temporary positions were recently advertised (Fisheries Officer – report compiling and editing, and Technical Support Officer) to assist with this process. There will be an update on this in the next issue of the *Fisheries Newsletter*.

Some early results from the regional dataset

Now that site reports are nearing completion, the PROCFish/C and CoFish scientists can start looking at other project objectives: a regional comparison of the huge data set, as well as identifying indicators or proxies for reef fishery status.

The search for finfish indicators

The PROCFish/C finfish team has begun analysing the status of resources and examining the condition of fish communities throughout the region. One of the greatest challenges in studying resources is in selecting indicators and conditions that can be easily assessed and used for fishery management. A wide range of parameters are influenced by fishing stress and are (or could be) used to evaluate resource condition. Some are species-based, while others are based on the condition of the entire fish community and ecosystem. In multi-species fisheries (such as those associated with tropical reefs) the latter approach is the most indicative. Moreover, in the framework of the ecosystem approach to fisheries, stakeholders need to consider the entire ecosystem (including humans as resource users and sources of environmental impacts) when selecting management options. Coral reef multi-species fisheries and their associated ecosystems are inherently complex, however, and the models available to study ecosystem conditions are much more intricate than those used to study trends in single target species.

The selection of indicators to evaluate resource condition (e.g. from healthy to over-exploited) is complicated by the absence of a quantifiable "pristine state" (i.e. the status of the resource prior to any fishing pressure). The fish communities being studied have long been exploited, and information on ongoing stock changes over time in such communities are generally lacking. One alternative is to compare the status of exploited study sites with communities that receive little or no impact due to fishing, and that have similar environmental conditions (e.g. location, geomorphology and habitat), but this is seldom possible. As a result, the only feasible option is typically to compare sites with different fishing pressures. The resulting picture is complex, composed of overlapping responses by the fish community to natural biological forcing, environmental conditions, and human impacts.

We applied some of the most commonly used parameters in the study of resources to the available data gathered during the PROCFish/C and CoFish assessments. We looked first at the two most widely used parameters: total fish density and total fish biomass.

Density, measured as fish/m^2, is calculated by species, family or total community from *in situ* underwater counts of individuals. Biomass is obtained from the combination of fish counts and their visually estimated lengths. Tabulated information on length–weight relationships provides biomass (or weight) by species, from which biomass by family, and for the total fish population can be calculated. When the total density of commercial fish is plotted over the region for all PROCFish/C study sites (Fig. 2), a very patchy distribution of fish is obtained, with some sites exhibiting obvious fish density peaks, and others clear lows.

A clearer image emerges when the variation between the different sites within a country is analysed. At this relatively smaller scale, variability patterns can be discerned in density and biomass. These can be associated with various factors (e.g. the extrapolated catch per village per year, which is one of the parameters used in socioeconomic studies to assess the impact of fishing activity on reef resources). This variable is one of many indications of the status of fisheries in a village; it does not consider, for example, the density of fishers, consumption, level of dependence on fishing as a source of income, and distance from a market, all of which, along with other information, should be considered when assessing the fishing pressure on resources.

We examined two atolls in Kiribati. Both sites showed a high dependence on fishing for both subsistence and income generation, but the percentage of catches dedicated to export and the density of fishers were higher in one of the sites. When the value of yearly catches is compared with in situ biomass, an inverse relation is revealed between the two variables: higher fishing pressure corresponds to smaller stocks. It is rare to encounter such a clear trend, given the high variability in natural conditions and exploitation patterns across Pacific countries and territories. Moreover, the opposite result could be obtained, if, for example, the prey of exploited target species increase in numbers due to a reduction in their predators through fishing.

Average fish size changes: To test a different status marker we analysed the situation at Palmerston Atoll in the Cook Islands, where past data on some exploited species were available (such a situation is very unusual). Palmerston Atoll

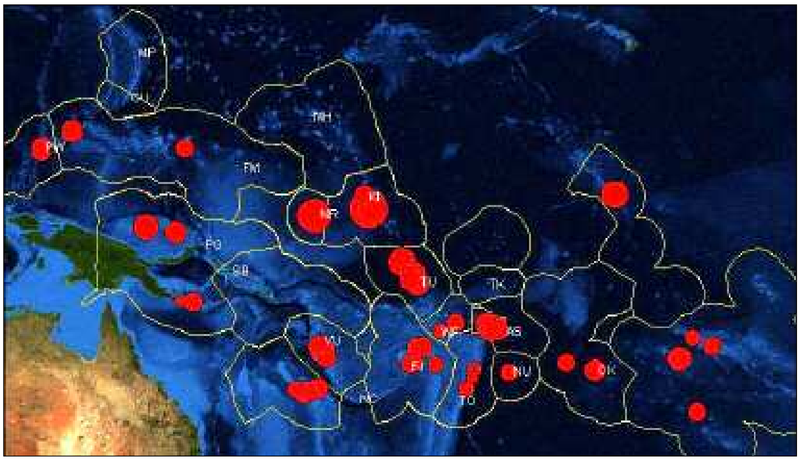


Figure 2: Variation of total commercial fish density throughout the PROCFish/C sites.

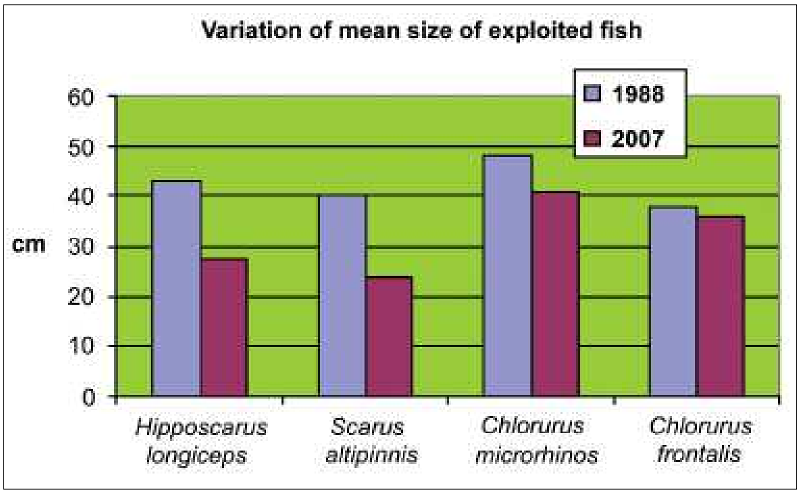
has a long history of exploitation of parrotfish for both local consumption and export to the capital, Rarotonga, for marketing. A comparison of body length records for some species from surveys done in 1988 with our underwater observations of the same species revealed a decrease in the average size of some commercial species (Fig. 3), clearly pointing to a fishing-related impact.

Size of carnivores: The average size of carnivores can also be used as a possible indicator of resource status. Data from five sites in New Caledonia highlight a clear negative relation between mean carnivore size and fishing pressure: the average size of targeted carnivores was larger where there were fewer disturbances from fishing (yearly catches per surface unit, Fig. 4).

Size ratio: The size ratio (i.e. the ratio between the average size of a species and the maximum size such a species would normally attain) is a frequently used indicator of fishing pressure. This value provides an indication of the health of the species population at a determined location and can be averaged by family, feeding guild or fish community. Note, however, that alterations in the size ratio (and in density and biomass) do not occur exclusively in response to fishing pressure, but also in relation to environmental and biological (including behavioural) conditions. In addition, maximum sizes are not absolute; even if we could witness communities in a hypothetical "pristine state", species size could be different from the maximum expected value due to specific adaptations to community forcing and particular habitat conditions.

We sought to identify a link between size ratio and fishing pressure using data from Fiji. The characteristics of the PROCFish/C sites in Fiji (e.g. geography, population, tradition, access to transportation) were very different, resulting in varying impacts on fish communities. Two of the four sites displayed similar geomorphological characteristics, and both had high dependency on finfish for subsistence needs. While the lower catch site showed the highest density of fishers, suggesting resources were being impacted, the second site displayed the lowest fish consumption in the region.

Trophic composition: Changes in trophic composition (i.e. the distribution of total biomass or



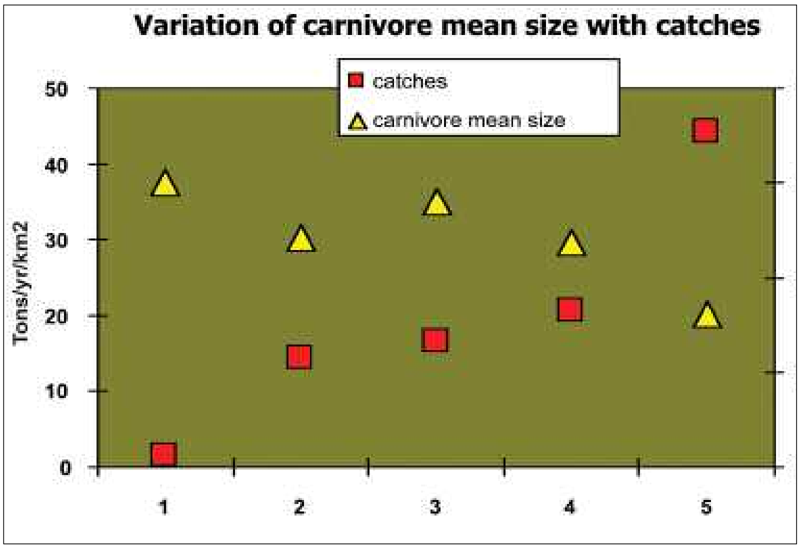


Figure 3 (top): Changes in size of four species of mostly targeted parrotfish at Palmerston Atoll (Cook Islands) from measurements made in 1988 (Preston et al. 1995[1]) and CoFish underwater assessments in 2007.

Figure 4 (bottom): Variation of average length of carnivorous fish and intensity of catches at five sites in New Caledonia.

[1] Preston G.L., Lewis A.D., Sims N.A., Bertram I., Howard N., Maluofenua S., Marsters B., Passfield K., Tearii T., Viala F., Wright D. and Yeeting B.M. 1995. The marine resources of Palmerston Island, Cook Islands. Report of a survey carried out in September 1988. South Pacific Commission Inshore Fisheries Project Technical Document. Noumea, New Caledonia. 61 p.

Figure 5 (top): ***Hipposcarus longiceps*****, an herbivorous species.**

Figure 6 (bottom): ***Caranx melampygus*****, a carnivorous species.**

density among different feeding guilds: herbivores (Fig. 5), piscivores, planktivores, other carnivores (Fig. 6) and detritivores) can serve as an indicator of fishing pressure. Generally, one would expect the percentage of carnivores to decrease with increasing fishing stress, because they are the largest species, and typically the most appetizing. We examined the trend among the four sites in Tuvalu. Two sites were more urbanised, and displayed low fishing pressure; the other sites were much more dependent on fishing, both as source of income and for subsistence. The ratio of carnivores was inversely related to fishing pressure, reaching almost 40% at low fishing pressure sites, vs less than 30%, at the higher fishing pressure sites.

Future finfish analyses will examine (i) how various biological parameters respond to fishing impacts on a regional scale, (ii) the selection of the most significant status indicators, and (iii) integration of *in situ* resource and socioeconomic research. Such tools will support fishery management by facilitating the monitoring of changes in finfish status over time.

Defining an area for invertebrate fisheries comparisons

To date, the PROCFish/C and CoFish projects have conducted questionnaire surveys with fishers to better understand resource use, and underwater visual censuses of important resources in order to understand the status of target invertebrates. Socioeconomic data from interviews indicate the level of fishing (number of fishers, amount of catch) across all study sites. Similarly, in-water surveys reveal the availability (density and population size profile) of important resource species.

Comparison of similar invertebrate fisheries across the Pacific ideally requires that the area exploited by the fishery be measured. It is important to quantify the extent of a fishery in order to understand resource responses to fishing pressure. The areal extent of the following habitat categories have been calculated for PROCFish/C and CoFish sites.

Habitat category	Description
1	Shallow water reef within a lagoon or protected environments (coastal intermediate and back reef. Area in km^2 – Figure 7).
2	Shallow water reef that is exposed to oceanic influence (exposed fringing reef front, outer barrier reef, offshore shoals. Area in km^2 – Figure 7)
3	Size of the lagoon (area in km^2)
4	Land area, for discrete island groups (area in km^2 and
5	Reef perimeter of exposed barrier reef and exposed fringing reef (linear measure in km)

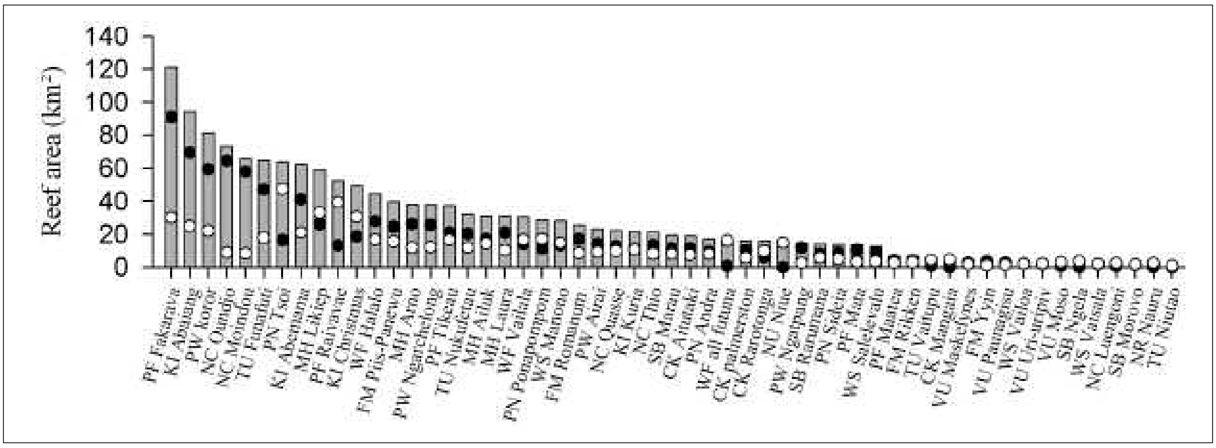


Figure 7: Overview for the calculated area (km²) for shallow reef at PROCFish/C and CoFish survey sites in 17 Pacific Island countries. In the graph, the total shallow water reef area (bars) is depicted alongside protected lagoon reef (dark points) and reef exposed to oceanic influences (light points).

Such area measures are useful in determining the areal extent of general shallow water reef fisheries. For example, fishers who glean or dive on shallow water reefs for giant clams (one of the more important invertebrate food fisheries in the Pacific) exploit the area calculated by the sum of habitat categories 1 + 2 above. Trochus and lobster fisheries are currently compared across sites by referencing the lineal measure of exposed reef front (category 5).

Determining the "best" habitat category to use when comparing fisheries across sites is not simple, and one category is unlikely to fit all needs; even a generic category for a single species fishery may be difficult to measure accurately, as species are not well dispersed across recognised habitat types.

It is clear from our early work that there are no shortcuts for determining fishery areas, and information collected from either in-water environmental surveys or remote sensing alone can provide only a rough areal estimate. A more accurate and reliable determination of the area coverage according to important species groups requires local knowledge and intensive *in situ* resource measurements (using GPS, with followup GIS work).

Some invertebrate fisheries pose particular challenges. To determine the area exploited by sea cucumber fisheries (sold as beche-de-mer), infaunal bivalve fisheries (which target shell beds), or fisheries that concentrate effort on certain habitats (e.g. seagrass or mangroves), several questions must be answered that cannot be resolved using "remote" tools alone (e.g. remote images and habitat maps).

First, the true nature of the fishery must be resolved. Currently, some 35+ sea cucumber species in the families Holothuriidae and Stichopodidae are thought to be harvested in the Pacific Islands region. Greater endemicity occurs in Melanesian countries, which are closer to the centre of biodiversity, while species richness generally declines with distance (eastward) from Papua New Guinea (Fig. 8). The environmental complexity of a site also affects the site's potential to support different species groups.

On average, about 13 commercial species are harvested per country (this count is likely an underestimate due to the lumping of species in the *Actinopyga* spp. and *Bohadschia* spp. groups, because of morphological similarities and taxonomic aggregation).

Although some sea cucumber species are recorded across many shallow reef habitats, most species are sourced from just a few specific habitats (e.g. some are found preferentially in sea-

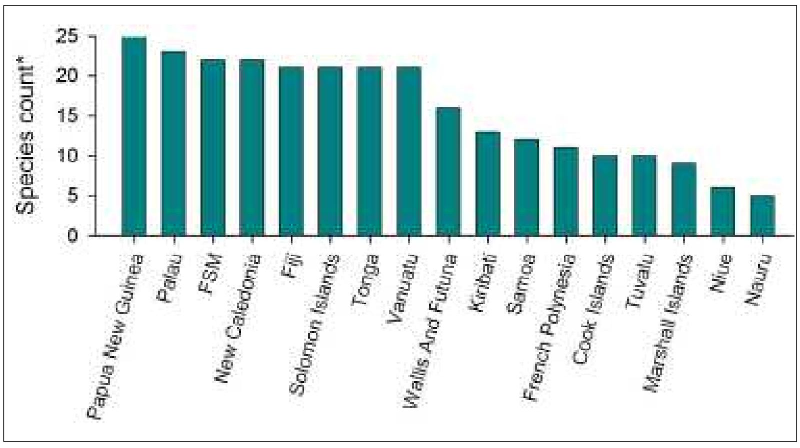


Figure 8: Count of commercial species of sea cucumbers per country.

grass near mangroves), while others are confined to reefs exposed to oceanic swell. Therefore, in order to determine reef areas for a "sea cucumber fishery", at least 5–10 different habitat measures related to species or species groups are needed. Such measures would be difficult to determine from remote (satellite) imagery alone, even with limited local knowledge that could be gleaned from a survey.

Second, it is necessary to determine which habitats can reliably be estimated from remote imagery. For example, can the area of seagrass in a study site be reliably measured from relevant satellite imagery (e.g. Landsat), or is it necessary to determine the actual area using a GPS? For some habitats, remote imagery is useful (general shallow reef), but in most cases the resolution is inadequate, especially when the goal is to determine bottom cover (which may be under water of marginal clarity, or in the case of mangroves, under canopy cover, which blends well with general tree cover as one travels away from the coast). In other cases, no remortely accessed data are available to produce area measurements, e.g. for infaunal shell beds.

A third question relates to the importance of scale when choosing generic area measures. Many invertebrate target species are not evenly distributed within discernable habitat boundaries, but are aggregated, often occupying a small proportion of these habitats. Such variability is of particular importance when making population estimates from site samples, but will also affect the relevance of general fishery area estimates, when these are based purely on habitat or environmental gradients. For example, in trochus fisheries, trochus are usually found in "patchy" aggregations within a recognised reef habitat (such as an exposed barrier reef slope). Our experience suggests that a minimum of two measurements are needed to accurately determine the area covered by a trochus fishery: (i) "core fishing areas" (those with the greatest concentrations or aggregations of trochus), and (ii) "marginal fishing areas" (where trochus are found, but in low density).

In summary, we lack a generic approach to the areal measurement of beche-de-mer fishing grounds and infaunal shell beds. Areal data can be assembled for fisheries of major importance (e.g. trochus) on a site-by-site basis, given adequate time to make *in situ* measurements of specific areas with the help of local fishers. In some cases, habitats such as seagrass beds can be distinguished relatively easily (e.g. if they are found in discrete locations, and high resolution satellite imagery, such as "Quickbird", is available). In other cases our understanding remains incomplete, and we continue to examine how the areal extent of all fisheries can be determined by employing standard area measurements collected at all study sites using knowledge gained during site visits and available remote imagery linked to GIS.

Sub-regional workshops

One of the major outcomes of the PROCFish/C and CoFish projects is the set of methodologies, approaches and tools that have been developed for assessing the resource and user status of reef and lagoon resources in the region. The methodologies are aimed at bringing together the data collected from the various surveys, in particular to join biological and ecological with socioeconomic and fisheries datasets. The need for such methodologies and tools has been highlighted by the demand for training in these areas.

Socioeconomic workshops

The first of three sub-regional workshops on "Socioeconomic fisheries surveys in Pacific Island countries: Collecting a minimum dataset and using SEMCoS" was conducted in December 2007, and was reported on in the last issue of the *Fisheries Newsletter*. The other two sub-regional workshops were held from 21–25 January (Fig. 9), and 31 March–4 April 2008 (Fig. 10).

The main resource material for these workshops was the recently published PROCFish/C and CoFish manual "Socioeconomic fisheries surveys in Pacific Islands: A manual for the collection of a minimum dataset", and accompanying software. This manual covers the design and implementation of socioeconomic fisheries surveys, including questionnaire survey design, data input, data analysis, interpretation of results, and drafting of recommendations. The software and manual are available in English and French, and copies were given to all participants. Additional manuals were provided to the fisheries departments in all member countries and territories. Both versions of the manual and software are available on the SPC webpage:

http://www.spc.int/coastfish/Sections/reef/publications.htm

These workshops followed the same format as the first. All participants were made familiar with 1) the objectives and back-

Figure 9: Second socioeconomic workshop, 21–25 January 2008: from left to right, back row: Dorothy Solomona (Cook Islands), Franck Magron (PROCFish/C), Dave Mathias (Federated States of Micronesia), Mecki Kronen (PROCFish/C), Ebelina Tsiode (Nauru), Tony Taleo Wamle (Vanuatu); front row: Candice M. Guavis (Marshall Islands), Lora B. Demei (Palau), Luanah Koren (Papua New Guinea), and Wesley Garofe (Solomon Islands)

Figure 10: Third socioeconomic workshop, 31 March to 4 April 2008: from left to right, last row: Enoha Terou (French Polynesia), Henri Humuni (Province Îles Loyauté, NC); middle row: Jean-François Kayara, Province Nord, NC), Bruno Mugneret, (Wallis and Futuna), Mecki Kronen (PROCFish/C), Franck Magron (PROCFish/C); front row: Bernard Fao (Province Sud, NC), Philippe Postic (Province Sud, NC), Elenea Takaniko (Wallis & Futuna), Maire Bustamante (French Polynesia)

ground of planning and conducting socioeconomic fisheries surveys, 2) how to plan and collect data, 3) the 10 major subject areas of the manual (including examples for each step), 4) calculation and detailed explanations of some of the extrapolation and calculation formulas applied, 5) survey questionnaires, and 6) other information sources needed. A detailed introduction to SEMCoS software was provided, and emphasis was given to steps involving installation, de-installation, database backup, and the export and import of data. Participants learned to establish the hierarchical order of any survey to take into account country, region, island, village and survey properties. Several exercises aimed at teaching how to complete the questionnaire forms from household interviews, and finfish and invertebrate fisher interviews, to access, design and run queries.

Upcoming underwater visual census (UCV) finfish workshops

In early April 2008, the PROCFish/C and CoFish projects announced a series of four sub-regional workshops on underwater visual census (UVC) methodologies for assessing reef fish resources will be held in Noumea from June to August 2008. Because this form of survey requires two divers to work together as a team, the project is funding two participants per country. The schedule for these workshops is as follows:

a) The first training workshop will be held in Noumea from 16–25 June 2008, and will include participants from Fiji, Nauru, Papua New Guinea, Solomon Islands and Vanuatu;

b) The second workshop will be held in Noumea from 30 June–9 July 2008, and will include participants from the Federated States of Micronesia, Kiribati, Marshall Islands, Palau and Tuvalu;

c) The third workshop will be held in Noumea from 21–30 July 2008, and will be conducted in French only, for participants from French Polynesia, New Caledonia, and Wallis and Futuna;

d) The fourth workshop will be held in Noumea from 4–13 August 2008 and will include participants from Cook Islands, Niue, Samoa and Tonga.

The PROCFish/C and CoFish finfish team look forward to receiving the nominations from the 17 participating countries and territories for these workshops, and to providing the training so that in-country fisheries department staff are better equipped to undertake future surveys by themselves or with minimal assistance from SPC.

AQUACULTURE SECTION

ACIAR aquaculture mini-projects

Project leaders for the ACIAR-funded aquaculture mini-project scheme met in Fiji in February to develop small, flexible project proposals that will help aquaculture development in the Pacific region to overcome bottlenecks. The meeting was also an opportunity to learn about ACIAR post-graduate scholarships, which are open to students at the University of the South Pacific.

Five projects, with a forecasted total budget of AUD95,000, will be developed into final proposals. A further nine projects — with a projected budget of approximately AUD115,000 — will be further developed into concept notes (see Table 1).

Project funding will target the eight ACIAR Pacific Island countries, although non-ACIAR countries are also invited to

Table 1: Mini-projects formulated during the project leaders meeting