



# Fisheries

## Newsletter

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## Editorial

Successive meetings of the Standing Committee on Tuna and Billfish, and most recently the inaugural meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, have recommended that a new large-scale tagging project, focusing on bigeye tuna, yellowfin tuna, and skipjack tuna, be carried out to provide new information that will increase the certainty in the assessment of these fish stocks.

The tagging data generated by the project will be incorporated directly into stock assessment analyses and will provide data on medium- to large-scale tuna movements. As the first phase of this regional project, tagging will be conducted in the exclusive economic zone of Papua New Guinea (PNG), using a chartered pole-and-line vessel. The first of two three-month tagging cruises in PNG is scheduled to begin in mid-August 2006. The second cruise will occur from March to June 2007. We will keep *Fisheries Newsletter* readers informed on the progress of this new project.

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SPC implemented a regional tuna-tagging project in the late 1980s and early 1990s. Funded by the European Commission, the project released approximately 150,000 tuna, tagged with conventional tags (including the skipjack tuna in the photo), and received approximately 20,000 recoveries.



SECRETARIAT OF THE PACIFIC COMMUNITY

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## ■ NEARSHORE FISHERIES DEVELOPMENT AND TRAINING SECTION

### Merging two sections of SPC's Coastal Fisheries Programme

The 5th Heads of Fisheries meeting endorsed "Assisting SPC members in their commitment to apply the ecosystem approach to fisheries (EAF) to coastal fisheries and aquaculture by 2010" as the main overall objective of the Coastal Fisheries Programme (CFP) Strategic Plan for 2006–2009. The new focus on EAF requires the different CFP sections to more closely coordinate their work activities.

Lindsay Chapman was appointed as CFP manager in October. Subsequent to the endorsement of the new CFP Strategic Plan by Heads of Fisheries, two sections (Training and Development),

which already had a common focus, have been amalgamated. The resulting section — Nearshore Fisheries Development and Training — will address objective #3 of CFP's Strategic Plan: "Assisting governments and administrations in the development of domestic nearshore commercial fisheries within a sustainable context". It is expected that this rearrangement, together with the implementation of EAF, will promote a more holistic approach to assessing and addressing the needs of SPC member countries and territories in the areas of coastal fisheries and aquaculture.

The new section consists of:

- one Project Assistant: Christine Bury
- two Fisheries Development Officers: William Sokimi and Steve Beverly
- one Fisheries Development Officer (DEVFISH project): Jonathan Manieva
- one Fisheries Training Adviser: Terii Luciani
- one Nearshore Fisheries Development and Training Adviser: Michel Blanc



### Practical component of the SPC/NMIT Fisheries Officers Course

The practical component of the SPC/Nelson Marlborough Institute of Technology (NMIT) Pacific Islands Fisheries Officers Course was held at the Vanuatu Maritime College (VMC) in Santo, from 5–30 June this year. Nine students, from seven Pacific Island countries, attended the course: one each from Fiji (Aminiasi Tora), Nauru (Gary Degia), Samoa (Tevita Apulu) and Vanuatu (William Morris); two from Papua New Guinea (Ralph Ainui Ryan and Junro Boisen), and three from Kiribati (Kokoria Temare, Kobure Norman, and Naunta Taatu).

The course was coordinated and supervised by SPC's Fisheries Training Adviser, Teriihauroa Luciani, SPC Fisheries Development Officer, William Sokimi, and VMC Masterfisherman, Nare Wolu. VMC staff, under the guidance of Captain Ken Barnett and Ms Caroline Nalo, also

played a major role in facilitating the course.

The focus was on training participants to achieve the necessary skills to work on and handle small fishing vessels safely and economically through proper planning of fishing trips using Safe Operation Plans (SOPs – a

scaled down version of the Safety Management System). Participants learned practical fishing methods commonly used on small commercial fishing craft in the region. They were also required to familiarise themselves with 1) constructing fishing gear for deep-bottom fishing and mid-water/FAD



**Participants undergoing sea survival training**



fishing methods, 2) sustainable fishing practices, and 3) basic principals of marine biology and ecology.

During week one, participants attended intensive training classes on sea survival and safety, basic first aid, and fire fighting. These classes, which were conducted by VMC tutors, included classroom briefings and practical applications, using equipment available at the college. Certificates were issued for each course.

This first week of training also covered fishing methods that would be used during the course, identification of fishing grounds, and construction of fishing gear for the different fishing methods.

From week two onwards, participants practised various fishing methods. Participants were also de-briefed on Monday mornings about the previous week's activities and on the activities for the coming week. Participants were divided into three SOP groups to ensure that the fishing vessels departed for the fishing grounds in compliance with the requirements of the SOP departure checklists and the fishing gear checklist.

Each group was assigned a full week of SOP duties. After the Monday morning briefing, participants were required to load up the vessels in accordance with the types of fishing methods assigned for the week.

Each week was dedicated to carrying out a different fishing



**Top: Fire fighting training at VMC's fire fighting training units**

**Middle: Participants hard at work constructing branchlines**

**Bottom: Constructing mid-water/FAD fishing methods jigging gear**

method. Week two focussed on developing deep-bottom fishing skills; week three, vertical long-line fishing skills; and week four, horizontal tuna longlining skills.

Complementary fishing methods were also carried out simultaneously with the "theme" method for the week. These methods included trolling around the FAD and reef drop-offs, mid-water chum bait fishing (palu-

ahi) and mid-water jigging. Two nights were devoted to bouke-ami bait fishing.

On Tuesdays to Fridays of each week, participants departed for the fishing grounds at around 04:30 hours. Fishing operations were carried out from 07:00 to 15:00 hours and arrival back at base was normally around 17:00 hours. Upon arrival, participants were assigned specific duties: one group headed straight to the processing room to process and record the day's catch. Another group took charge of offloading damaged gear, used ice and general utensils, and then reloaded the vessels for the next day's fishing operation taking into consideration the amount of fuel used that day. The same group also replaced damaged fishing gear and thoroughly cleaned the vessel. At the end of each working day, the SOP team carried out an SOP check of the vessels and made a list of jobs to be completed before the next fishing trip.

The fish processing team ensured that the daily catch was processed according to current market preferences for deep-bottom species and tuna species. If local sales were to be carried out, the crew were in charge of overseeing the processing and packing for the local buyer, and retaining a record of the amount of fish sold.

At the end of the day, the team ensured that the processing room and tools were clean and ready for the next day's operation. The team also recommended the amount of ice to be ordered for the next trip and kept unsold fish in a slurry in the processing room. Although no fish were exported from Santo, partici-



**Top: Constructing flag markers for the high flyers for vertical longline and horizontal longline fishing**

**Bottom: Hauling in a rosy jobfish while deep-bottom fishing**





**Top: Three ruby snappers caught in one haul while deep-bottom fishing**

**Middle: Hard at work setting a vertical longline**

**Bottom: Fish on the line**



pants were shown how to pack fish for the export market. The processing team was rotated every day.

The total catch at the end of the course was 58 fish weighing 255.5 kg. The catch was low, considering the number of days fished, but was sufficient to give participants practise in the different fishing methods, and the onboard handling and processing of fish. (Bad weather was the major factor that contributed to the low catch.) Deep-bottom fishing caught 30 fish weighing 90.5 kg, vertical longlining caught 8 fish weighing 79.5 kg, horizontal longlining caught 5 fish weighing 11 kg, and trolling caught 15 fish weighing 74.5 kg.

Each Friday, at the end of the day's fishing trip, normal activities such as stowing away gear and cleaning were carried out. After lunch on Saturday's, participants offloaded the fishing gears used during the week, and reset the fishing vessels with the appropriate fishing gear for the next week's fishing methods. Sundays were set aside for excursions to Santo's many attractions, including the Blue Holes, Champagne and Palekula beaches, and Million Dollar Point.

Throughout the three weeks of practical fishing, seas were rough and winds gusted up to 30 knots. The daily routine of getting up early, preparing the fishing vessels for sea using SOPs, conducting fishing and post harvest operations, and preparing the vessel for the next fishing trip served the participants well and helped them understand the intricacies and dilemmas that commercial fishermen face on a daily basis.

The bad weather highlighted the importance of using SOPs when preparing vessels for fishing trips, and gave participants an insight into the hardships and risks that small-scale commercial fishermen are confronted with. The use of SOPs assures that standard precautionary measures are taken to ensure a fishermen's safe return from a fishing trip; prudent seamanship and safe boat handling are also important factors.

Three fishing vessels were used during the course: the F/V *Etelis* and F/V *Emm Nao* were used during deep-bottom fishing and vertical longline exercises, and the F/V *Evolan* for the horizontal tuna longline exercise. All vessels fished outside the reef (up to four nautical miles) when the weather permitted, and otherwise operated in the lee of the islands lying off Santo's Luganville town. Each vessel had an SOP plan that suited its size and the number of persons travelling onboard for the training exercises. Peter Petherbridge, a New Zealand Volunteer Service Abroad (VSA) volunteer attached to the college, deserves acknowledgment for developing and promoting user-friendly, effective SOPs for the VMC vessels.

### Bouke-ami bait fishing

Two "bouke-ami" or "stick held dip net" baiting exercises were successfully carried out during the course. The bouke-ami



**Top: Deep-bottom fish in slurry**

**Bottom: Weighing fish before processing**

method of catching bait fish was promoted as it can be used for both live bait vertical longline fishing or horizontal longline fishing.

Participants' lack of experience with this method, coupled with strong currents at the baiting site, limited the size of the catch, but enough fish were caught to demonstrate the potential of the baiting method, particularly when 12 V underwater lights and a dimmer were used to

attract bait fish to the vessel. The bait lights were set at 18:00 hours and by 20:00 hours sufficient bait had aggregated to carry out the exercise. Because of various constraints, the baiting exercise had to be conducted early. The baiting operation should ideally be carried out with minimal tidal current (i.e. at peak high or peak low tide), as this allows the nets to be set and hauled with the least effort, and lessens the likelihood that the net belly will be pulled up





shallow, thus scaring the bait away. However, during the exercises the peak low tides fell during the day, while peak high tides were in the early morning.

There are techniques for carrying out bouke-ami fishing with a current running, but it takes time for an inexperienced crew to grasp the concepts without undergoing the basic training; this was demonstrated by the results obtained in the exercises that were carried out. Both baiting exercises were conducted while a current was running, and resulted in a catch of around 10 kg for each set. Approximately 150–200 kg of bait fish were aggregated around the lights, and if the baiting exercise had been carried out by experienced fishermen, at least half of what was aggregated could have been caught in one haul.



As most readers will be aware, the coordination role in fisheries officers training has been transferred from SPC to the University of the South Pacific (USP), in an effort to regionalise a training programme that continues to be in high demand within Pacific Island countries and territories' fisheries administrations. USP is currently developing a certificate/diploma programme in Sustainable Fisheries, which



**Top: The F/V *Etelis* is a 10-m marine plywood vessel powered by a 48 hp inboard diesel engine, and is licensed to carry 10 persons plus the vessel's skipper.**

**Middle: The F/V *Emm Nao* is a 5-m marine plywood vessel powered by a 75 hp Yamaha long shaft outboard motor, and is licensed to carry 6 persons.**

**Bottom: The F/V *Evolan* is a 12-m fibreglass vessel powered by a 75 hp Yanmar inboard diesel engine, and is licensed to carry 10 persons.**

will strive to retain the spirit and content of the SPC/Nelson course as much as possible. The initial delivery of the 100-level certificate course is tentatively scheduled for mid-2007. This certificate, as well as the associated Diploma, will primarily target Pacific Island fisheries officers.

After 27 years of existence<sup>1</sup>, the historical partnership between NMIT and SPC in training Pacific Island fisheries officers is coming to an end in 2006. However, SPC and the New Zealand School of Fisheries will continue to jointly organise and offer relevant fisheries training programmes, including the suc-

cessful short courses for the private sector. The next scheduled course is a two-week programme for commercial fishing vessel skippers, in October 2006.

While USP will play a major role with its certificate/diploma programme in Sustainable Fisheries, SPC will continue to enhance fisheries officers' familiarisation with small-scale commercial fishing operations. It is envisaged that the aforementioned practical fishing course will continue to be offered in the region, with financial and technical support from SPC. The course will be open to those fisheries officers requiring either first-time exposure to com-

mercial fishing operations, or those in need of refresher training in those skills. The course will also be an optional component of the USP Certificate in Sustainable Fisheries. Provided a sufficient number of applications are received from fisheries administrations, the next practical fishing course will be delivered in October 2007, with a format similar to the 2006 course (a one-week safety certificate followed by three weeks of training in practical fishing skills). The official announcement for the course will be made early in 2007.



<sup>1</sup> The initial course was run in 1979, and since then, over 300 fisheries officers have undergone training at the NMIT.



**Left: Preparing the bouke-ami net for the baiting exercise**



**Right: Sardines caught during the baiting exercise**

## DEVFISH project update

The Development of Tuna Fisheries in Pacific-ACP States Project (DEVFISH), which is jointly implemented by the Forum Fisheries Agency (FFA) and SPC, continues to undertake its first year's work programme activities. The period April to June 2006 accounts for the final quarter of the first year's work programme.

### 1st sub-regional industry workshop, Apia

The first of a series of sub-regional workshops was held in Apia, Samoa in April. The meeting brought together representatives of fishing industry and fishermen's associations, man-

agers of leading tuna fishing companies, as well as government officials involved in tuna fisheries management and development from Samoa, Tonga, Cooks Islands and Niue.

The focus of this first meeting was on the tuna longline fishery in the south and southeast parts of the region. The workshop focused on:



- identifying solutions to common problems, and providing direction for future activities of the DEVFISH project and other EU-funded instruments,
- identifying policy improvements that promote private sector participation,
- assisting regional networking of Pacific Island private sector interests in tuna fisheries, and
- informing and raising awareness about other relevant regional agencies and programmes available to private sector.

Private sector tuna fisheries representatives expressed cautious optimism for the future of the tuna longline industry in their countries, despite severe oceanographic anomalies that have adversely affected tuna catch rates over the past three years, and called for closer dialogue between, and continued support from, their governments and financial stakeholders to enable the industry to overcome its current problems.

Adam Langley, of SPC's Oceanic Fisheries Programme, informed workshop participants about

cyclical oceanographic factors that affect the distribution of tuna and more specifically albacore stocks in the region.

Participants identified a number of priority actions that regional organisations could undertake to facilitate planned development of domestic fishing industries. These include:

- Data analysis and assessment of the longline tuna resources in national waters;
- Support for fisheries associations, to improve their capacity and representation in decision-making forums;

- Assistance with modernisation of fishing operations through satellite fish-finding technology; and

- Advice on tuna industry development strategies.

Specific priorities for Samoa, Tonga, Cook Islands and Niue were also identified. DEVFISH is taking the lead as far as possible in implementing the meeting's recommendations.

The second sub-regional industry workshop is scheduled for September in Fiji.



**Participants at the 1st DEVFISH sub-regional workshop held in Apia, from 5 to 7 April 2006)**

### ***Second roundtable consultation, Noumea***

The DEVFISH team and support agencies — FFA, SPC and the European Union (EU) — held their second annual consultation in April 2006 at SPC, Noumea.

This was a technical consultation between FFA, SPC and DEVFISH project staff to update planned activities for 2006–2007 before presenting these activities to the project oversight

steering committee in May. EU representatives from Noumea also participated in this consultation.



### *Project steering committee meeting, Nadi, Fiji Islands*

The first DEVFISH project steering committee meeting was held in May in conjunction with the Forum Fisheries Committee (FFC) meeting in Nadi. The project steering committee endorsed the updated planned activities for 2000–2007.

The steering committee comprises representatives of the European Commission delegation, Pacific Islands Forum Secretariat, Forum Fisheries Agency, SPC, and the 14 Pacific ACP countries (although Samoa, Niue, Cook Islands and Niue were not able to attend).

DEVFISH personnel also sat in on the Global Environment Facility project meeting, other regional meetings, and held informal discussions with a number of delegates. Some ideas for future assistance to countries were also discussed with national representatives.



### *Country visits to Palau, Federated States of Micronesia and the Marshall Islands*

Continuing the series of visits to Pacific ACP countries, DEVFISH Project staff Mike Batty and Jonathan Manieva travelled to Palau, the Federated States of Micronesia (FSM) and Marshall Islands in June. The purpose was to:

- collect up-to-date information on the local and locally based tuna fishing industries of the three countries,
- review the economic and policy environment in which they operate in each country,
- review the status of fishing associations and mechanisms for consultation between government and fishing industry, and
- identify constraints and possible areas for assistance under the project.

#### **Tuna fishery status**

The three countries have adopted different approaches to the development of locally based tuna fishing operations. Their EEZs all support major longline fisheries, targeting bigeye and yellowfin tuna, but the extent to which the longline fleets make use of local bases for transshipment has varied over time and between countries. FSM also has one of the largest surface tuna resources in its extensive EEZ, whereas purse-seine catch-

es in Palau and Marshall Islands waters are much smaller and tend to fluctuate considerably from year to year.

Palau has three locally based fishing companies that have been operating for some years: Palau International Traders Inc (PITI), Palau Marine Industries Corp (PMIC), and Kuniyoshi Fishing Co (KFC). The first two are foreign investment companies, while KFC is registered as a local company. PITI is a part of the Luen Thai group of companies — which are also active in the Marshall Islands and FSM — while KFC markets its tuna through Sanko Bussan (which has bases in Papua New Guinea and Guam). All three compa-

nies act as agents for longliners from different countries (mainly Taiwan). As well as obtaining Palau fishing licences, they arrange offloading, export and marketing of the catches and re-supply of the vessels. Many of the boats are also licensed to fish in the waters of other countries, typically FSM, Indonesia and/or the Philippines.

Normally more than 100 longline vessels are licensed each year. In 2003, only 90 licences were issued, but this increased to 102 licenses in 2004 and 139 in 2005. The number of off-loadings also more than doubled over this period, from 686 in 2003 to 1378 in 2005. These increases appear to be due to



**A Taiwanese longliner offloads its catch to PMIC in Palau**



higher catch rates in Palau's EEZ, as well as improved air-freight opportunities out of Koror, the capital. In 2005, more than 2600 tonnes of fish were caught in Palau's EEZ. Fishing effort is normally concentrated in the south and east of the EEZ during the second half of the year. Exports of sashimi grade fish by airfreight exceeded 3600 tonnes, which includes landings of fish caught in the waters of neighbouring countries.

Purse-seine fishing activity in Palau's EEZ is limited. Although between 18 and 31 foreign access vessels have been licensed under bilateral arrangements in each of the last five years, the highest annual catch was only slightly over 4000 tonnes, with no fishing at all in some years. There are no locally based purse seiners and no transshipment activities. A small locally based pole-and-line vessel also operates, supplying skipjack to the local market.

FSM has one of the largest and most productive surface fisheries in the region, with annual purse-seine catches of more than 200,000 tonnes in some years. Most of this catch is taken by foreign vessels fishing under access arrangements. In 2004 there were six FSM flag purse seiners, which caught a total of 27,000 tonnes. Since then, two vessels have left and one has sunk. The three remaining vessels are partly owned by state governments, with the shareholding recently acquired by management of the two companies.

Transshipment activity has increased in recent years. Proximity to fishing grounds at a time of rising fuel prices and improved port management seem to be mainly responsible. In 2003 there were 135 trans-

shipments, mainly in Pohnpei, and one major Korean fishing company has recently established an office in Pohnpei. Local shipping agents and the ports authority have benefited from increased earnings. In 2005, information gathered from local agents indicated an average of 20–25 purse-seine transshipments per month.

The longline catch in FSM's EEZ varies between 5,000 and 10,000 tonnes per year and is also dominated by foreign access vessels. Use of local bases has declined over time, and extensive facilities in each state are now lying idle. In 2004, 18 FSM-registered longliners were licensed and these vessels landed 850 tonnes of fish. Many of these longliners were owned by national or state governments, but by 2006, they were no longer operating for financial reasons. Only a small fleet of privately-owned longliners based in Majuro continue to fish. The Pohnpei State Government has recently agreed to lease the facilities of the Pohnpei Fisheries Corporation to Luen Thai, and it is expected that this will result in a resurgence of longline fishing activity as well as catch processing.

The Marshall Islands has also established itself as an important

transshipment base for purse seiners, particularly for the Taiwanese fleet. In 2004, 227 transshipments — accounting for more than 163,000 tonnes of tuna — were made in Majuro. Of this amount, more than 46,000 tonnes were caught by the six Marshall Islands flag vessels of the Koos fishing company.

Locally based longline fishing activity centres on the Majuro Fish Base, which is leased to Marshall Islands Fishing Venture — a Luen Thai company. Around 40 vessels, mainly Chinese, operate out of the base and account for much of the longline catch in Marshall Islands waters, as well as the offloading of fish caught elsewhere. Landings in 2004 were over 3000 tonnes. An experimental longline fishery targeting sharks (and managed by the Edgewater Fishing Company), has recently stopped operating.

### Tuna processing

In Palau, the longline catch has tended to be packed in very basic facilities, with whole tuna consigned to Japan and headed and gutted fish sent to the US market. With a limited local market and a relatively high export duty, disposal of lower grade fish and bycatch has been

### Inactive longliners owned by State and National enterprises in Pohnpei



a problem. One company sends its reject fish to Bangladesh by airfreight, presumably for processing, but many vessels retain the fish on board until they have an opportunity to dispose of them elsewhere. Recently, however, a new company Palau Fresh Tuna Product Inc, has set up a small plant (2 tonnes/day) to prepare fresh and frozen loins for export with the first container exported in June 2006.

In FSM, the main processor of longline-caught fish has been the Pohnpei Fisheries Corporation, which relied on the "reject" fish from any locally based longline operation for its source of supply. For many years the company operated at a loss due to insufficient throughput. Lease of the facilities to a fishing company with its own vessels will hopefully allow more viable operations in future.

Of the three countries, the Marshall Islands is the only one that has supported a factory that processes purse seine-caught tuna. The PM&O loining plant was built in 1999 and operated until mid-2005, processing around 10,000 tonnes of tuna per year into cooked loins. When fully operational, the

plant provided more than 500 local jobs. Its closure seems to have resulted from financial difficulties of the parent shipping company, and the government has recently agreed on allowing the Shanghai Deep Sea Fisheries Corp to take over the operation. Marshall Islands Fishing Venture also processes much of the longline catch into loins and steaks for export to the US, providing employment for more than 100 workers.

### Economic and policy issues

#### Fuel

Continuing increases in world fuel prices have obviously impacted fishing operations in all three countries, but there are also differences in local pricing. The cheapest fuel in the Micronesian region is on Guam, where a fishing vessel can buy diesel for USD 2.41 per US gallon (USD 0.66 per litre). In Palau, the price is USD 2.90, in Pohnpei USD 3.26 (USD 0.91/L), and in Majuro USD 3.50 (USD 0.97/L) from the commercial supplier. In Majuro, the Marshall Islands Electricity Co (a government-owned utility company with large fuel storage facilities) has been providing fuel to licensed fishing vessels at the more com-

petitive rate of USD 2.58 per US gallon (USD 0.72/L), but has recently had difficulty in maintaining sufficient stock.

#### Airfreight

The export of fresh longline-caught tuna in all three countries relies on dedicated air freight services. The Luen Thai operations use their own fleet of 727 cargo aircraft (Asia Pacific Airlines), which are also the US mail carrier to all three countries. This provides the option of delivery to Guam for onward shipment to Japan, or direct shipment to the US mainland. The two other companies in Palau use cargo flights operated by Far East Air Transport into Taiwan, or Fed Ex to Manila, for onward shipment to Japan. Compared with Guam, where airfreight on large passenger aircraft can cost as little as USD 1.20 per kg, costs are relatively high. Airfreight from Palau to Japan was stated to cost USD 2.50–2.70 per kg, depending on the carrier and route. For purse-seine operations, the lack of capacity for airfreight of heavy spare parts was said to be a constraint. Airfreight to and from FSM is also handicapped by the short 6000-foot (1829 m) runways in each state, which limit the load carrying capacity of aircraft currently servicing these airports.

#### Wages and taxes

By Pacific Island standards, all three countries have relatively high wage rates, with legal minimum wages of USD 2.00–2.50 per hour. Locally based purse seiners in FSM and the Marshall Islands employ some national crew, and the great majority of shore-based fishing company employees are locally recruited in these countries. In Palau,

**The former PM&O loining plant in Majuro — expected to re-open under new management**





more relaxed labour laws have resulted in most shore jobs being filled by migrant workers. There is no local employment on longline vessels in any of the three countries.

All three countries are regarded as providing a low tax environment. Top rates of income tax are 10% (FSM) to 12% (Marshall Islands), import duties are typically around 5% for most commodities, and sales taxes (raised by local or state governments) are at similar levels. The nature of company taxation, which is currently based on total turnover, has been identified as a constraint to the fishing industry, since such costs cannot be passed on to the buyer. In the Marshall Islands, fishing companies are exempt from the 3% Gross Revenue Tax for their first five years of operation; while FSM is planning tax reforms that would base company tax on profits rather than turnover.

### *Development strategy*

The status of domestic fisheries in each country reflects differences in their development strategies over the last 15 years. In FSM, the emphasis was on government investment and ownership of fishing vessels and shore-based facilities. While some of the purse-seine vessels have remained operational, most of the ventures have not proven to be viable. Recent moves towards more private-sector involvement seem to signal a change of approach.

The Marshall Islands government also invested in a small fleet of longliners in the early 1990s, but soon concluded that this operation was not working. Following some technical assistance on policy issues in the late 1990s, the emphasis changed to creating an enabling environment for private sector and foreign investment. This resulted in a substantial increase in local-

ly based fishing activity and transshipment, with various spin-off benefits to the local economy. Experts concluded that the Marshall Islands is the most "industry-friendly" of the three countries.

Palau also has also attracted substantial foreign investment, but the tourist industry is judged to have greater potential than fisheries, and strong measures have been taken to protect the environment. There is relatively little employment of Palauans in the tuna fishery, and perhaps more focus on collecting government revenue than on possible wider economic benefits, although the recent development of aquaculture to supply live bait to long line vessels illustrates the sort of spin-offs that are possible.

### *Constraints*

Some specific constraints identified by the tuna industry in each country included:

- In Palau, the export duty of USD 0.25 per kg on all tuna, irrespective of species and quality, discourages offloading non-sashimi grades. The ban on retaining sharks, shark fins or other shark parts, and the closure of a productive fishing area to the east of the main island for recreational fishing interests are also issues.
- In FSM, the high penalties applied for technical fisheries offences (as opposed to illegal fishing), the lack of availability and the high cost of air transport for both passengers and freight, and the complexities of working with different branches of national and state governments are serious constraints.
- In the Marshall Islands, the availability of fuel from the Marshalls Energy Company

(MEC) and the cost of alternative supplies was the main problem. There has also been some public concern over the level of Chinese immigration into the Marshall Islands, and this may be affecting the ease of obtaining visas and work permits.

### *Fishing associations*

The only association that specifically represents the tuna fishing industry is the FSM National Offshore Fisheries Association. Its chairman is also acting chair of the regional tuna industry association, PITIA, and is active in representing fisheries and other private sector interests in a range of regional forums. In Palau, the three fishing companies consult informally, and may work together to coordinate air-freight consignments, but see little need for a formal association. In the Marshall Islands, with only two companies and an approachable fisheries authority, even less need was perceived. In inshore fisheries, Palau has a long tradition of fisheries cooperatives, but these have become less active in recent years and their role in marketing the catches of rural fishermen has disappeared.

In the Marshall Islands, private sector input into fisheries policy issues is provided by two representatives from the board of the Marshall Islands Marine Resources Authority (MIMRA), and it seems that this board could provide an appropriate body to handle in-country project requests to DEVFISH. In FSM, the board of the National Oceanic Resources Management Authority (NORMA) comprises representatives of each of the four states, but does not include fishing industry representatives. Consultation on the Tuna Management Plan involved travel to all four FSM states, but it would be expensive to repeat this process or to arrange for

representatives to travel to a central point. In Palau, the Palau Fisheries Advisory Committee is a high-level policy-making body, chaired by the Minister of Resources and Development. The committee includes one nominated private sector representative, but there may be a need for wider canvassing of tuna industry concerns.

### Areas for project assistance

As in previous visits, a number of requests for information were received from the fishing industry and government officials.

Both Palau and the Marshall Islands expressed an interest in receiving help from DEVFISH/FFA on tuna industry development action plans, in connection with reviews of their current Tuna Management Plans.

The Fisheries Development Policy Specialist and the Fisheries Development Officer would like to thank all the people who gave valuable time to meet with them during the visits, often at short notice. The assistance of government fisheries personnel who arranged meetings is also gratefully acknowledged.

### In-country and regional activities

Past and current project highlights are presented below.

#### CATSAT trial

Tonga Exporters Fishing Association identified and

requested — through their national coordinating committee — in-country support for the option of new technology that enables better targeting of fish by fishing boats for such situation, which would improve efficiency and reduce costs. Tonga industry received assistance to trial the CATSAT fish finding technology from CLS Argos Aust-NZ-South Pacific for the Association's members for a six-month trial period. The trial commenced in May and is still in progress.

#### Gender study

As part of an activity to promote gender equality in participating Pacific Islands private sector tuna development, a consultant was engaged in April to study regional perspectives. The study was completed in June.

#### Tonga wharf management study

In response to another request from Tonga's national coordinating committee, and as a part of a broader regional study, assistance was provided in commissioning a study on wharf management in early June. The findings of this report are now being circulated to identified primary shareholders and to relevant authorities for their consideration and ultimate implementation.

#### Solomon Islands

Assistance to the Solomon Islands included a waste water treatment study and refrigeration design study for Soltai Ltd.

### Associations' assistance

Ongoing discussions and verification of details for expressed in-country assistance is progressing with respective countries (Niue, Tuvalu, Solomon Island, Nauru), which have identified needs for strengthening their national consultative processes and national representation of private interests involved in tuna fishery development. This involves formation of commercial fishing association and also capacity enhancement assistance.

The Fisheries Development Policy Specialist and the Fisheries Development Officer would like to thank all the people who gave valuable time to meet with them during the visits, often at short notice. Assistance of the government fisheries personnel who arranged meetings is also gratefully acknowledged.

Detailed updates and reports of the project can be viewed at:

[www.ffa.int/DEVFISH](http://www.ffa.int/DEVFISH)



## Training needs assessments in Polynesia and Papua New Guinea

During the reporting period, the Nearshore Fisheries Development and Training Section has been involved in two important studies of fisheries-related training needs in the region.

### Business planning and management in Polynesia

Following the successful introduction in Papua New Guinea (PNG) of a fisheries version of

the International Labour Organization (ILO) training programme, Start and Improve Your Business (SIYB), SPC, with funding support from the Commonwealth Secretariat, has



coordinated the introduction of the same training programme in Vanuatu and the Solomon Islands.

This project consisted of a training of trainers (TOT) course at Santo in June 2005, a series of in-country courses in both countries, and the official accreditation by the ILO of several trainers in each country. This training programme (Start Your Fishing Business – SYFB), which is now available through several institutions in each country, is aimed at developing fishing business planning and management skills amongst prospective or existing entrepreneurs.

A review of the programme by the Commonwealth Secretariat and SPC resulted in an interest to ascertain the relevancy of the training programme for Polynesian countries. As an initial step, a training needs assessment and feasibility study in relation to the introduction of this SYFB program was conducted in May 2005. The consultant contracted by SPC (Hugh Walton from the company Gillett, Preston and Associates) travelled to Tonga, Samoa and the Cook Islands in May 2006 to interview stakeholders involved or interested in small business management training. The study report was subsequently produced and distributed to relevant institutions in the three countries as well as in Niue and Kiribati, which had previously indicated an interest to participate in the programme.

The focus of the current SYFB training programme is on small-scale fisheries businesses, which is relevant to Melanesian countries where it is generally agreed that fisheries development is still possible in most coastal areas. However, it is apparent from the recent study that the challenges facing rural communities in Tonga, Samoa and the Cook Islands are very

different from those in PNG or Vanuatu. In the Polynesian countries, there is very limited scope for increasing fishing effort in inshore areas and this is reflected in the current focus on the conservation and management of reefs and inshore resources. Nevertheless, there was a general consensus in the countries surveyed that a modified fisheries SIYB programme could support the development of small-scale businesses in the marine sector, provided the focus of the programme is on the use and promotion of "non-fishing" business models, and thus fits into the current conservation and management initiatives of local institutions.

The study further recommended the following general themes for the SIYB training programme in Polynesia.

- The inclusion of a resource management component to the programme;
- A focus on improving the efficiency of existing inshore fisheries operators (through improved business skills or value-adding to seafood products, not through catching more fish!);
- A shift in focus from fishing businesses to businesses based on marine resources in a broader sense such as eco-and adventure-tourism, sport fishing, and other alternative income opportunities;
- In the case of the Cook Islands, a specific programme for pearl farm operators.

The programme model developed for Vanuatu and the Solomon Islands (TOT course for participants from all countries followed by in-country courses) appeared to be well suited to the needs of the countries surveyed. The study report further recommended the PNG

Master Trainers used for the Vanuatu/Solomon Islands project should deliver the TOT course and provide support for the subsequent in-country programmes. Samoa was suggested as a suitable venue for the delivery of the TOT course.

Following this Training Needs Analysis, the Commonwealth Secretariat and SPC agreed to facilitate the introduction of the SIYB training programme in Polynesia. The Nearshore Fisheries Development and Training Section will have a coordinating role for the TOT course, which is scheduled for the first quarter of 2007. The selection of participants will be undertaken in collaboration with the fisheries administrations and relevant business-support institutions in each country.

#### *Training needs assessment of PNG fisheries sector*

In June, SPC's Nearshore Fisheries Development and Training Adviser travelled to PNG to participate in a training needs analysis (TNA) of the PNG fisheries sector. This work was done in collaboration with two fisheries consultants, Hugh Walton (Gillett, Preston and Associates) and Grant Carnie (Australian Fisheries Academy).

The TNA was commissioned by the Board of the National Fisheries Authority (NFA), as part of deliberations concerning the potential development of a diploma and degree programme at the University of Vudal (Rabaul) and the National Fisheries College (Kavieng). The terms of reference for this detailed sectoral training needs and cost-benefit analysis, required the study team to give consideration to the:

- development of the diploma and degree programme with the University of Vudal and NFC,

- needs of fishing companies and shore-based processing facilities,
- potential training needs associated with aquaculture development,
- operation of existing NFC courses in Commercial Fisheries and Post Harvest Fisheries,
- needs of the artisanal sector, and
- inclusion of a regional perspective in the analysis.

The study included consultations with national and provincial governments, provincial fisheries administrations, commercial and industrial fishing operators, operators of large and medium sized processing facilities, NGOs and community representatives, and training providers. The report was formulated on the basis of stakeholder consultations in Port Moresby and selected provincial locations. Despite the limited timeframe available for the TNA, the study team members made visits to Wewak, Madang, Lae, Kavieng and Rabaul, in

addition to attending meetings and interviews previously conducted in Port Moresby.

A preliminary report was drafted by the study team during meetings in Kavieng, and finalized through email correspondence. The finalized draft report has since been presented for consideration to the NFA Board.



## Other activities of the Nearshore Development and Training Section

- A refresher SYFB training of trainers (TOT) course was conducted at Santo, in July. The course, conducted by two Master Trainers from PNG, was attended by 2 Solomon Islands and 11 Vanuatu trainers. By successfully completing the TOT process, the participants are now officially recognized as national trainers under the International Labour Organization (ILO) certification framework. The refresher courses also marks the completion of SPC's and the Commonwealth Secretariat's assistance to Vanuatu and the Solomon Islands in the area of small fishing business management. The onus is now on local institutions and trainers to market and deliver the SYFB training programme in-country
- The third regional course on vessel operations management and electronic aids for commercial fishing skippers will be delivered at the New Zealand School of Fisheries, at Nelson, from October 2–13, 2006. The course will be similar to that of the two previous courses with a

combination of classroom-based sessions, presentations on specific topics by relevant guest speakers from the Nelson-based fishing industry, and field visits. The course will be jointly sponsored by the governments of Australia, France and New Zealand and the European Union through the DEVFISH project. While primarily targeting the private sector, the course is also open to skippers from national fisheries administrations, provided the vessels they operate have a clear training mandate. The selection of course participants will be undertaken by SPC's Nearshore Fisheries Development and Training Section in August.

- The services of Fisheries Development Officer Steve Beverly have been contracted by the Joint Institute for Marine and Atmospheric Research (JIMAR) at the University of Hawaii at Manoa to supervise and monitor tuna longline deep-setting trials. The fishing trials were conducted in Hawaiian waters from June to July 2006, and preliminary

results are very encouraging. More on this study in the next issue of the *Fisheries Newsletter*.

- A video-DVD to promote at-sea tuna loining and freezing operations has been produced by SPC's Nearshore Fisheries Development and Training Section staff. The video-DVD will be available for distribution by the end of August 2006...hopefully in time for a meeting of tuna industry stakeholders in the Cook Islands.



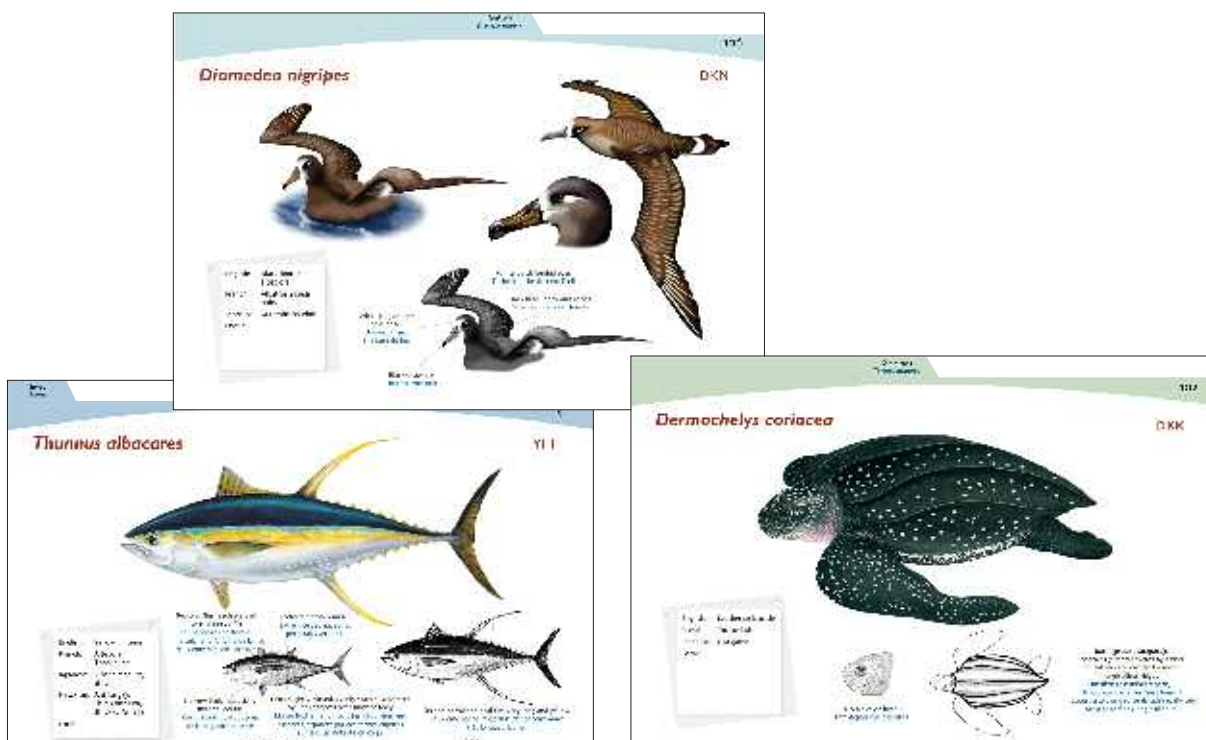
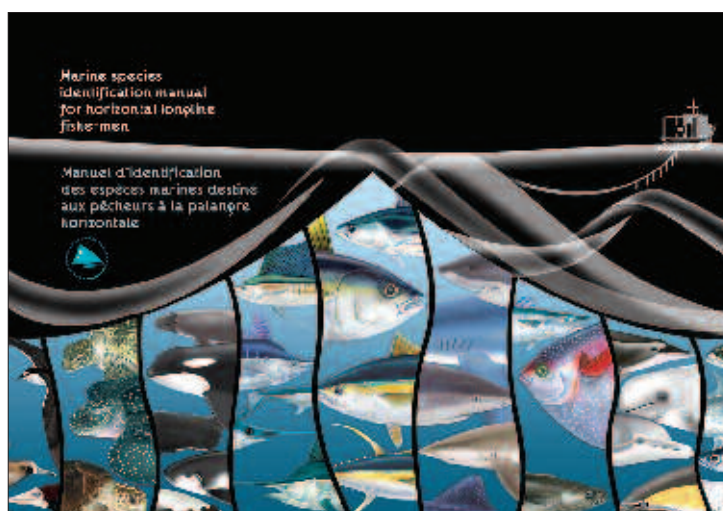
## Identification tool for horizontal longline fishermen distributed

After some unexpected pre-production delays, the "Marine species identification manual for horizontal longline fishermen" is now available. Over 3000 copies of the manual have been distributed and another 2800 copies will be kept at SPC Noumea for future use.

This bilingual manual (French and English) covers the main species likely to be caught or

interacting with horizontal longlines in the Pacific, plus some species that are uncommon. The final section of the manual covers species of special interest, including sea turtles, toothed whales and dolphins, and seabirds. For the main species, there is a colour picture of the species plus a line diagram with common identifying features marked. For each species, the scientific name is given, as well

as the FAO species identification code for reporting purposes, and the common name in English, French, Japanese and Hawaiian for marketing purposes. Staff of SPC's Coastal Fisheries Programme are now working on a second manual that will cover deep-water snappers and associated species that are caught from 100–400-m depths. This manual is expected to be available in 2007.





## ■ AQUACULTURE SECTION

### 17th NACA Governing Council Meeting, Tehran, I.R. Iran

SPC's Aquaculture Adviser represented SPC at the Network of Aquaculture Centres for Asia-Pacific (NACA) Governing Council Meeting, which reviewed and approved the next five-year work programme for the organisation. The council also elected the next Director General for NACA — Professor Sena De Silva, a Sri Lankan-born Australian national, based at Deakin University. This brings an end to the tenure of Pedro Bueno, former Director General who was a strong proponent of forging working relationships between Asia and the Pacific region.

At the meeting, host Vice-Minister for the Ministry of Jihad-Agriculture (fisheries) reported that production from aquaculture accounts for one-third of all Iranian fisheries. He noted that aquaculture production continues to expand, with further development of prawn farms. Participants visited the snowy, mountainous region of northern Iran, where intensive and large-scale trout farming is a profitable enterprise.



Trout farm in northern Iran

### FAO Global Aquaculture Review and Synthesis, Guangdong, China

A key request from the second session of the FAO Sub-committee on Aquaculture, held in Trondheim, Norway in 2003, was to compile a global report on aquaculture status and trends. This document would also identify key priorities for

aquaculture development. The UN Food and Agriculture Organization (FAO) has already conducted a series of regional reviews, including the Asia-Pacific region, which SPC has been involved in. Experts who compiled the regional review

were gathered to produce the global review, and this meeting was also attended by SPC's Aquaculture Adviser. The final document will be presented at the next FAO sub-committee meeting in India in September 2006.



### Regional mariculture workshop, Guangdong, China

SPC's Aquaculture Adviser participated in the regional workshop on "The Future of Mariculture: A Regional Approach for Responsible Development of

Marine Farming in the Asia-Pacific Region", held at Guangdong City, Guangzhou Province. Mariculture is rapidly expanding in Asia, particularly

in China where, according to the government, there are several million fish cages compared with just several hundred a few years ago. This increase is attrib-

uted to the rapidly growing middle class sector, which is able to afford and prefers a regular diet of seafood products.

Workshop delegates travelled to the Hong Kong border — where there is intensive mariculture — and held consultations with aquaculture farmers of live seafood products. The challenges of capitalism were apparent, as smaller and less productive fish farmers are being overtaken by larger companies. (Our lunch host, whom owns a large scallop farm in the area, also has a seven-story fish restaurant.) At Guangdong City, a dialogue with traders from the Guangzhou Huangsha Seafood Market was conducted. More than 500 tonnes of seafood are sold at the market every day with an annual turnover of USD 1 billion. Market officials plan to expand the facilities to cater for a USD 2 billion trade expected within the next five years.

In workshop deliberations, the Pacific region's comparative advantage of high biodiversity became apparent. Therefore, techniques such as larval trapping (trapping fish larvae at pre-settlement stages in crest nets) for ornamental or food fish may offer a particular niche market for the region. However, utilisation of the Pacific region's biodiversity also increases the need to implement proper bio-security and environmental management programmes.



**Top: Live seafood at the Guangzhou market**

**Bottom: Scallop farm along Honk Kong border**

## Aquaculture highlights from Papua New Guinea

In April 2006, SPC's Aquaculture Adviser and PNG's National Fisheries Authority's Manager for Aquaculture and Inland Fisheries, Jacob Wani, visited PNG for three weeks, reviewing the emerging developments in aquaculture. Below are some brief highlights of that visit.

### Bougainville Province

At Buka township, the administration centre for Bougainville, a public meeting was organised. A wide range of topics were discussed and a strong interest was expressed by locals in aquaculture. Some people have taken the

initiative of undertaking their own trials. One man from Nissan Island reported that he was able to successfully ranch juvenile sea cucumbers in lagoon enclosures. Questions regarding the farming of barramundi, rock lobster and other species were also raised at this meeting.



Access to the Bougainville mainland from Buka is by small fibre-glass taxi boats and requires crossing a channel with a dangerously fast current. According to Johnny Horricks, an ex-NZAid volunteer, there are about 150 interested or current fish farmers in Bougainville. Most farmers raise tilapia or carp in the inland areas along the southern part of the island where access to coastal fish is difficult. There are local freshwater species (e.g. an opaque bronze shrimp found in the Wakuani River), which may have potential for the ornamental trade.

One development on Bougainville worthy of attention was the use of copra oil as a fuel for diesel engines. Apparently the application of this technology is relatively simple and many four-wheel drive diesel trucks and certain diesel generators have already being converted. Such innovations could overcome the bottlenecks preventing industrialisation in remote parts of the Pacific.

### Milne Bay Province

Jane Bagita from the provincial fisheries department reports that aquaculture has been included in the Milne Bay Provincial Management Plan as one of the key areas for development. There is already a low level of fish farming along the inland north coast with fish fingerlings provided by the National Development of Agriculture and Livestock (NDAL). The government also has interest in trialling *Kappaphycus* seaweed and sea cucumber farming. At Bubuletta, the NDAL Training



**Top: Freshwater shrimp in Bougainville (Photo courtesy of J. Horricks)**

**Middle: Pearl farm in Milne Bay**

**Bottom: Pearl hatchery in Milne Bay**



Centre is planning to set up demonstration fish ponds.

A few hours' boat ride from Alotau is Samurai Island where the largest pearl farm in PNG has been established by Coral Sea Mariculture Pty. The farm is cultivating the silver-lip pearl oyster (*Pinctada maxima*), which produces the translucent white South Seas pearl. I observed considerable progress since my first visit in 2002. The company has purchased a waterfront area and properties to establish a hatchery, seeding house, staff accommodation, maintenance buildings and offices.

The hatchery has had successful spawning runs and has adopted techniques for nursery grow-out while spat are still at very early stages of growth. The farm maintains about 50 oyster long lines. There are about 15 fulltime workers although the number can rise to around 30 during peak activity. This brings an injection of about AUD 100,000 dollars in wages to the local community. The immediate target is to seed around 60,000 oysters per annum. However, once production of high quality round spherical pearls is achieved, the company will be in a better position to start phasing in mabe pearls (perhaps using village satellite farms) and other value-added activities such as jewellery and handicrafts. Given the technical expertise, business acumen, patience and consultation with stakeholders shown by the Australian managers Kim Harvey and Colin Jarick, this farm could be on track as a showcase for aquaculture success in Papua New Guinea.

### Western Province

Tabubil is the administrative centre of Ok Tedi Mine (OTML), the giant copper and gold mine in PNG's Western Province. OTML produces 20% of PNG's total foreign revenue. Fifty per-

cent of the company is owned by PNG Sustainable Development Ltd, which invests one-third of its profits into developing the Western Province. The company has tremendous logistical capacity and resources, and mining executives are keen to combine this with technical expertise of national and regional agencies such as SPC to develop the province. This model is seen as the emerging standard for the mining industry as a means of returning tangible benefits to landowners.

At 2000 meters, there is the mine pit where rainbow trout are housed in pens for restocking into the surrounding lakes. The trout are an important fishery to local tribes. At Tabubil's aquaculture facilities, staff have recently succeeded in breeding a local fish — sooty grunter (*Hephaestus fuliginosus*) — which, along with barramundi (*Lates calcarifer*), are the two main species targeted for farming in the lower elevations. Feed formulation trials are being carried



**Top: Barramundi cage farming in Fly River**

**Bottom: Ok Tedi Mine fish ponds at Tabubil**



out at the feed station using local crops. The various elements are being combined in a demonstration integrated fish and duck farm, which is being set up at Tabubil for research and training purposes.

### East New Britain Province

Prior to our visit the provincial governor's office had approached SPC to assist in *Macrobrachium* farming on Rabaul.

Carpenter PNG Ltd which owns the copra mill, cocoa plantations and cattle farms on Rabaul are presently constructing in a large prawn farm at Tovuru. Ten, one hectare ponds have been dug and local sources of *Penaeus monodon* prawns will be farmed. The company has invested 2 million PNG kina (about USD 675,000) into the venture. Located on a picturesque beach known for its scuba diving, the Tovuru prawn farm also shares land used for the company's cattle farm.

Kerevat prison correctional facility may seem an interesting site for an aquaculture project but, according to Superintendent John Porris, budget cuts have forced all correctional facilities to become self-sufficient in food supplies. More than 10,000 tilapia and carp fingerlings are being held in farm ponds and there are plans to farm the local *Macrobrachium* shrimp as well.

At Kabira village we visited some small fish ponds where carp and GIFT tilapia have had very good growth rates, using local feed ingredients. This is another example of the poten-



**Top: Fish ponds at Kerevat Prison Facility**

**Middle: Household ponds at Kabira village**

**Bottom: Prawn farm under construction at Rabaul**

tial for fish farming amidst a rural village setting.

The Eco-Tech Training Centre at Waragino is funded by a Japanese NGO (OISCA). Students are taught how to grow a variety of agricultural crops, and there is a crocodile farm and fish farming ponds. The training centre is expanding the fish farming operation and a simple hatchery has recently been completed to demonstrate breeding techniques. The rice paddy fields at the centre may

also be a site to trial some integrated aquaculture.

#### New Ireland Province

The National Fisheries College in Kavieng is planning a joint education programme with Vudul University. Across the bay from Kavieng is Nago Island, where there is a beach-front property owned by NFA. There are plans to develop this estate into a tourism lodge that will also provide the source of electricity and water for a mari-

culture research facility next door. Several hours drive down New Ireland's east coast is Fissoa Vocational School, which has set up an integrated Nile tilapia and duck farm for training its students. Kavieng has an abundance of freshwater and aquaculture species.

Our visit to a local eel-watching site indicates that there is a healthy abundance of eels on the island.



### Fiji Freshwater Aquaculture Industry Association

The Fiji Freshwater Aquaculture Industry Association was loosely established in 2003, and as the result of the SPC/Australian Centre for International Agricultural Research/Fiji Fisheries coordinated Freshwater Aquaculture Strategic Development Plan workshop in August 2004, the association was formally registered under the Government of Fiji's Industrial Association Act on 5 December 2004.

The association's major objectives are to:

- 1) represent its members to the Government of Fiji, and to inter-governmental and non-governmental organisations;
- 2) negotiate all matters relating to the promotion and development of the Fiji freshwater aquaculture industry;
- 3) advise the national government on issues affecting the industry, and provide rele-

vant and timely policy initiatives; and

- 4) develop and utilize a regional approach to the acquisition of funds, facilities and equipment in order to minimize duplication and promote sustainable development. The association is also tasked with assisting in the development and implementation of national statutes, regulations, codes, standards and procedures.

Association membership is primarily open to anyone actively involved in the development of Fiji's freshwater aquaculture industry. The association and its operational base are presently located at the Naduruloulou Freshwater Aquaculture Station, and sub-branches in other parts of Fiji will also be opened.

The association started with 20 financial members. This number is expected to reach 150 by the end of 2006, given the undertaking that the association will continue to uphold its objective to promote, protect and maintain just and proper treatment of members in all aspects.

The inaugural annual general meeting of the association was held at the Naduruloulou Aquaculture Station in June, and was attended by farmers, fisheries staff and SPC's Aquaculture Officer.

Major outcomes of this meeting included:

- 1) the election of the new Executive Council, which solely comprises paid members of the association;
- 2) the drafting of an association proposal seeking assistance through a government approved mechanism to consolidate the operational management of the association;
- 3) the implementation of workable administrative procedures in the usage of the association's set of harvesting and marketing equipment; and
- 4) agreement on the need to strengthen the working relationship between the association and the township councils in the marketing of tilapia and prawns in the various strategically located municipal markets.





## Mud crab study tour

In May, SPC's Aquaculture Officer conducted a study of mud crab hatchery and farm operations at the Vietnam Ministry of Fisheries, Research Institute for Aquaculture No. 3. This institute carries out research, technology verification, and training and information dissemination for mud crab farming in Vietnam.

### Research Institute of Aquaculture No. 3 and its departments

Research Institute Nos. 1, 2 and 3 are responsible for existing and future aquaculture developments in Vietnam. Research Institute of Aquaculture (RIA No. 3) has 12 departments throughout the country, with many relevant activities applicable to Pacific Island countries (PICs). RIA No. 3 is divided into the department of mollusc culture and the department of crustacean culture.

Some of the achievements of RIA No. 3 include:

1. seed production and commercial culture of shrimps (e.g. black tiger shrimp, white shrimp), freshwater prawns, mud crabs, swimming crabs, Babylon snails, abalone, milkfish and grouper;
2. production of *Artemia* cysts in salt fields.
3. hatchery breeding and sea cucumber nursery and grow-out using earth ponds or on the seabed in pens and cages;
4. advanced lobster culture in coastal areas in central Vietnam
5. surveying the environment of culture ponds; and
6. diagnosing and pre-testing diseases of black tiger shrimp.

RIA No. 3 has extensive international cooperation activities and implemented projects with organisations such as the United Nations Development Program, the UN Food and Agriculture Organization, the Australian Centre for International Agricultural Research, the WorldFish Center, the Danish International Development Agency, Tasmanian Inland Fisheries Service, the International Development Research Centre, International Union for the Conservation of Nature, and Japanese International Cooperation Agency. Some of the countries that RIA No. 3 has worked with include: Australia, Cambodia, Denmark, Hungary, Israel, Japan, Lao PDR, Malaysia, Norway, Philippines, Russia, Taiwan, and Thailand.

### Mud crab culture

Various species of mud crab (*Scylla* spp.) are found throughout Vietnam where they form the basis of a small but important inshore fishery. Crabs are easily caught using simple traps or nets, and remain alive for considerable periods after capture. They are of high value and an important source of income for small-scale fishers in parts of Vietnam.

Mud crab aquaculture has taken place for many years in Vietnam. For the last three to five years, pond-rearing of hatchery-reared mud crab seed has occurred. Seed production techniques have been perfected and the supply is considered reliable. Most crab aquaculture production now relies on commercial hatchery-reared stocks. A major constraint restricting further expansion of mud crab aquaculture in Vietnam is the lack or limited supply of commercial feed.

Mud crab aquaculture study is housed within the department

of crustaceans headed by Mr Nguyen Co Thach. Research is being conducted at RIA No. 3 in collaboration with ACIAR to develop commercial feeds. RIA No. 3 has also made breakthroughs in mud crab broodstock maintenance and maturation methods. Unfortunately, there are no papers or publications in English available, and staff can only provide verbal updates.

Larval rearing improvements have been achieved, but according to Mr Thach, further developments are still required to achieve high survival and commercially profitable production. Crab seed are usually stocked into ponds at a minimum size of 2–3 g to undergo a nursery phase.

### Lessons learned

Mud crab hatchery operations are similar to those used for *Macrobrachium rosenbergii* in other parts of Southeast Asia. One of the key elements to RIA No. 3's success could be in its use of locally produced *Artemia* cysts, which are much smaller, and according to Dr Thua, are of the highest quality available in Asia.

Grow-out of juvenile (hatchery reared) crabs is common in Vietnam. During grow-out in ponds, crab growth and survival are strongly linked to the stocking rate, with a stocking rate of 0.5–0.7 per m<sup>2</sup> being the norm. This stocking rate gives the highest productivity and economic benefit in simple earthen ponds.

Mud crabs reared in grow-out ponds are usually fed "trash" fish. Feeding with trash fish at times can lead to water quality deterioration due to fouling. Dried pelleted rations seem to be the best option but these are



**From top to bottom:**

**Crab trap - checking  
condition of female crabs**

**Crab farm in Nha Trang**

**Crab ready for market**

**Juvenile crabs ready for stocking**



low in supply. An important aspect of feeding is to remove all uneaten trash feed at the end of each feeding time.

### **Mud crab aquaculture possibilities in Pacific Island countries**

Mud crab aquaculture has a huge potential in Pacific Island countries (PICs). Based on observations in Vietnam and the Philippines, mud crab aquaculture operations require significant capital input for both seed production and the grow-out phase. The larval stage requires controlled conditions in a properly equipped hatchery on a site with a source of high quality seawater. Pond grow-out requires a substantial area of earthen ponds with access to brackish water.

Hatchery and grow-out operations require expertise and knowledge in the care of juveniles, husbandry, water quality control, tank and pond management, nutrition, processing and marketing. An important consideration for the viability of mud crab aquaculture in PICs will be production costs. Experiences in Vietnam show that mud crab aquaculture can be a very profitable enterprise. One initial approach for PICs would be simple grow-out operations in earthen ponds

with wild-caught juveniles stocked at 0.5 per m<sup>2</sup>, and fed on trash fish.

Developing mud crab aquaculture in PICs could be one of the many means to increase availability of food and income for those living in coastal areas. The livelihood of Pacific Island coastal communities depends on their capacity to produce food through a wide range of

activities, which often include diverse practices such as farming and fishing. Aquaculture practices in some rural areas have proven to contribute to enhanced and diversified food supply and income generation. However, due consideration should be given to the need for all practices (including mud crab aquaculture) of food production to expanded, or at the least, included on a small scale.

For mud crab aquaculture to be developed for the general benefit of coastal communities in the Pacific, it is important for SPC to facilitate collaboration with institutes such as RIA No. 3 and the Southeast Asian Fisheries Development Center (SEAFDEC) in the Philippines.



## Symposium on fish ponds in farming systems, Can Tho University, Vietnam

SPC's Aquaculture Officer attended a symposium on fish ponds in farming systems, which was held at Can Tho University in Vietnam in April. The workshop was organised jointly by Can Tho University and the Wageningen Institute of Animal Science's Interdisciplinary Research and Education Fund (INREF), and by ViFiNet — the Network of Vietnamese Aquaculture Institutes. The workshop was funded by Wageningen University and the European Union-funded Technical Centre for Cooperation and Rural Development.

POND — the Program of Optimization of Nutrient Dynamics (in Integrated Fish/Livestock/Crop farming) — is funded by INREF. INREF carries out interdisciplinary research, development and education, and develops policies relevant for sustainable development, produces research results that make a difference for end uses, and builds strategic international partnerships.

In order to secure sustainable food production for an increasing population, a high nutrient efficiency is essential. This can be achieved through the use of genetically improved crop and animal species adapted optimally to the farming environment. While intensification seems necessary to maintain an ever-growing population, there is a concern for ecological, economical and social sustainability. Low nutrient use efficiencies may harm the environment. Genetically improved species and strains generally need higher levels of inputs. The poorer groups in society may not have access to new technologies because of a lack of capital and/knowledge. Several studies indicate that farms with more links between various sub-enterprises use nutrients more efficiently and improve the livelihoods of the farm households. This stresses the need to develop sustainable integrated fish-livestock farming systems using adapted animal breeds

and defines the main objectives of INREF-POND:

- Quantify nutrient dynamics in such integrated aqua-agriculture farming systems (IAA-FS), using selected fish breeds.
- Identify the most optimal combination of components, contributing to improved systems resilience and sustainability of: income, food security and environment.

The studies relating to the research outlined above began in 2000 and this symposium was organised to inform interested people and organisations in Southeast Asia and Africa on the results, and to determine the applicability of findings to marketing possibilities.



## Mozambique tilapia eradication and initiation of Nile tilapia pond culture in Nauru

The "Eradication of Mozambique tilapia (*Oreochromis mossambicus*), restocking of Nile tilapia (*Oreochromis niloticus*), and improved aquaculture pond management in Nauru" is a mini-project funded by the

Australian Centre for International Aquaculture Research (ACIAR), and coordinated by SPC. The project has the following specific objectives:

- Carry out consultations with Nauru fisheries staff and pond owners to survey, select and re-design two derelict ponds;
- Develop and trial protocols for eradication of unwanted



fish, primarily *O. mossambicus* and *Gambusia* spp., in the two derelict ponds;

- Improve and prepare ponds for stocking with local stocks of Nile tilapia; and
- Conduct a workshop for staff and pond owners on tilapia grow-out operations, feed preparation, and hatchery operations.

#### Pond site selection

Consultations were carried out with Nauru fisheries staff to identify possible sites for the project. After surveying several

pre-selected sites, Junita's derelict pond and Jovani's pond were selected.

- Junita's pond is located in Menen District and was originally constructed for milkfish culture. However, it was not used due to infestation by *O. mossambicus* and *Gambusia* and other fish. The pond was approximately 800 m<sup>2</sup>.
- Jovani's pond is located in Nibok District. It was selected after several rounds of consultations with pond owners. Jovani is a fisheries staff member who has experience raising tilapia, espe-

cially *O. niloticus* in his backyard ponds. The pond is small and infested with *Oreochromis* species and *Gambusia*.

#### Pond preparation

Junita's pond site was cleared of all bushes and debris, and water pumps were used to pump out water. Once the pond was almost empty, a teaseed cake mixture (toxicant) was prepared and applied in the pond. Almost all fish were seen floating within 40 minutes of application.

The pond was de-silted (mud removed) and its shape and size



**Top left: Dewatering (to ensure minimum water is in pond) before applying teaseed cake**

**Top right: After application of teaseed cake — dead tilapia in the pond**

**Bottom left: Reshaping, improving and de-silting the fish pond using an excavator — the only one in Nauru**

**Bottom right: Tilapia *Oreochromis niloticus* — used for restocking pond**

was improved using an excavator. De-silting reduces water seepage, and removes unwanted fish or fish larvae that survived the teaseed cake treatment. After improvements, the pond dimensions were 32 m x 26 m, giving a total area of 830 m<sup>2</sup>. The water source has a salinity of 4 ppt. An outlet feature was installed to allow water to flow away.

Jovani's pond surroundings were cleared manually and the water pumped out. All fish were removed with a push net. The pond was cleared of rubbish and bushes. Teaseed cake mixture was applied, and all fish were seen floating after one hour. The pond was de-silted manually with buckets as there was no provision for a machine to work at this site. The water source is an underground spring. The pond size is 7 m x 5 m, giving total area of 35 m<sup>2</sup>.

### Stocking

Several sources of Nile tilapia (*O. niloticus*) fingerlings were

identified. They were found in a swamp behind Jovani's village in Nibok District and in a swimming pool at one of the Nauru Phosphate Corporation settlement houses. These tilapia came from the stock introduced from Fiji in 1998 by FAO.

A total 1300 fingerlings of all sizes were collected using a push net from Jovani's village pond, and transported in buckets of water to Junitas's pond. A total 1250 with average weight of approximately 5 g were visually selected and restocked into the ponds.

In addition, 16 male tilapia with an average weight of 60 g, and 34 females (average weight 50 g) have been stocked in hapa in Junitas' second derelict pond. These fish will be maintained by the fisheries department for a future breeding programme.

### Other activities

A swimming pool (7 m x 3.5 m x 1.5 m) at a settlement in Aiwo District had been used for raising

*O. niloticus*. Upon the owner's request, the tank was drained, the fish were graded, and the tank refilled. The pool was stocked with 160, 5-g fingerlings.

### Workshop

A workshop was held at the Anabar fisheries office, as included presentations and discussions on: procedures for applying teaseed to eradicate *Mossambicus*, pond designing/ de-siltation, fingerling handling and transportation, stocking, simple feed making, and requirements for tilapia hatchery and grow-out operations. Other topics included sampling protocols, daily management procedures, and measurement of water parameters and feed inputs.

Fisheries staff expressed interest in a follow-up workshop covering pond maintenance. There is also a need for hands-on training in grow-out aspects of tilapia for farmers. Also there is need to source fish feeds, possibly using the company importing stock feeds.



## REEF FISHERIES OBSERVATORY

*Staff of the coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) and the Coastal Fisheries Development Programme (CoFish) conducted fieldwork in the Federated States of Micronesia, French Polynesia and the Solomon Islands in the first half of 2006. Field activities in Papua New Guinea and Cook Islands were also set up. In addition, there was a mid-term evaluation of PROCFish/C, and the outcomes of this evaluation were presented at the Heads of Fisheries meeting.*

### PROCFish/C mid-term evaluation

The mid-term evaluation of the PROCFish/C programme, and to a lesser extent the CoFish programme, was undertaken by Dr Paul Medley from the UK-based consulting firm, Marine Resources Assessment Group (MRAG) Ltd. Dr Medley conducted interviews with programme staff and others in Noumea, and travelled to Fiji, Vanuatu, and Wallis and Futuna to gain insight on programme

activities from a national perspective.

The evaluation covered several areas, including an assessment of the degree to which programme activities have achieved defined goals, objectives and targets. The evaluation also 1) reviewed problems faced, lessons learned, and the project's success at strengthening capacity; 2) assessed the relevance of

the original project design in light of achievements or failures to achieve expected objectives; 3) assessed costs and benefits of the project; and 4) assessed the programme's sensitivity to environmental and gender issues.

The overall evaluation of the PROCFish/C programme was positive, although some weaknesses were identified. In regard to the programme design, Dr



Medley produced an alternative logframe to assist with improving future reporting, monitoring and evaluation of the programme. The review also highlighted that there was no objective to cover the provision of specific advice to countries, although this was being done at the specific request of member countries and territories.

Government staff who were consulted during the evaluation reported that the purpose and results were relevant to the policy needs of inshore fisheries management. It was felt that the PROCFish/C and CoFish programmes were raising the profile of inshore fisheries and the increased need for management arrangements to be developed and implemented. It was felt that programme activities were being carried out effectively, with little scope for improvement. However, the dependence on underwater visual census (UVC) and fishery independent data have contributed to the programmes' slow progress.

Capacity building is a major component of the PROCFish/C and CoFish programmes. The conclusions of the mid-term evaluation were that attachment trainings have increased local capacity, although mainly in the areas of data collection and data entry. There is also limited human resource capacity within fisheries departments, and this has added to the overall capacity building problem. Sustainability of PROCFish/C and CoFish work is another issue that will, in part, be addressed when Pacific Island staff employed by the programmes return to their home countries with skills they have learned. The production of handbooks and manuals was also seen as another step in capacity building, although there will need to be trainings conducted in how to use these resource materials.

The main area of concern raised in the programme's mid-term evaluation is its low visibility in the region. This is mainly the result of country reports not having been completed and provided to countries. However, the data has been made available, and in many cases, individual site reports have been produced. The evaluation also provided some suggestions for overcoming this low visibility, including the development of communication plans with countries and giving presentations on results. Even with these limitations, interest in programme results among countries has not diminished.

The mid-term evaluation strongly supported the need for a no-cost extension of the programme to allow it to fully meet its objectives. There are sufficient funds remaining for at least an 18-month extension, and up to two years for some staff.

The PROCFish/C and CoFish Steering Committee met in Noumea in April 2006 to review progress and to discuss the findings of the mid-term evaluation. Eleven Pacific ACP and French OCT countries were present at the meeting, along with observers from several non-ACP countries, programme and other SPC staff. Staff of the PROCFish/C team presented results of work to date in the areas of socioeconomics, finfish, invertebrates, and database development. Presentations were also made covering a general overview of the programme and the work conducted so far, the recommendations of the mid-term evaluation, and the proposed workplan for 2006. The Steering Committee's four main outcomes, which were presented at the fifth Heads of Fisheries meeting and subsequently endorsed, and as follows:

1. The Steering Committee strongly supported the find-

ing in the mid-term evaluation's suggestion to seek a no-cost extension of the programme to ensure it would fully meet its stated objective. It was obvious that with only 11 months remaining for the PROCFish/C and CoFish programmes, there was insufficient time to complete necessary fieldwork, let alone complete the data analysis and report writing to get the results back to country. A no-cost extension for the programme was essential and there was funding in the budget to support this. *(Note: All of the paper-work for a two-year, no-cost extension for the programmes was provided to the Regional Authorising Agency in June. This process has been actioned, and the programme awaits the decision of the EC in regard to this request).*

2. All members of the Steering Committee expressed concern that no country reports had been completed and provided back to countries, and this situation needed to change. Fisheries Departments could not keep justifying to their governments the funding spent in support of PROCFish/C fieldwork activities, with no results or report to show. Countries needed their reports in a timely manner so they could use this information for the management of inshore resources. The Steering Committee clearly stated that a strategy needed to be developed between PROCFish/C and countries to ensure reports, even at a site level in draft form, started to be provided in a timely fashion.
3. Capacity building within countries was also highlighted as an area the programmes should focus. Capacity building was occurring in regard to survey methodologies and data

entry, however data analysis and interpretation of data was highlighted as one area of capacity building countries needed. The Cook Islands offered to host such a workshop, making sure that adequate computers would be available. A second area for capacity building was in the area of using GIS and Map

Info data. Countries needed the skills to present information visually to senior decision makers and ministers to be able to get different messages with regards to inshore resources and local marine habitats. In-country capacity building in general was an overall theme for the countries present at the meeting.

4. In reviewing the logical framework for the PROCFish/C programme, the Steering Committee supported the proposed changes made by the reviewer and presented in the mid-term evaluation of the programme.



## Workshop on mapping marine habitats

PROCFish/C's Senior Finfish Scientist, Laurent Vigliola, attended a workshop in Wellington, New Zealand on "Marine benthic habitats: The key to environmental management". Most of the presentations focused on seafloor mapping. There were many examples of how habitat mapping could be used to develop ecosystem-based fisheries management plans, which generally relates to the "concept of essential habitats". Some concerns were raised about how necessary "essential

habitats" are for fisheries resources. Combined results from the PROCFish/C and the Institute for Marine Remote Sensing millennium coral reef mapping projects addressed those concerns.

Laurent's presentation, "Coupling habitat and fisheries data at multiple spatial scales to improve the management of coral reef fisheries in Pacific Island Countries", provided an example of the implicit assumptions of habitat mapping when

applied to fisheries management: 1) that habitat and fisheries resources are indeed linked, and 2) that mapping habitat can help in mapping fisheries resources for use in management. The outcome of the meeting was a first draft agenda for an international workshop to be held in Noumea in 2007, tentatively titled "Seafloor and habitat mapping for integrated ocean management in the Pacific".



## Fieldwork in the Federated States of Micronesia (FSM)

### CHUUK

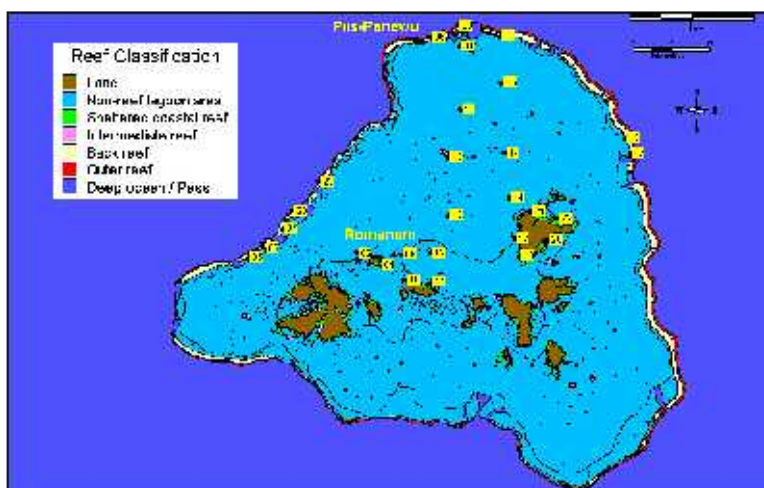
Chuuk Lagoon's marine resources were surveyed (from the northern and western bases of Piss-Panewu Island and Cherong village at Romanum; Fig. 1) during April.

This work was undertaken in collaboration with the Chuuk Department of Marine Resources. Mr Romio Osiena, Director of Chuuk Fisheries, provided support and staff to assist with field work logistics. Several Chuuk fisheries staff (Kerat Rikim, Allen Marcus and Fritz Nifon) and one staff member from

Pohnpei Fisheries (Mr Dave Mathias) were trained in the PROCFish/C UVC (Fig. 2) and invertebrate methodologies and participated in fieldwork activities. In addition, three Chuuk

fisheries staff were trained in conducting socioeconomic surveys. The PROCFish/C team consisted of Aliti Vunisea, Laurent Vigliola, Pierre Boblin, Kim Friedman and Kalo Pakoa.

**Figure 1: Areas surveyed in Chuuk Lagoon (map provided by IRD and Coral Reef Millennium Mapping Project)**





The two survey sites consisted of Romanum, a small volcanic island with two villages, Winisi and Cherong, and Piis-Panewu, a coral atoll with two villages, Nukan and Sopotiw. In these four communities, families live in large extended households of 16–20 people each. Most families have gardens where they cultivate root crops. Results from the socioeconomic surveys indicate that seafood is the main source of food and income for the people of both Romanum and Piis-Panewu, with most families eating fish nearly seven days a week throughout the year. Canned fish is also consumed, but is not very popular as most people prefer fresh fish. Fishing is a way of life and is a daily activity for people. Although there is a shift towards the use of modern fishing gear, skill and traditional knowledge of tides, winds, moon phases, etc. are still prominent. Younger men are heavily involved in fishing for income and most of them fish in groups. Men do most of the reef finfishing, while women collect invertebrates and use handlines to catch reef fish within the inshore areas, mostly for home consumption.

At both survey sites, the PROCFish/C underwater visual censusing (UVC) team's finfish divers observed a very healthy ecosystem, which included a diversity of corals and finfish, large numbers of edible species, many large individuals of species, large numbers of apex predators, and frequent sightings of rarer species such as humphead parrotfish and giant humphead wrasse. Altogether, these preliminary observations indicate a very healthy reef finfish resource. Regular visits to the market indicated good agreement between catch and finfish UVC assessment. Both underwater surveys and visits to the market indicated parrotfish, rabbitfish, goatfish, surgeonfish, fusiliers,

chub, squirrelfish, soldier fish, emperor fish, snappers and groupers are the main families of reef fish caught. A quick look at reef fish catch at the market confirmed preliminary findings of the socioeconomic survey that spearfishing may be one of the most important, if not the main, fishing technique used.

In general, a large range of invertebrates of commercial and subsistence use were present, but generally in depleted condition, across the whole ecosystem. Records of giant clams revealed depletion in species

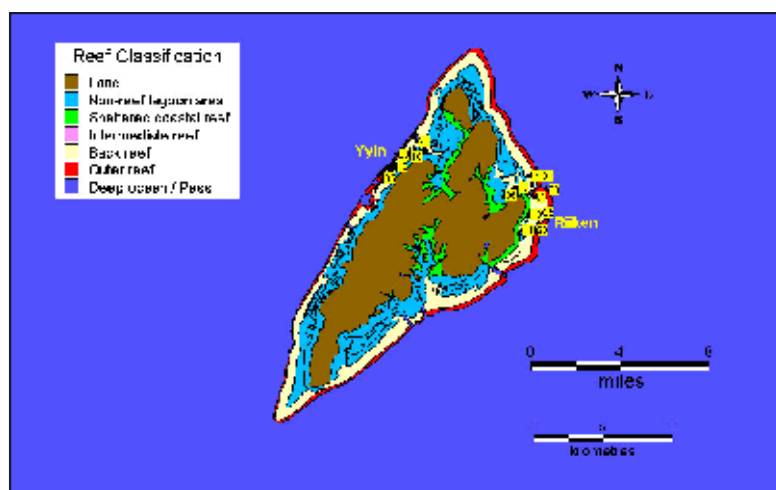
number, density and size. *Trochus niloticus*, which was introduced by the Japanese some 70 years ago (from Rabaul, PNG), is now widespread in the lagoon. Records from assessments show stocks were lower than expected, although recruitment of juveniles was still strong (Fig. 3).

Although Chuuk is a large semi-enclosed lagoon system that predominantly reflects an oceanic influence, there is a wide range of environments present. This was noticeable in sea cucumber findings, where



**Figure 2 (top): Divers being trained in UVC methods**

**Figure 3 (bottom): Juvenile trochus from coral rubble reeftops**



**Figure 4 (top):** The survey area off Yin and Riiken (map provided by IRD and Coral Reef Millennium Mapping Project)

**Figure 5 (bottom):** Counterpart, James Pong with fish size charts during interviews



A total of 41 households were surveyed from the four villages, with coverage ranging from 67–100% of all households in each village. A household survey (interview) (Fig. 5) was undertaken, and if the household was involved in either finfish or invertebrate fishing, a separate survey (interview) was conducted for each person within the household.

Results indicate that finfish are important for subsistence but not for commercial purposes, whereas invertebrates are not important for subsistence or commercially in any of the villages surveyed. Reef fish and tinned fish consumption is relatively high at 44 and 44.7 kg/person/year in the east coast villages of Riiken and Wanyaan, respectively, and 46.9 and 25.2 kg/person/year in the west coast villages of Yin and Gilfith, respectively. The shift from subsistence to a cash-based lifestyle may explain the high consumption figures of canned fish and other canned and frozen imported products.

Finfish surveys revealed low numbers of most edible groupers and emperors, although healthy stocks of surgeonfish, wrasses, parrotfish and snappers were observed. There is medium to high species diversity, although the size of fish are predominantly small to medium, and there are low numbers of larger-sized fish. Fish also tended to shy away from the divers, which indicates moderate levels of spearfishing and related fishing activities. There were also signs of intense

19 commercial species were recorded. Initial findings indicate that sea cucumbers were depleted, but despite large exports that were anecdotally reported in 2000, there was still wide distribution of commercial species. Chuuk is suffering a long-standing infestation by the crown of thorns starfish. These infestations were extensive and at a moderately high density across the north of the lagoon; densities were highest (and corals most effected) around high island shorelines.

#### YAP

The two areas identified for surveying on Yap were Yin and Gilfith on the west coast, and

Riiken and Wanyaan on the east coast (Fig. 4). This work was undertaken in collaboration with the Yap Department of Resources and Development, Marine Resources and Management Division. The Director, Joe Glikko, assisted with setting up the logistics, while the Division Chief, Andy Tafleichig, was the main contact person. Andy and his staff (Mike Hasurmai and James Pong) were involved in all fieldwork activities. Steve Palik from the Kosrae Marine Resources Division underwent training in UVC methodologies and assisted with the survey work. The PROCFish/C team for Yap consisted of Mecki Kronen, Samasoni Sauni, Ribanataake Awira, Ferral Lasi and Emmanuel Tardy.



fishing pressure in the sheltered inshore reef areas, which is easily accessible by fishers.

At both sites, giant clams were found sporadically on the outer part of the lagoon at low to moderate densities and some large-sized individuals. *Trochus* were also found at both survey sites, and in moderate densities in the Yyin area. Weather conditions hampered fieldwork off Riiken, with only a low density of *trochus* recorded in the southern part of this survey area. Seventeen species of sea cucumber were recorded for the two survey sites, mainly in low numbers for the higher-value species, although the average size of most species was large. The large size (Fig. 6) and low numbers of sea cucumbers indicate that the species is not over-fished, but rather ecological factors may play a major influence.

#### MOOREA, FRENCH POLYNESIA

Moorea was the last site to be surveyed in French Polynesia. The PROCFish/C team consisted of Mecki Kronen, Laurent Vigliola, Pierre Boblin, Kim Friedman and Kalo Pakoa. The PROCFish/C team was assisted by Maire Bustamante, Arsène Stein, Maëlle Poisson, Emmanuelle Bovy, Frédéric Faana, August Faatuarai and others from the Papeete and Moorea offices of Service de la Pêche, and René Galzin, Yannick Chancerelle and other staff from the Centre de Recherches Insulaires et Observatoire de l'Environnement (CRIOBE).

The survey covered the village of Maatea, one of the few traditional communities on Moorea. About 12% of all households (235, with a total population of 1177), 25 finfishers, and 5 invertebrate fishers were individually interviewed. About 20–30% of the Maatea families depend on reef resources for income generation, with the catch most-

ly sold within the Maatea community (Fig. 7). The share of catch that is distributed on a non-monetary basis is relatively small. The per capita consumption of fresh fish is 62 kg/year, which is quite. This consumption figure also includes pelagic

fish species, which are less expensive and thus becoming more frequently substituted for reef and lagoon species. Fisheries authorities are concerned about overexploitation of reef and lagoon fishing resource of Moorea lagoon and



**Figure 6 (top):** One of the sea cucumber species (*Stichopus vastus*) recorded in Yap

**Figure 7 (bottom):** Fish market at Maatea, Moorea

reef areas. Local associations have succeeded in banning certain fishing practices (e.g. ature fishing using a beach purse seine-type net) in the Maatea fishing grounds.

The finfish assessment found that Maatea's coral reef was healthy, with relatively high live coral cover (up to 50% with an average of about 25%), but there were obvious signs of past mass coral mortality (up to 30% dead coral, 11% average). Fish assemblage was neither exceptional nor absolutely depleted, but somewhere in between, and likely not at the level it should be when considering the quality of the habitat. PROCFish/C divers generally found that large species such as sharks and other apex predators, large parrotfish, and large surgeonfish were rare or of very small size

when present. In contrast, smaller species were present in relatively large numbers.

Invertebrate resources were present, but low in diversity as expected. *Tridacna maxima* was the only giant clam recorded on the reef. Densities varied from high in one area, to low on the rest of the reef. The presence of high numbers of smaller-sized invertebrates is an indicator of both harvesting pressure and good recruitment. The beche-de-mer resource is represented by tigerfish, white teats, lollies and prickly reds. Tigerfish are scattered over the reef, lollies mostly on the inner reefs, and white teat fish are found in one of the passages. The most promising resources are the introduced mother of pearl species: *Trochus niloticus* and *Turbo marmoratus* (green snail). Both species were

re-introduced to Moorea from Tahiti, with 800 trochus in 1963 and 90 green snails in 1980. Since their introduction, the resources in Moorea remained closed to commercial fishing. Some collection of trochus for meat occurs on Moorea and Tahiti. Trochus and green snail are found on outer, middle and inner reefs, and high concentrations were found on two inner reefs in front of the channels.

#### SOLOMON ISLANDS

The first two sites in the Solomon Islands, Marau and Gela, were surveyed in June, however data entry is ongoing and the assessment of this initial work and the survey work in the other two sites will be reported on in the next issue of the *Fisheries Newsletter*.



### FAO/SPC regional workshop on improving information on the status and trends of fisheries

The reef database developed by the PROCFish/C team and distributed to the region was presented to the workshop by the PROCFish/C Database Manager, Franck Magron. In his presentation, Franck emphasised the advantages of using a structured and standard database for

data storage along with a user-friendly application for data entry and retrieval. While the current system mainly follows the methodology and types of surveys conducted by the PROCFish/C programme (e.g. underwater visual census of finfish, invertebrates resource sur-

veys, household and fisher surveys), it is planned to extend the system to new types of surveys to fulfil further needs of the region in terms of database management and associated software.





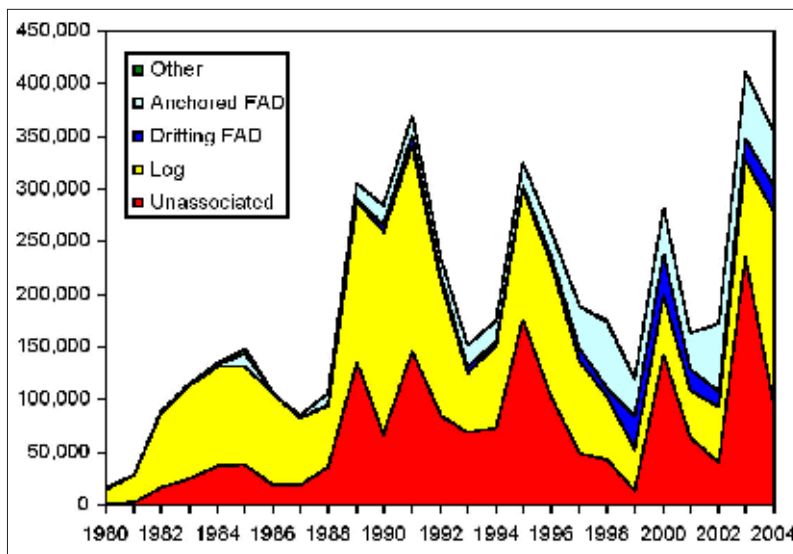
## OCEANIC FISHERIES PROGRAMME

### Regional Tuna Tagging Project Phase I: Papua New Guinea

The tuna fishery in the western and central Pacific Ocean (WCPO) produces approximately half of the world's tuna and is of high economic importance to Pacific Island countries and territories. Throughout the

WCPO, total annual catches of target tuna species (skipjack, yellowfin, bigeye and albacore tuna) are now approaching 2 million tonnes. The fishery comprises a variety of fishing activities, the most important of

which are the industrial-scale purse seine, longline and pole-and-line fisheries. Large catches are also made by numerous small fishing vessels employing a variety of fishing methods in the adjacent waters of the Philippines and Indonesia.



While the overall fishery is distributed widely from about 40°N to 40°S, by far the majority of the catch occurs in equatorial waters between about 10°N and 10°S. In this region, catches are dominated by purse seiners, which catch mainly skipjack and yellowfin tuna, with a smaller catch of bigeye tuna. Purse seiners have two main operational modes: setting on free-swimming (or unassociated) schools of skipjack and medium-large yellowfin; and, setting on schools associated with floating objects such as

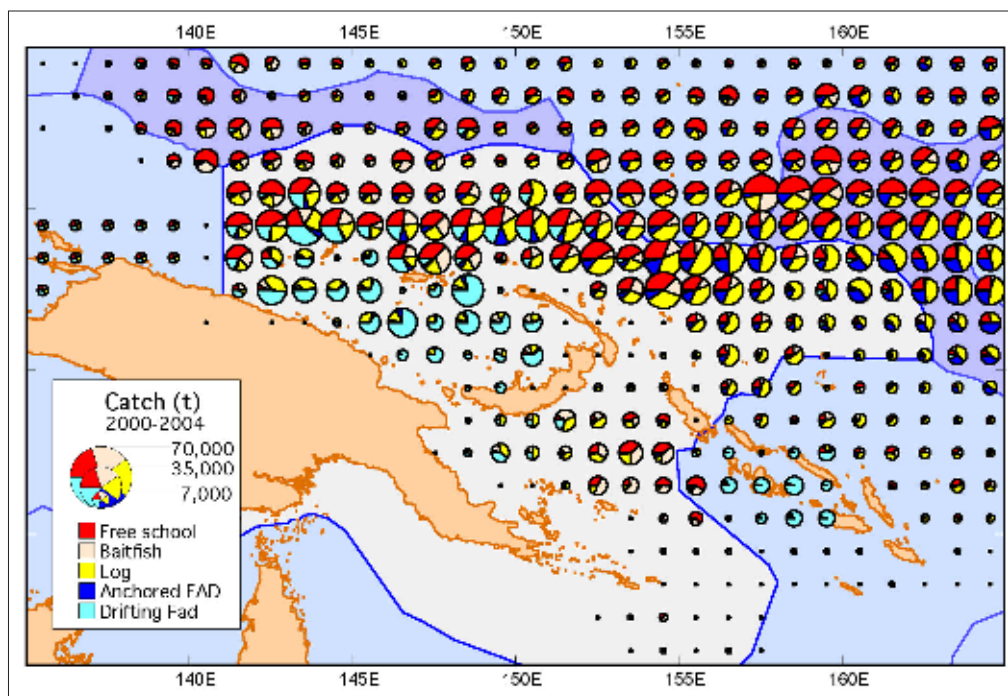


Figure 1 (top): Purse-seine tuna catch in PNG's EEZ by set type

Figure 2: (bottom): Distribution of purse-seine catch by set type in the vicinity of PNG, 2000–2004

drifting logs and anchored or drifting fish aggregation devices (FADs). These associated sets tend to catch larger quantities of small, juvenile yellowfin and bigeye tuna. Longliners target adult bigeye and yellowfin tuna in this region and at higher latitudes.

Papua New Guinea (PNG) is an extremely productive tuna fishing area. Catches in the PNG exclusive economic zone (EEZ) have averaged about 250,000 tonnes per year over the past decade, peaking at approximately 400,000 tonnes in 2003. Most of this catch has been taken by foreign-licensed and locally based purse seiners, although a locally based longline fleet also operates in the southern part of the EEZ. The purse-seine fishery in PNG is strongly dependent on sets on floating objects, in particular logs and drifting and anchored FADs (Figs. 1 and 2). Therefore, a significant proportion of the catch consists of juvenile yellowfin and bigeye tuna. There is also significant bycatch of other species taken in these sets.

Regular assessments of the status of skipjack, yellowfin and bigeye tuna stocks are undertaken by SPC's Oceanic Fisheries Programme (OFP). While skipjack tuna stocks are considered to be in good condition, serious concerns are beginning to emerge regarding the status of yellowfin and bigeye tuna stocks, particularly in this equatorial region of the WCPO. These assessments analyse catch, effort and size composition data from the fisheries, as well as available tagging data. While the fishery statistics are updated annually for the assessments, the most recent tagging data, which provide important fishery-independent information on fish movement, growth and mortality, dates back to the early 1990s.

Successive meetings of the Standing Committee on Tuna and Billfish, and most recently the inaugural meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission (WCPFC), have recommended that a new large-scale tagging project on all three species (but with particular attention to yellowfin and bigeye tuna) be carried out to reduce uncertainty in the assessments. Such a project would involve the large-scale tagging of skipjack, yellowfin and bigeye tuna throughout the area of operation of the major fisheries for these species in the WCPO. The major objective of such a project would be to improve the assessments of skipjack, yellowfin and bigeye tuna through the provision of information on medium- to large-scale movement characteristics and fishing and natural mortality rates. The tagging data generated by the project would be incorporated directly into the stock assessment analyses and contribute new information on these biological processes.

As a first phase of this regional project, it is proposed that tagging be conducted in the PNG EEZ using a chartered pole-and-line vessel. In addition to contributing to the regional objective outlined above, the Phase I activity would also address issues of specific importance to the management of the tuna fishery in PNG, including the estimation of local exploitation rates and increasing the understanding of the dynamics of tunas associated with FADs.

FAD fishing is also an issue at the regional level. Over the past decade, the deployment of drifting FADs by purse seiners has become a routine practice. FAD technology has also developed rapidly, with many operators deploying acoustic sensors on the FADs, which they are able to interrogate remotely to estimate

the quantities of tuna aggregated. These developments have greatly increased the efficiency of purse seining, increasing catches of skipjack and juvenile yellowfin and bigeye tuna. However the extent of efficiency increase is difficult to quantify as there is little information available on the dynamics of tuna attraction and residence on FADs. The existence of a large array of anchored FADs in PNG, which have been deployed over the past 10 years, provides an opportunity for detailed study of the behaviour of the associated tuna, which may yield important new information relevant to the management of FAD fishing in both PNG and the wider WCPO.

#### OBJECTIVES OF THE PROJECT

The specific objectives of Phase I are to:

1. **Obtain information on the large-scale movement of tuna in, and from, PNG's EEZ.** This information is important for understanding the relationship of PNG stocks with those of adjacent areas. Movement rates are particularly important for assessing the potential for interaction between fisheries operating in different areas. The comparison of tagged fish movements from the Bismarck Sea that will result from this project with tagged fish movements from the same area in the early 1990s (before extensive anchored FAD deployment) will provide important new information on the meso- to large-scale effects on tuna movement of large anchored FAD arrays.
2. **Obtain information on current exploitation rates of tuna in PNG's EEZ.** Information on local exploitation rates is important for understanding the impact of fishing at the

EEZ scale. In particular, it allows estimation of the extent to which current catch levels may reduce the standing stock of tuna and the catch-per-unit-effort of the fisheries, a phenomenon commonly known as "local depletion".

3. **Obtain information on the dynamics of tuna associations with FADs, in particular species-specific information on residence times, vertical and horizontal movements and FAD interactions.** This information is required for a better understanding of the effects of FADs on tuna stocks and their vulnerability to fishing, and for the design of appropriate management measures.
4. **Obtain data that will contribute to regional tuna stock assessments.** Conventional tagging data are an important component of tuna stock assessments, providing quasi-fishery-independent information on exploitation rates, natural mortality, movements and other parameters.
5. **Obtain information on the trophic status of free-swimming schools of tuna, and tunas associated with FADs, other floating objects and seamounts.** This information is required for the general understanding of the ecosystem impacts of FADs compared with other types of tuna aggregations.
6. **Characterise the variability and extent of catches of bycatch species from purse seine catches in PNG.** PNG's National Fisheries Authority runs an observer programme with high coverage rates, which offers the opportunity to document bycatch levels and their variability in purse-seine sets on anchored FADs and other set types.

## PROJECT ACTIVITIES

### Tag releases

The project will aim at tagging approximately 30,000 tuna (~ 60% skipjack, 30% yellowfin, 10% bigeye), with conventional tags in six months of vessel operations. Tagging will be concentrated in the main area of the purse-seine fishery (Bismarck Sea, Solomon Sea and adjacent areas), and cover tuna associated with anchored and drifting FADs, floating logs, seamounts and unassociated schools.

During the tagging cruises, smaller numbers of the three species will be tagged with electronic tags to record more detailed information. Approximately 300 tuna (100 of each species) will be tagged internally with archival geolocation tags.

### Biological sampling

The tagging cruises will present opportunities to collect stomach and tissue samples for trophic analysis from tuna that are not tagged. Samples will be collected from all species captured across all school associations and, as far as possible, across a wide size range.

### Tag recoveries

Recovery procedures will be established in major tuna landing ports in PNG and elsewhere in the region utilising, for the most part, established catch monitoring programmes. Industry briefing, publicity, tag-reward payment, and data collection will be focused through individuals identified in each location.

A publicity campaign will be mounted throughout the region to publicise the project. Publicity will occur via tagging posters distributed to landing ports and processing facilities, announcements in local news media and personal contact of

project staff with the fishing industry and local communities. A website will also be established for the purpose of disseminating publicity and information about the project, and possibly as a means of collecting tag-recovery data.

Rewards for the return of tags will be paid to tag finders. For conventional tags, a reward of USD 10 per tag return will be paid. For archival tags, a reward of USD 250 for each tag return will be paid. For acoustic transmitting tags, a reward of USD 100 for each tag return will be paid. These differential rewards reflect both the value of the hardware and of the data accompanying the tag. Assuming that there is complete reporting of the higher value tags, any significant differences in return rates between conventional and electronic tags might be attributable to non-reporting (of conventional tags). This information will be important for subsequent modeling of the tag-return data.

### Data processing and analyses

Data processing and analysis will be undertaken at SPC headquarters using existing technical and scientific staff resources. Conventional tagging data will be entered into the OFF's existing tagging database, in which the data from SPC's previous tagging programmes, and those of several other national programmes in the WCPO, are stored. Similarly, the data from returned archival tags will be downloaded and incorporated into an existing archival tagging database maintained by SPC's OFF. NFA will be given access to all data collected by the project.

### Capacity building

Considerable capacity building spin-offs are anticipated through the involvement of NFA staff in all aspects of the project, including project plan-



ning, fieldwork, interpretation of data and the development of fishery management recommendations.

### Partners

In terms of project implementation, the main partners in the project are OFP and NFA. However, OFP will also be collaborating with the University of Hawaii on several aspects of the project, notably the deployment of FAD receivers, associated acoustic tagging, and the analysis and publication of results from this activity.

In terms of project funding, a number of donors are contributing to the project. These include

the NFA, the Australian Centre for International Agricultural Research, the New Zealand Agency for International Development, the University of Hawaii, and the French Pacific Fund. In addition, existing SPC-executed projects funded by the Global Environment Facility and the European Commission will also contribute, consistent with the objectives of those projects.

### CONCLUSION

SPC implemented a regional tuna tagging project in the late 1980s and early 1990s, funded by the European Commission at a level of about USD 4 million. The project released approximately 150,000 tuna tagged

with conventional tags and received approximately 20,000 recoveries. The data generated by this project have formed an important input to regional tuna stock assessments and has provided important baseline information on tropical tuna movement, mortality and longevity.

The present project, while addressing specific tuna fishery management issues in PNG, is expected to be the first phase of a new regional tuna-tagging project that will immediately follow the PNG activity. Phase II is expected to have a budget in the vicinity of USD 5 million and several significant funding commitments are already in place.



## ■ AN ETHIC FOR MARINE SCIENCE: THOUGHTS ON RECEIVING THE INTERNATIONAL COSMOS PRIZE

*In October 2005, Daniel Pauly travelled to Japan with his wife Sandra to receive, on October 18th, the 13th International Cosmos Prize from the Expo '90 Foundation in Osaka. The prize is awarded for research work that has achieved excellence and is recognised as contributing to a significant understanding of the relationships among living organisms, the interdependence of life and the global environment. Below is Dr Pauly's acceptance speech.*

Ladies and Gentlemen,

I would like to express in Japanese my thanks to the International Cosmos Prize committee and the Expo'90 Foundation for having me here, but I have to do so in English – a foreign language to you, but also to me.

Receiving an award such as the Cosmos International Prize invites serious reflection, and I will share with you some of the thoughts that I have had since that glorious day in early July, when travelling in France, I was informed that I would be this year's prize recipient.

People have good reasons to be worried about the fate of life in the ocean, as we now engage our whole industrial might in chasing and catching, for our food, the top predators of marine ecosystems. Increasingly, these predators are being depleted, and we now turn to their prey, smaller fishes and invertebrates, some highly valuable. This phenomenon is now known as "fishing down marine food webs", and it explains a vast number of observations, which before remained unconnected. Fisheries have been able to move easily from larger to smaller targets, aided by high technology — such as echolocation and global positioning systems — and abetted by a processing technology which can turn even the most improbable sea creatures into tasty morsels.

Life in the ocean, though, was not designed to be ground up by a transoceanic food produc-

tion machine. In fact, it was not designed at all, but evolved over the eons, and its ability to produce a surplus that we can share, year for year, is an emergent property of marine ecosystems, contingent on their continued existence as complex entities. If the species we target are depleted, and the ecosystems in which they are embedded are drastically simplified, this surplus is reduced, and eventually vanishes. This is the situation we have now in many parts of the world's oceans. I wish to emphasize this: global catches from marine fisheries are declining, in spite of, or rather because of, increasing fishing effort.

There are those who believe that the problems of fisheries do not justify speaking of a crisis, and that various technological fixes will suffice for solving these problems. Among these fixes are updated versions of our traditional management schemes, jazzed up to include explicit laying out of the costs and benefits of various options on fishing levels, and the presumed risk attached to each. This would enable "managers" to make rational choices under a given set of economic and political constraints. Presently, this approach, which sees this laying out of options as all that scientists can do, and which therefore limits our role to that of vending machines, is very popular in fisheries sciences.

However, our inability to tackle another, much bigger problem — global warming — indicates that we are, as a species, usually

unable to make rational decisions to avert long-term harm to ourselves, even if the risks can be estimated, especially if these decisions involve short-term sacrifices. The recent tsunami in South and Southeast Asia, and the even more recent flooding of New Orleans, underline this. In both cases, planning for an eventual catastrophe and working with nature, not against her, would have saved thousands of lives, and avoided immense material damage. Yet, the managers had no plans, and the populations concerned, when they could vote, elected politicians who at best had other priorities, and at worst actively campaigned against such investment for the public good.

This has been similar in all the great collapses of fisheries, where after the catastrophe, in virtually all cases, the voice of prudence — usually that of scientists — was shown to have been ignored by the managers, in favour of the voices of short-term interests. Where does this put me — one single person — amidst a cacophony of voices? I understand the award of this wonderful prize to be a vindication, and an encouragement to raise the stakes. And the stakes must be raised. We scientists working on environment-related issues have been too meek when managers, lobbyists and politicians have twisted the results of our work to fit their agenda. The main tool they have used to silence us, and to reduce us to vending machines, is the notion that an engagement for the environment would compromise our scientific objectivi-

ty. Yet this argument is never evoked in medicine. Indeed, passionate engagement for the patients, against disease-causing agents is not only the norm, but also an essential element of doctors' professional ethics.

This is not the case for environmental scientists, probably because many of us work for governments, and can be easily silenced, or even made to serve a short-term political agenda. Universities, however, are less constrained, and we should expect university researchers to make themselves heard when science is not put to use for the public good. And the public good it must be, because science is a collective venture, ultimately funded by the public, our ultimate master.

There is, presently, in a number of Western countries, an intense public debate about the compatibility of science and religion. I believe these to be incompatible, but this a minority view: most people, including many scientists, believe not only that the two can co-exist — both in one's head, and in the public discourse — but that this co-existence can be mutually enriching. If this is so, why is there so much resistance against the co-existence — in the heads of environmental scientists and in their discourse — of two eminently compatible modes of relating to

nature (i.e. a "scientific mode", which describes nature, and a "conservation mode", which strives to maintain it?).

We must learn to combine scientific integrity with taking firm positions, not only on the conservation of the plants and animals about which we have expertise, but also for the continued existence of the ecosystems of which they are parts. Humans have become the major ecological force on Earth, but we can secure continued services from these plants, animals and ecosystems only if we give them the space they need, and the time they need. Most people don't know that. It is the job of scientists working on ecosystems, and on wild flora and fauna to remind politicians and the public of that, and being silent when this is not taken into account is unethical.

As the magazine *Science* sees it, my award of a major scientific prize by one of the most important fishing nations on earth has put squarely in the mainstream the notion that over-fishing is, regrettably, our dominant mode of interaction with ocean life. What is not yet in the mainstream is that the simplest, and most effective approach to re-establish some semblance of abundances past is for humans to withdraw from parts of the ocean, and to let nature, there at

least, heal the wounds we have inflicted. Thus, to be more specific, I will work for the establishment, throughout the world, of more marine protected areas, and similar zones of reduced human impacts. Right now, they cumulatively cover less than 1% of the world's oceans, with about only one-tenth of that effectively protected. And not enough new ones are declared for the goals we have set for ourselves to be reached (e.g. protecting 10% of the world's oceans by 2010).

I must come to an end. The best way to thank you for this unforgettable afternoon, to thank the International Cosmos Prize committee and the Expo '90 Foundation for this wonderful prize, and to thank the many people — foremost His Highness The Crown Prince — who have welcomed me and my wife in your beautiful country is to continue, with renewed vigor, the research and public speaking for which I was awarded the Cosmos International Prize for 2005. And so I will. Thank you.

Daniel Pauly

(Source: *The Sea Around Us Project Newsletter*, issue 32, November/December 2005, <http://www.seaaroundus.org/>)



## ■ US DESIGNATES "WORLD'S LARGEST" MPA IN NORTHWESTERN HAWAIIAN ISLANDS

US President George W. Bush has designated a giant marine protected area around the Northwestern Hawaiian Islands (NWHI), a long stretch of coral islands, seamounts, banks, and shoals that extend westward from the main Hawaiian Islands. With an area of 139,793 square miles (362,000 km<sup>2</sup>), the NWHI Marine National Monument is

being touted by US officials as the largest MPA in the world, surpassing Australia's Great Barrier Reef Marine Park (344,400 km<sup>2</sup>). The monument holds what are considered to be the healthiest and least-disturbed tropical coral reefs under US jurisdiction, as well as thousands of marine species, including abundant populations of top-level predators.

The site will be co-managed by the National Oceanic and Atmospheric Administration (NOAA), the US Fish and Wildlife Service, and the State of Hawai'i. All NWHI commercial fishing activities, which primarily consists of eight licensed bottom fishing operators, will be banned within five years inside the protected area. The



Pew Charitable Trusts, an NGO, is negotiating with these bottom fishing operators on potential buyout payments for surrendering their permits immediately. Such payments would effectively end commercial fishing at the beginning rather than end of the five-year phase-out period. Recreational fishing — already minimal in the NWHI due to the remoteness of these mostly uninhabited islands — will also be prohibited, although the managing agencies will determine whether catch-and-release fishing methods will be allowable by permit around one atoll (Midway).

Traditional Native Hawaiian cultural practices, including fishing for pelagic species, will be allowed by permit as long as consumption occurs within the NWHI, and the monument will eventually receive an official Native Hawaiian name. Harvest by crews of research and management vessels and other permitted individuals will also be allowed. The proclamation of the monument is available online at

<http://www.whitehouse.gov/news/releases/2006/06/print/20060615-18.html>

"This protected area is important not only for the place it is protecting but also for the precedent it sets," says Elliott Norse, president of Marine Conservation Biology Institute, which worked with other NGOs to campaign for protection of the NWHI. "The US has been wrestling with the issue of creating either small, well-protected areas — with strict limits on activity — or large, not well-protected areas. This one is designed to be a very large, very well-protected area."

### Building on previous protection

The NWHI have been the subject of presidential interest since

former President Theodore Roosevelt designated some of the islands as a bird sanctuary in 1909. In 2000, former President Bill Clinton designated a coral reef ecosystem reserve over roughly 340,000 km<sup>2</sup> of the NWHI. It contained several no-take zones but allowed fishing elsewhere by small numbers of Hawai'i-based commercial pelagic fishermen and bottom fishing vessels, as well as sport fishermen (*MPA News* 2:6). The bottom fish fishers are the operators now negotiating for a buyout. (The pelagic fishery was only occasionally active and relatively unprofitable.)

A public process has been underway since 2002 to solicit public comments on potential site regulations, in anticipation that the coral reef ecosystem reserve would eventually be designated as a national marine sanctuary. During that process, the concept of stricter limits on activity in NWHI received substantial support from Hawaiian residents as well as national and international environmental groups, and in September 2005, Hawai'i Governor Linda Lingle banned nearly all extractive activity in state waters of the NWHI archipelago, out to 3 nm from the shore (*MPA News* 7:4). President Bush cited the public support for strict protection in his proclamation of the new NWHI Marine National Monument. His designation of the site as a "national monument" rather than a national park or national marine sanctuary allows the protected area to take effect immediately.

There has been one strong voice of dissent: the leadership of the Western Pacific Regional Fishery Management Council, or WesPac, which oversees fishing in the region's federal waters and reports to NOAA. Kitty Simonds, executive director of WesPac, has questioned for several years the wisdom of pro-

hibiting limited fishing by a small fleet, arguing that the council was doing an effective job of balancing conservation with sustainable fishing in the NWHI. In June 2000 upon President Clinton's designation of the ecosystem reserve, Simonds asked *MPA News*, "Why shut the fisheries down if there are no threats?" WesPac instead recommended stricter fishing regulations, including limits on bottom fish and pelagic takes, closure of other fisheries, and no-take marine reserves in 40% of the NWHI. After President Bush designated the national monument, WesPac responded, "We believe the abundance and biodiversity of the area attests to the successful management of the NWHI fisheries by the Council these past 30 years, and indicates that properly regulated fisheries can operate in the NWHI without impacting the ecosystem." Simonds says WesPac will ask Congress to allow the bottom-fish fishery to operate indefinitely in the monument.

The strict protection for the NWHI represents a major victory for local and national environmental organisations, which employed a range of techniques to build political support. A core group of NGOs — the 'Ilio'ulaokalani Coalition (a Native Hawaiian cultural organization), KAHEA (an alliance of Native Hawaiians and environmental activists), and Hawai'i offices of two national organisations (Environmental Defense and Sierra Club) — worked for six years to ensure transparency of NWHI public planning processes, strengthen public participation, and brief decision-makers. The Pew Charitable Trusts, a national organisation (formerly a foundation), launched a multifaceted campaign in 2005 to sway local and national support in favour of limits on NWHI commercial fishing, including

leading the effort currently underway to craft a buyout package to retire the existing commercial fishing permits. Other organisations — The Ocean Conservancy, the Hawai'i Audubon Society, and Marine Conservation Biology Institute (MCBI) — played multiple roles in research and advocacy, including enlisting the assistance of influential celebrities and politicians. In April, a dinner for President Bush was arranged at which he viewed a new film by Jean-Michel Cousteau on the need to protect the NWHI ("Voyage to Kure") and he discussed the film afterward with Cousteau and scientist Sylvia Earle, another proponent of protection.

Cha Smith, executive director of KAHEA, calls the national monument a milestone in marine and cultural rights protection. She adds, however, that the public should remain vigilant during the forthcoming process to refine and inform the details of the monument's management plan. "There need to be very specific criteria established for the approval of research projects," she says. "Projects must be tied directly to the needs of the resource and driven by the management goals. Right now there is a research 'gold rush'...and that must stop. The permitting process must also be transparent, with adequate opportunity for public comment and a panel of scientists representing terrestrial wildlife, ecosystem science, coral reefs, sea birds, and marine mammals." In addition, Smith wants to make sure that management agencies receive the funding necessary for effective management. Congress, which was not consulted on designation of the national monument, will have oversight of its funding.

Norse of MCBI says adequate funding will be especially critical for enforcement. Poaching of sharks in other remote protected

areas of the Pacific, such as Bikini Atoll in the Marshall Islands, has occurred in recent years. "I would like to see adequate funds established to provide Coast Guard spot checks of the protected area and pass-overs by satellites," he says. "I would love for there to be some creative thinking about real-time ways we could monitor movement of vessels throughout. Vessel monitoring systems (which are now required for vessels entering the national monument) are not enough, as they only monitor the vessels that obey the law to carry them." Without adequate enforcement, says Norse, the relatively pristine archipelago "will be like a supermarket with the doors open 24 hours a day and no personnel and no cameras."

Rick Gaffney, president of the Hawai'i Fishing and Boating Association, is also concerned about funding. His organization supported strict protection for the archipelago despite the fact it would limit activities of its members — recreational fishermen. "There appears to be no money attached to the proclamation," says Gaffney. "Enforcement will be very expensive, and the Coast Guard has already been scaling back its activity in the region for funding reasons."

There is concern among some environmental advocates over a provision in the proclamation to allow "sustenance fishing" there by permit. The term — not to be confused with "subsistence fishing", which is often allowed for local and indigenous groups in MPAs worldwide — is defined as allowing for the capture and consumption of fish within the monument as long as it is incidental to an otherwise-permitted activity, such as research. "It's not clear who this is meant to sustain," says Norse. "The definition of research can be so broad that presumably a ship full of tourists could be dubbed

'researchers' and they could go sustenance-fishing."

As acting superintendent of the NWHI Marine National Monument, Aulani Wilhelm will oversee the application of such terms, and says data will be kept to ensure that any sustenance fishing — or other activity — does not harm the ecosystem. "The biggest challenge we face in managing and enforcing the marine national monument is making sure that our efforts will be sufficient to implement the proclamation provisions and ensure a protection regime worthy of this special place," says Wilhelm. "NOAA, along with the US Fish and Wildlife Service and the State of Hawai'i, is charged to develop a strong and coordinated management regime to cooperatively manage the area in a way that is unparalleled elsewhere in the US. Given the strong conservation provisions, relatively remote location, and enormous size of the monument, obtaining the resources and funding necessary to study, manage, monitor, and enforce the area will continue to be a challenge every year."

Source: *MPA News*, vol. 8, no. 1 (July 2006)



## ■ RESTAURANT SEAFOOD PRICES SINCE 1850s HELP PLOT MARINE HARVESTS THROUGH HISTORY

Seafood prices collected from US restaurant menus dating to the 1850s will help plot the shifting harvest of marine species, according to a study to be announced at Oceans Past a Census of Marine Life conference in Denmark on the History of Marine Animal Populations.

Led by paleoceanographer Glenn Jones at Texas A&M University at Galveston (USA), researchers are charting over 150 years of inflation-adjusted seafood prices from menus, most from cities such as New York, Boston and San Francisco. The menus shed light on shifting tastes for and supplies of such popular seafood as lobster, swordfish, abalone, oysters, halibut, haddock and sole.

Though still at an early stage, the research already shows a dramatic rise in the price of abalone coincident with the collapse of stocks along the California coast.

San Francisco menus, which started to feature the slow-growing mollusc in the 1920s, document that the inflation-adjusted

price of an abalone meal held steady at about USD 7 (in 2004 currency) for roughly 20 years.

The price spiked sharply in the 1930s as the species was overharvested and again in the 1950s, since which time the price has risen 7 to 10 times faster than inflation. California banned commercial abalone fishing in 1997 and most supplies in state restaurants today are imported from Australia and New Zealand, priced on menus at USD 50–70.

Similarly, the restaurant price of lobster has tracked its fluctuating abundance and popularity over the decades, according to Dr Jones.

"Prior to the 1880s, it was unusual to see lobster on menus at all except in bargain-priced lobster salad," he says. "It was considered a trash fish no one wanted — it was not something you'd want to be seen eating. In fact, in Colonial America, servants negotiated agreements that they not be forced to eat lobster more than twice a week."

Tastes started to change in the 1880s, with lobsters even appearing on menu covers. The 1930s saw prices fall with the Great Depression, but they ballooned in the 1950s, with restaurants pricing lobsters at one-quarter pound (113 g) weight increments, another reflection of declining supplies, says Dr Jones.

"It's interesting on menus today to see the appearance of four and five pound (1.8 to 2.3 kg) lobsters," he notes. "There is little chance those are coming from the inshore fisheries, which are so heavily fished a lobster is sent to market as soon as it's up to weight. What it indicates to me is the opening up of new deep areas on the outer continental shelf, 200 miles (322 km) offshore."

Among other observations gained from the archived menus: oyster prices remained relatively flat for some 100 years, then climbed at twice the inflation rate starting in the 1950s.

And the price of a wild canvas-back duck meal rose from today's equivalent of USD 20 in



Postcard of abalone shells in Santa Barbara, California circa 1920.



the 1860s to USD 100 in 1910 as stocks collapsed. Professional hunters harvested up to 1000 per day to supply restaurants, says Dr Jones, fostering the federal government's decision to outlaw the commercial slaughter of migratory birds in 1913.

"As supplies dropped and prices rose, some of these species became a status symbol. It seems to confirm that many people simply want to eat something that is rare."

Some 200,000 restaurant menus have been uncovered by the research team in various archives, primarily in New England. Of these, many are banquet menus showing only the food served; Dr Jones estimates just 10,000 include the date, city and prices.

Yet to be done is a sorting of five-star versus two-star restaurants, which Dr Jones says will narrow the price spread in a given year but will not diminish the trends seen overall (plotted

on several preliminary charts, appended). "When you think about it, a menu was a piece of ephemera; it wasn't meant to be saved but thankfully some people collected them. We believe this is the first time anyone has tried to work with this trove of historical information."

(Source: *National Fisherman*,  
December 2005  
[www.nationalfisherman.com](http://www.nationalfisherman.com))



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# HOOKS USED IN LONGLINE FISHING

A fish hook is a seemingly simple thing but it does have discernable parts. The Mustad website (<http://www.mustad.no/about/hooks/index.php>) describes a typical hook as having an eye, shank, bend, bite/throat, a point and barb, and a gape (sometimes called gap). Four different dimensions are given in Figure 1: total length, front length, gape, and bite/throat. According to Mustad, the most important of these are the size of the gape and the size of the bite/throat. Nothing, however, in the Mustad hook size numbering system readily appears to correspond to these dimensions. In fact, they report there is no uniform system of hook measurements.

## FISH HOOK NUMBERING SYSTEMS

Mustad hooks, as well as most hooks manufactured in Europe or the United States, come in a range of sizes from 22 (the smallest) to 20/0 (the largest).

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*Fisheries Development Officer*  
**SPC, Noumea**  
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**([SteveB@spc.int](mailto:SteveB@spc.int))**

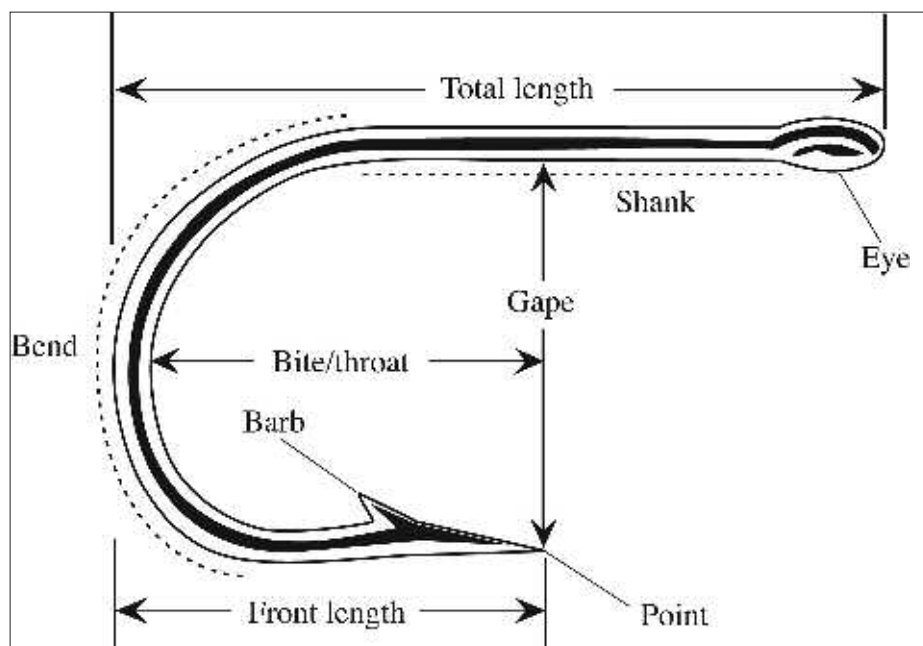
Small hooks are numbered in a descending order so a #21 is bigger than a #22, a #20 is bigger than a #21, and so on right up to a #1 which is the biggest small hook. Large hooks are numbered in an ascending order starting with the smallest, 1/0, and going to the largest, 20/0. Not every hook style is available in the full range of sizes from 22 to 20/0, however. Furthermore, there is little consistency in methods for applying this ranking system in the profusion of fishing gear catalogues. A 10/0 hook made by one company may not correspond in actual size to a 10/0 hook made by another. Generally, the 22 to 20/0 system is just a ranking system and has

little to do with actual hook dimensions. There are exceptions to this, however (see discussion below on circle hooks).

## HOOKS USED IN PELAGIC LONGLINE FISHING

### Japan tuna hooks

Basically there are three kinds of hooks used in pelagic longline fishing: Japan tuna hooks, circle hooks, and J hooks (Beverly et al. 2003). Japan tuna hooks (Fig. 2) have been the most popular for years, especially with tuna longliners. They come in a variety of sizes but are usually described by a Japanese measurement called sun, which is about 3.3 cm (OFCF 1993) and is used to measure the length of the hook. A 3.4 sun hook, for example, is 3.4 sun x 3.3 cm/sun long. In other words, a 3.4 sun hook is 11.2 cm long. This is the entire length of the wire making up the hook from the eye to the tip of the point (not to be confused with total length in Fig. 1). This measurement says nothing about the shape of the hook or the size of the bite/throat or gape, however. The most popu-



**Figure 1: Hook anatomy from Mustad website**  
(<http://www.mustad.no/about/hooks/index.php>)

lar sizes of Japan tuna hooks for longlining are 3.4, 3.6, and 3.8 sun. Japan tuna hooks come either with a ring or without a ring in the eye. The most popular hook for tuna longlining is a 3.6 sun stainless steel Japan tuna hook with ring.

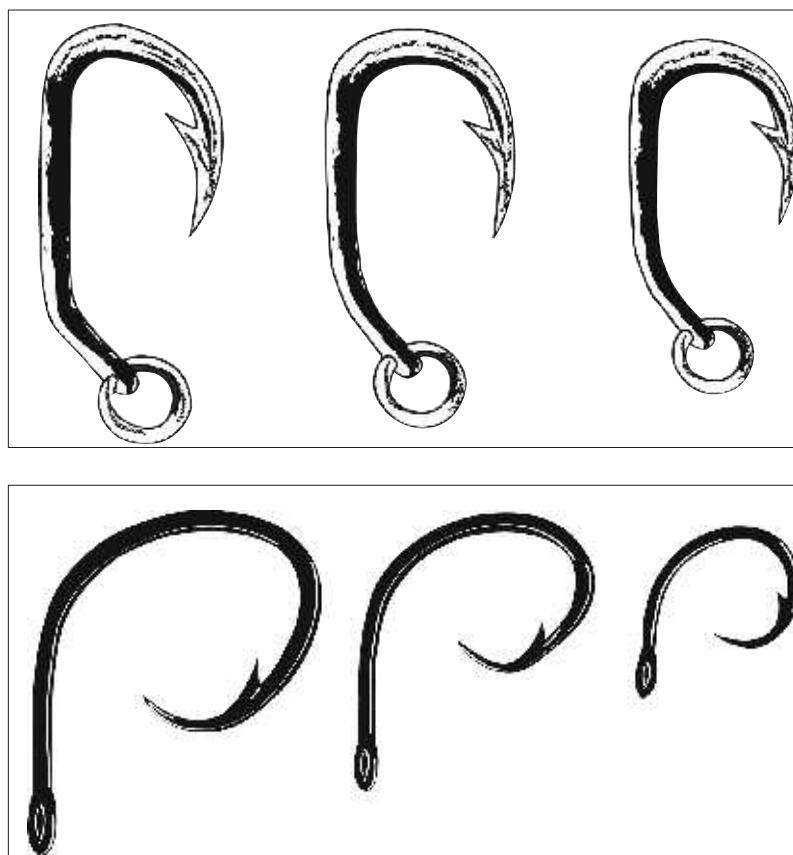
### Circle hooks

Circle hooks (Fig. 3) are also called G hooks or tuna circle hooks, and are generally measured the same way that Japan tuna hooks are measured. Japanese made circle hooks used in longline fishing generally come in sizes ranging from 4.2 sun to 5.5 sun. Again, the number refers to the entire length of wire making up the hook from the eye to the point, just as with the Japan tuna hook. Most Western made circle hooks are numbered and measured in a similar way. The difference is that the numbers refer to centimetres, not sun. Thus, an 18/0 circle hook measures 18 cm from the eye to the tip of the point. This is equal to a 5.5 sun Japanese made circle hook (conversely, a 3.4 sun Japan tuna hook would be an 11/0 in the Western system). Some manufacturers, however, use a completely different numbering system for circle hooks. Tankichi and Maruto brand hooks, for example, are numbered from 28 to 44 (POP 2004). Table 1 compares Western and Japanese circle hook sizes. Circle hooks are commonly used for fisheries other than pelagic longline, such as deep water snapper fishing. They are popular because of their rotating effect, which makes them self setting. In fact, circle hooks are also called rotat-

ing hooks. When a fish bites and applies pressure, the circle hook rotates and sets itself. Sizes for circle hooks generally range from 8/0 to 16/0 but recently, larger sizes such as 18/0 and even 20/0 have been available. The most popular sizes for longline fishing range from 14/0 to 18/0. Circle hooks do not usually come with rings. A good discussion of circle hooks can be found in ASMFC (2003).

### J hooks

J hooks are very similar to big game trolling hooks used to catch marlin and other big game fish species (Fig. 4). J hooks come in sizes ranging from 1/0 to 12/0, and are usually associated with longline fishing for swordfish. The most common sizes of J hooks used for swordfish are 8/0 and 9/0. A 9/0 J hook measures 15 cm from the eye to the point so it is not easy



**Figure 2 (top):** Japan tuna hooks with ring from Hi-fishing Tackle Company website ([http://www.hi-fishing.com/tuna\\_fr.htm](http://www.hi-fishing.com/tuna_fr.htm)). Hooks not drawn to scale

**Figure 3 (bottom):** Circle hooks from Mustad website (<http://www.mustad.no/abouthooks/index.php>). Hooks not drawn to scale

**Table 1. Comparison of Western circle hook sizes with Japanese circle hook sizes.**

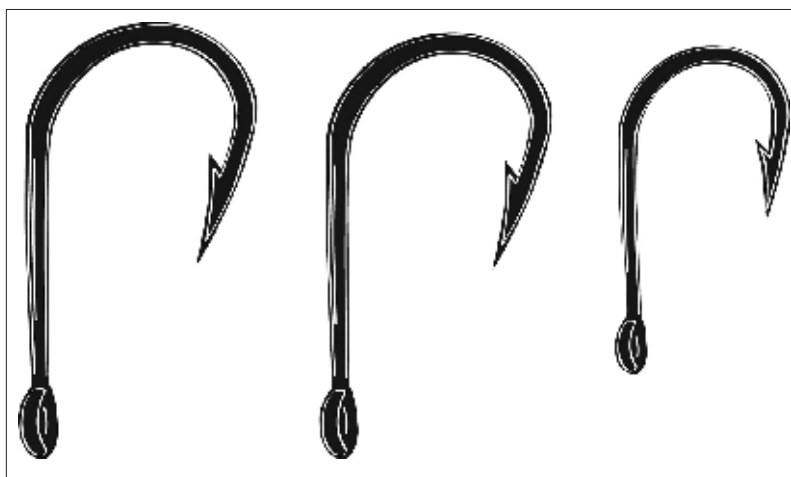
Western circle hook (cm)	Japanese circle hook (sun )	Tankichi and Maruto
12/0	3.6	28
14/0	4.2	36
16/0	4.8	44
18/0	5.5	na



to compare numbers for J hooks with other hook designs. A 9/0 J hook, in fact, is similar in size to a 16/0 circle hook. Swordfish fishermen prefer J hooks because swordfish have a soft lower jaw. The jaw is easily torn, causing loss of the fish. J hooks tend to hold better than other hooks in a swordfish mouth (Beverly et al. 2003). They also have a better chance of hooking the hard bill of the swordfish because of their straight shape. The main feature of a J hook that makes it different from Japan hooks or circle hooks is that the barbed point is almost parallel to the shank of the hook. With Japan tuna hooks, the shank is bent towards the tip of the hook while circle hooks have a point that is bent until it almost points directly at the shank at a 90° angle. What this means is, of the three hook designs, the J hook has the largest gape. This could be one of the reasons that J hooks are implicated in higher turtle bycatch rates than the other hook designs.

#### HOOKS AND BYCATCH

Hook types in longline fisheries have received attention recently because of the problem of sea turtle bycatch. It has been found that using 18/0 circle hooks with mackerel bait can reduce the bycatch of turtles while maintaining the catch of tunas and swordfish (Watson et al. 2005). Notwithstanding all that has been said about hook parts and dimensions, however, the most important hook dimension in regards to turtle bycatch is probably none of the dimensions listed in Figure 1. The US National Oceanic and Atmospheric Administration has determined, in a study using captive loggerhead turtles, that the overall (narrowest) width of the hook is the most important measurement because it is what determines whether or not a turtle can swallow the baited hook

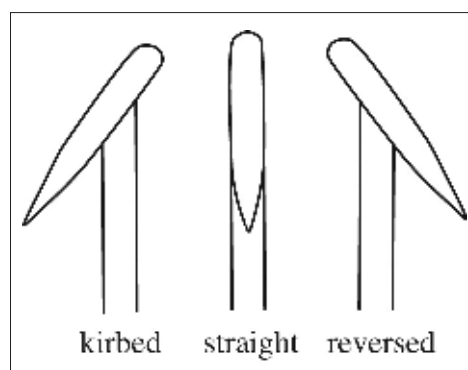


**Figure 4: J hooks from Mustad website**  
(<http://www.mustad.no/abouthooks/index.php>).  
*Hooks not drawn to scale*

(Watson et al. 2003). The study concluded that using hooks larger than 51 mm in width has the potential to significantly reduce post-capture mortality of loggerheads incidentally captured on longlines. A 16/0 circle hook, for example, has a width of 51 mm while a 9/0 J hook (which is similar in size to 16/0 circle hook) has a width of only 41 mm. Just based on this one reference point, the 16/0 circle hook would be preferable to the 9/0 J hook for reducing post-capture mortality of sea turtles.

Another confounding factor with hooks is the fact that they can be either offset or non-offset. With non-offset hooks (straight), the point lies in the same plane as the shank of the hook. With offset hooks, the point is bent away from the plane of the shank by anywhere from 5–25°. If the point is offset to the left, the hook is kirbed. If the point is offset to the right, the hook is reversed (Fig. 5). Japan tuna hooks, for example, typically have a 10–20° (kirbed) offset. Circle hooks and J hooks, however, can be either offset or non-offset. Both offset and non-offset hooks

have been tested in regards to turtle bycatch rates in pelagic longline fishing, and some issues have been raised. There are implications for acceptability by fishermen. For example, fishermen found it difficult to thread bait on non-offset circle hooks in one study (Watson et al. 2005). There are also possible implications with respect to the effects on target species and bycatch species catch rates, and on post-capture injury and mortality rates of turtles. Another complication is that before about 1995, longline hooks were available only in galvanised high carbon steel. Now they are available in stainless steel as



**Figure 5: Offset (kirbed and reversed) and non-offset hook points, from In-Fisherman website**  
([http://www.in-fisherman.com/magazine/exclusives/IFM0502\\_AboutHooks/](http://www.in-fisherman.com/magazine/exclusives/IFM0502_AboutHooks/))

well. This means that they last longer, especially when coming into contact during storage with other fishing gear such as the stainless steel snaps used on the branchlines (with two similar metals there is no galvanic reaction and, thus, less corrosion); but this also has implications for bycatch post-capture mortality. Stainless steel may last longer than galvanised steel in a turtle's mouth or esophagus. In fact, stainless steel hooks are not allowed in the US Atlantic swordfish fishery (Federal Register 2004).

Further research is being carried out in Hawaii and in Australia, comparing circle hooks with J hooks and Japan tuna hooks in tuna and swordfish longline fisheries. It well may be that this inexpensive and low tech solution to bycatch in the longline fisheries will be adapted on a wider scale. Any solution to bycatch in fisheries has to fulfill these simple criteria: be simple to implement, be inexpensive, contribute to lower bycatch rates, increase or not change target species catch rates, and be sustainable. So far the circle hook has met or surpassed all of

these criteria, at least in swordfish fisheries. The Japan tuna hook probably still has a place in deep-set tuna longline fisheries and the J hook probably still has a place in troll fisheries for large tuna and other game fish such as marlin. The J hook, however, has most likely seen its last days as a longline hook."

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# GENERAL BATHYMETRY OF THE PACIFIC OCEAN

Because of the increasing pressure on sedentary marine species — both in coastal areas and offshore seamounts — there is an increasing need for mapping the potential habitat of these resources so that fisheries managers and decision makers can make informed decisions about coastal resources.

Contrary to land resources, which can be mapped using satellite products, the marine environment is more difficult to map because water absorbs visible light and radar frequencies very quickly, and the ocean is basically opaque from the sky for depths beyond 50 m, even using airborne Lidar (laser bathymetry).

## TRADITIONAL OCEANOGRAPHIC SURVEYS

High-resolution mapping of the ocean floor requires expensive equipment (multi-beam and side-scan sonars), operated from oceanographic ships with high operational costs. For these reasons, direct ocean floor mapping is very limited, and traditional marine charts can miss important relief features outside the areas surveyed by hydrographic ships.

Figure 1 depicts the sounding lines used to produce the marine chart NZ14606. It shows that some areas have been intensively surveyed, such as the Tonga Trench or Savannah seamount chain (French Polynesia), whereas there is much less information for the Cook Islands or Line Islands (Kiribati). This is not necessarily a problem when the area is a large abyssal plain, but it does not allow the systematic inventory of underwater features such as seamounts and ridges.

On a global scale, the International Hydrographic Organization (IHO) and the Intergovernmental

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Oceanic Commission (IOC) of UNESCO digitised available marine charts (contour and track lines based on soundings, coast-lines) to produce a global 1-minute bathymetric grid known as the General Bathymetric Chart of the Oceans (GEBCO). Because it was produced from marine charts, this grid will not provide more information than paper charts, but it is a convenient global digital grid of ocean bathymetry.

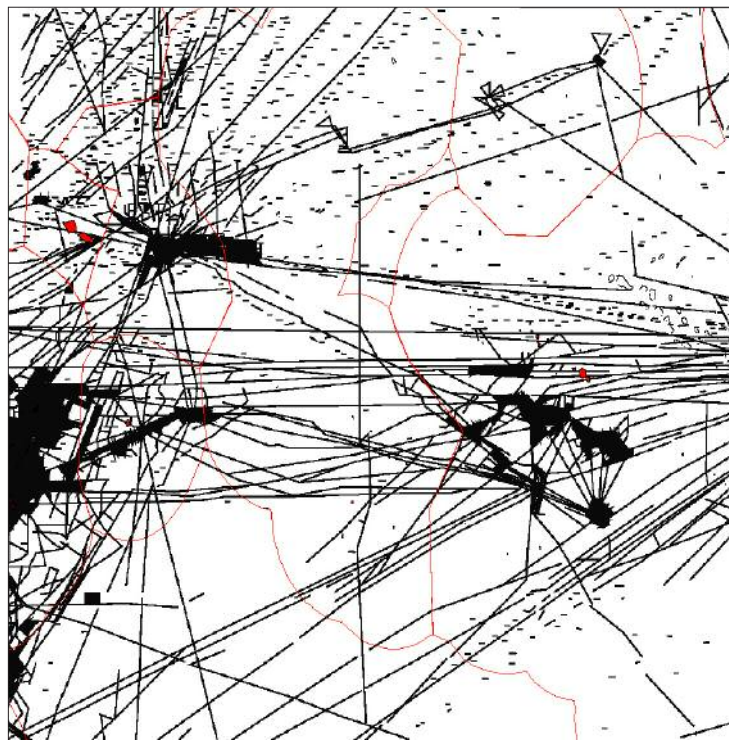
## PREDICTED BATHYMETRY

Because mapping the ocean floor is difficult and onerous,

oceanographic surveys target areas of interest such as trenches, ridges and seamounts. But it means the existence of these features must be known prior to the survey planning and it requires baseline information on the probable location of unsurveyed underwater features.

In June 1995, the US Navy declassified Geosat altimeter data (height of the sea surface) which, combined with ERS-1 radar data, allowed Smith and Sandwell (1994) to derive a map of marine gravity anomalies used later to predict the seafloor depth between the surveyed bathymetry tracks. In 1997, the authors produced a two-minute global map of predicted seafloor topography for latitudes between 72°S and 72°N (Sandwell and Smith 1997).

This initial work was later refined and several derived products are now available to the general public, combining the predicted bathymetry with other sources of information



**Figure 1: Diagram of sounding line density of chart NZ14606 and Pacific Island EEZs**



such as GEBCO or Shuttle Radar Topography Mission (SRTM) elevation data, and with various grid sampling (from 30 seconds to 5 minutes).

While Etopo2 is certainly the best known global seafloor predicted bathymetry product, the original Smith and Sandwell (S&S) data were slightly mis-registered in latitude and longitude when the grid was produced (Marks and Smith 2004), and this shift is apparent when comparing the predicted bathymetry with sonar data (see Figs 3 and 4 on p. 52), or when displaying atoll coastlines produced from Landsat 7 ETM+ (visible and infrared) or SRTM elevation data on top of shaded bathymetric data. Note that predicted bathymetry matches here the sonar data because the very same sonar data were used to produce the grid (and interpolated using gravity anomaly data).

The newer S2004 bathymetric grid produced by Walter Smith from the S&S data and blended with the GEBCO data is properly registered. It uses GEBCO data for depths shallower than 200 m, and a blend of the two datasets between 200 and 1000 m. That mitigates the fact that predicted bathymetry is less reliable for shallow water and the resultant grid is the best global bathymetric grid available at the moment (see Table 1).

The shaded bathymetry produced from S2004 for each country can be found on the SPC PROCFish Portal in the GIS repository<sup>1</sup>.

#### INVENTORY OF SEAMOUNTS

The availability of global bathymetric grids made it possible to conduct a systematic inven-

tory of potential seamounts using a filter that detects peaks and searches for local rises of 1000 m or more from the seabed. Kitchingman and Lai (2004) used the Global Digital Elevation Model (Etopo2) grid and identified between 14,000 and 32,000 potential locations of seamounts, Wessel (2001) used the S&S grid to extract around 15,000 seamounts locations for the whole world.

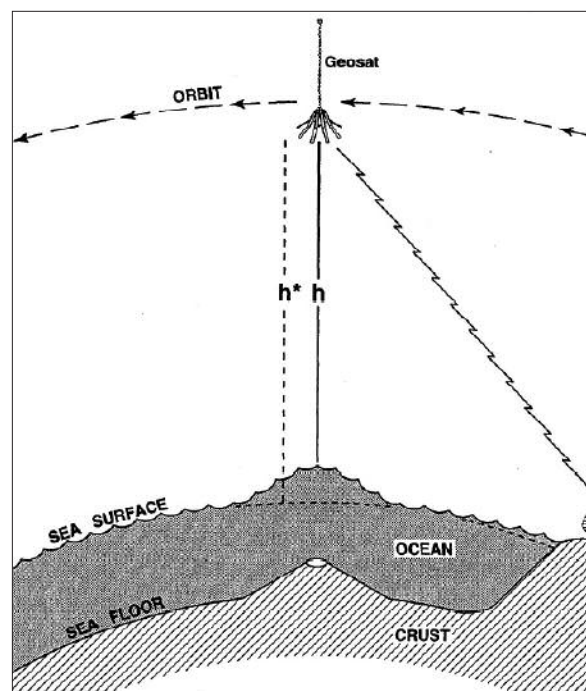
The methodology (filter and thresholds) and source data grid used for the inventory of these potential seamounts have a significant impact on the results and their usability. Because the Etopo2 grid is mis-registered, so are potential seamounts (the distance between Wessel and Kitchingman seamounts can be up to 10 km).

Moreover, predicted bathymetry is less reliable in areas shallower than 200 m, around land masses, and is averaged because of the initial S&S two-minute resolution. As a conse-

quence, atolls are often falsely detected as one or more seamounts, as depicted in Figure 5 on p. 52. Screening and cleaning of this data are currently undertaken by the Pacific Islands Oceanic Fisheries Management project (SPC Oceanic Fisheries Programme/ GEF).

#### HIGH-RESOLUTION MAPPING OF SEAMOUNTS

Once seamounts and other underwater features are identified, either from previous hydrographic surveys or using



**Figure 2: Satellite altimetry used produce gravity anomaly grid (reproduced from Sandwell and Smith 1997)**

**Table 1 Bathymetric grids and source data**

Grid	Resolution	Source	Comments
Etopo2	2 minutes	S&S, IBCAO, DBDBV, GLOBE	Mis-registration in latitude and longitude
GINA	30 seconds	S&S, IBCAO, GTOPO30	Correctly registered but smoothing effect observed (Marks and Smith 2004)
GEBCO	1 minute	Charts contour lines	Chart accuracy, smoothing effect
S2004	1 minute	S&S, GEBCO	Correctly registered
IBCAO:	International Bathymetric Chart of the Arctic Ocean		
DBDBV:	Digital Bathymetric Data Base - Variable Resolution		
GTOPO30:	Global 30 Arc-Second Elevation Data Set		
Globe:	Global Land One-kilometer Base Elevation		

<sup>1</sup> [http://www.spc.int/coastfish/sections/reef/PROCFish\\_Web](http://www.spc.int/coastfish/sections/reef/PROCFish_Web)

predicted bathymetry, they can be fully mapped by oceanographic vessels using multi-beam and side-scan sonars. Figure 6 (p. 52) shows the Capricorn Seamount as displayed with a one-minute resolution (S2004 grid) and with a 200 m resolution (multibeam data).

While the multibeam sonar captures bathymetry, a side-scan sonar captures texture and morphology. The side-scan sonar reflects the type of substrate and habitability of the area for deep bottom fish species and, when available, can be mapped on top of the bathymetry on a three-dimensional model.

High-resolution data for seamounts that have already been mapped is generally available from the Internet, in particular from the Seamount Catalog of the Seamount Biogeosciences Network (<http://earthref.org>), from where it is possible to download multibeam data, mixed with predicted bathymetry. On the PROCFish portal, there is a MapInfo file with the location of seamounts referenced in the catalog with direct links to the seamount pages.

The linkage between the deep bottom fish resources and seamounts is currently a research topic and is one of the topics of the Marine Geological Habitat Mapping (GeoHab)2007 conference that will be held in New Caledonia in 2007.

## CONCLUSION

While only a small part of the Pacific Ocean has been thoroughly mapped by oceanographic vessels, predicted bathymetry is available globally and allows the localisation of underwater features such as seamounts, which can be surveyed in detail at a later time using multibeam and side-scan sonars. Yet some caution is necessary when using S&S-derived products because of

the mis-registration observed in some products and because of the limited resolution of these grids.

Figure 7 summarises the various bathymetric grids and datasets cited in this article and indicates how they are related.

A future article will examine methods that can be used to produce shallow water bathymetry maps (between 0 and 50 m).

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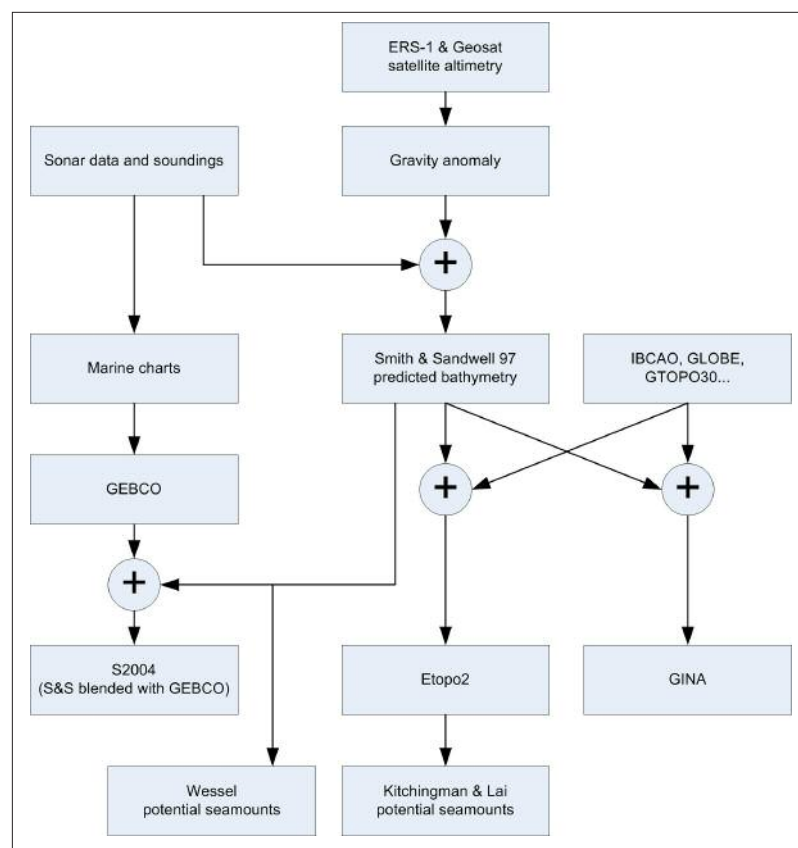
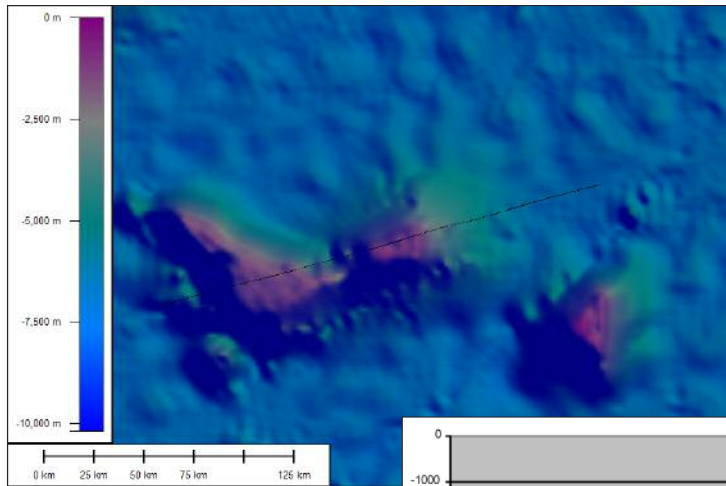
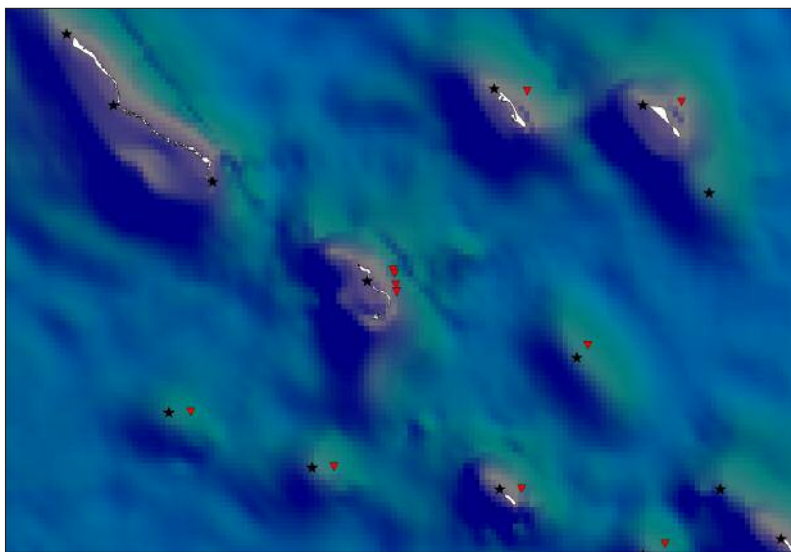
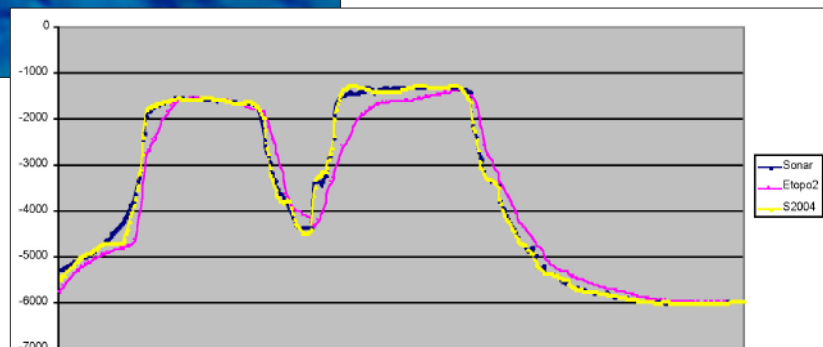


Figure 7: Datasets and their relationships

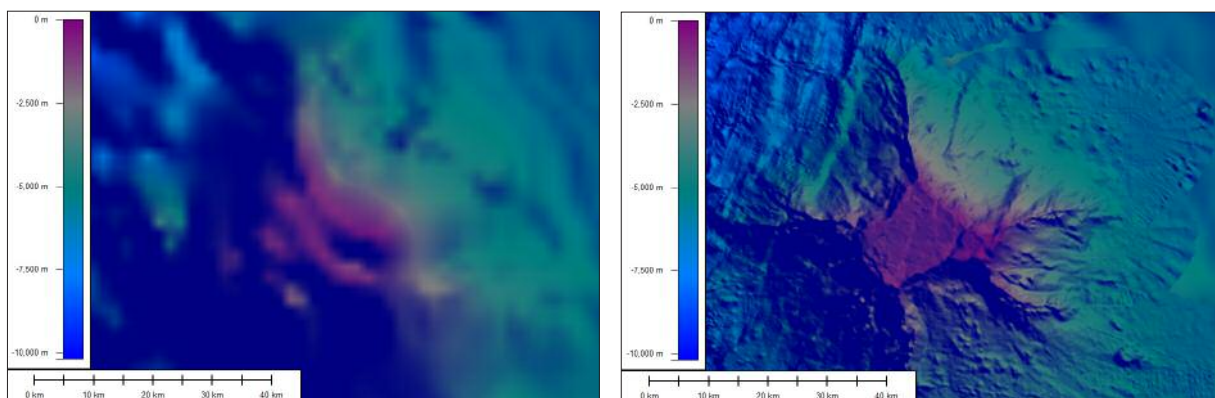


**Figure 3: S2004 shaded relief and sonar sounding points from NOAA's National Geophysical Data Center**

**Figure 4: Extraction of Etopo2 and S2004 values with corresponding sonar data along the transect shown in Figure 3**



**Figure 5: Kitchingman (triangles) and Wessel (stars) potential seamount locations**



**Figure 6 Shaded relief of Capricorn Seamount near Tonga trench at one-minute (S2004) and 200 m (sonar) resolution**