



Fisheries

Newsletter

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Editorial

Welcome to this issue of the *Fisheries Newsletter*. During this quarter, the first regular session of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPO) was held at SPC headquarters. The new Commission was established by the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the WCPO. The objective of the Convention is to ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the WCPO. Readers will find in this issue an overview of the tuna fisheries in the WCPO in 2004.

The new EU-funded Development of Tuna Fisheries in Pacific-ACP countries has started with the recruitment of Mr Jonathan Manieva, a citizen of Papua New Guinea. Jonathan's main task will be to assist in the establishment or enhancement of tuna fisheries associations in the 14 Pacific ACP countries.

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Jonathan Manieva is the new Fisheries Development Officer under the EU-funded Development of Tuna Fisheries in Pacific-ACP countries (DEVFish).



SECRETARIAT OF THE PACIFIC COMMUNITY

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■ FIRST REGULAR SESSION OF THE WCPFC SCIENTIFIC COMMITTEE

The first regular session of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPFC-SC 1) was held at SPC headquarters in Noumea, New Caledonia, from 8 to 19 August 2005.

Approximately 100 fishery scientists from coastal states and territories in the region and from major fishing countries, including Japan, Korea, Chinese Taipei, China, Indonesia, the Philippines, Canada, the European Union and the USA met to discuss the current status of the region's fisheries.

The new Commission's aim is to ensure the long-term conservation and sustainable use of the region's migratory fish stocks through effective management. The main goal of the meeting was to provide scientific advice to the Commission on the status of tuna stocks and bycatch species. The Commission was established by the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, which was agreed to by Pacific Island countries (among others) in 2000, entering into force in June 2004.

The matters considered by the Scientific Committee (SC) and its specialist working groups included:

- a review of the fisheries in the Convention area;
- a review of updated stock assessments

for the major target species (bigeye, yellowfin, skipjack, and South Pacific albacore, including implications for sustainability;

- scientific analyses requested by the Commission at its first meeting;
- data requirements of the Commission for scientific purposes;
- interaction and cooperation with the Technical and Compliance Committee (TCC);
- future work programme for the SC;
- special requirements of small island developing states and territories;
- budget and finance requirements for future SC work of the;
- future operation and administration of the SC; and
- cooperation with other relevant organisations.

During the course of the meeting, several working papers were presented, including one on the "Overview of Tuna Fisheries in the Western and Central Pacific Ocean", which also discussed the economic condition of the fishery. This paper is reproduced below

OVERVIEW OF WESTERN AND CENTRAL PACIFIC OCEAN FISHERIES

General overview

The provisional total Western Central Pacific – Convention area (WCP-CA) catch of tunas during 2004 was estimated at 2,021,773 mt, the highest annual catch recorded (the previous record was in 1998 at 2,009,546 mt) (Fig. 1). During 2004, the purse-seine fishery accounted for an estimated 1,263,161 mt (62% of the total catch — the highest catch ever for this fishery), with pole-and-line taking an estimated 297,515 mt (15%), the longline fishery an estimated 225,786 mt (11%), and the remainder (11%) taken by troll gear and a variety of artisanal

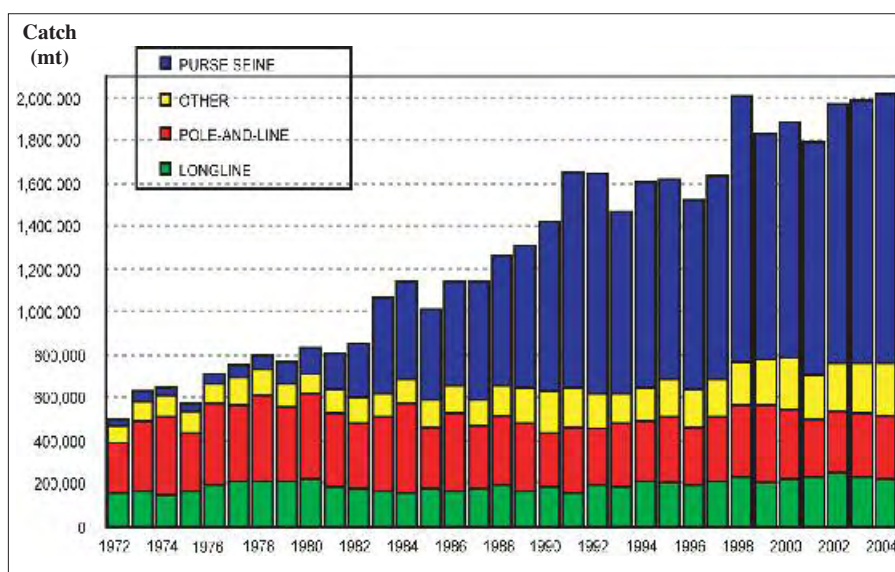


Figure 1. Catch (mt) of albacore, bigeye, skipjack and yellowfin in the WCP-CA, by longline, pole-and-line, purse seine and other gear types.

gear types, mostly in eastern Indonesia and the Philippines.

The WCP-CA tuna catch (2,021,773 mt) for 2004 represented 78% of the total Pacific Ocean catch of 2,582,774 mt, and 51% of the global tuna catch (the provisional estimate for 2004 is just under 4,000,000 mt).

The 2004 WCP-CA catch of skipjack (1,376,670 mt) and the proportion of skipjack in the total WCP-CA catch for 2004 (68%) were the highest ever. In contrast, the WCP-CA yellowfin catch for 2004 (413,201 mt; 20%) was relatively low compared with recent years. The WCP-CA bigeye catch for 2004 (125,940 mt; 6%) was the second highest on record, and the WCP-CA albacore (105,962 mt; 5%) catch was the lowest for four years.

The provisional 2004 purse-seine catch of 1,263,161 mt was the highest on record and maintained the catch in excess of 1,200,000 mt for the past three years.

The purse-seine skipjack catch for 2004 (1,059,061 mt; 84%) was the highest on record, although the yellowfin catch for 2004 (179,310 mt; 14%) was the lowest since 1996. The estimated

purse-seine bigeye catch for 2004 (24,790 mt; 2%) continues the declining trend in catches since the record 1999 catch (38,327 mt), primarily due to the gradual reduction in fishing effort on drifting FADs over recent years.

The purse-seine skipjack catch for 2003 (937,929 mt; 80%) was 34,000 mt less than the record for this fishery (in 2002, 971,849 mt). The purse-seine yellowfin catch for 2003 (214,535 mt; 18%) rebounded from relatively poor catches experienced in 2002 (only 174,366 mt). The estimated purse-seine bigeye catch for 2003 (20,316 mt; 2%) continues the declining trend in catches since the record 1999 catch (34,634 mt), primarily due to the gradual reduction in fishing effort on drifting FADs over recent years (Fig. 2).

The 2004 total catch for the main purse-seine fleets (FSM Arrangement, Japan, Korea, Chinese Taipei and USA — approximately 800,000 mt) was slightly higher than in 2003, but more than 50,000 mt less than in 2002. Chinese Taipei has been the highest producer in the tropical purse-seine fishery since 1996. The 2004 provisional catch estimate (198,240 mt) for this fleet

was similar to the level taken in 2003, but less than 50,000 mt compared with 2002, mainly due to several vessels changing flag at the end of 2002. Catches by the Japanese and Korean purse-seine fleets have been stable for most of this time series.

The number of Pacific Island domestic fishing vessels continued to grow in 2004 and is now at its highest level ever; this category is made up of vessels fishing under the FSM Arrangement and domestically-based purse-seine vessels operating in PNG and Solomon Islands waters. The FSM Arrangement fleet fish over a broad area of the tropical WCP-CA. The increase in annual catch by this fleet since 2000 corresponds to the increase in vessel numbers, and coincidentally, mirrors the decline in US purse-seine catch and vessel numbers over this period.

As in recent years, the Korean purse-seine fleet continued to concentrate on un-associated, free-swimming schools during 2004 (around 60% of all sets by this fleet). In contrast, log sets were the most predominant set type used by the Japanese, FSM Arrangement and Chinese Taipei fleets during 2004, and drifting FAD sets for the US purse-seine fleet. During 2004, the total number of associated sets (log and FAD sets) in the WCP-CA purse-seine fishery exceeded the number of un-associated sets for the first time since 1999. The increase in associated sets is typical of El Niño years, when natural floating objects (i.e. logs) are more prevalent and tuna schools associated with floating objects appear to be more available to the purse-seine gear.

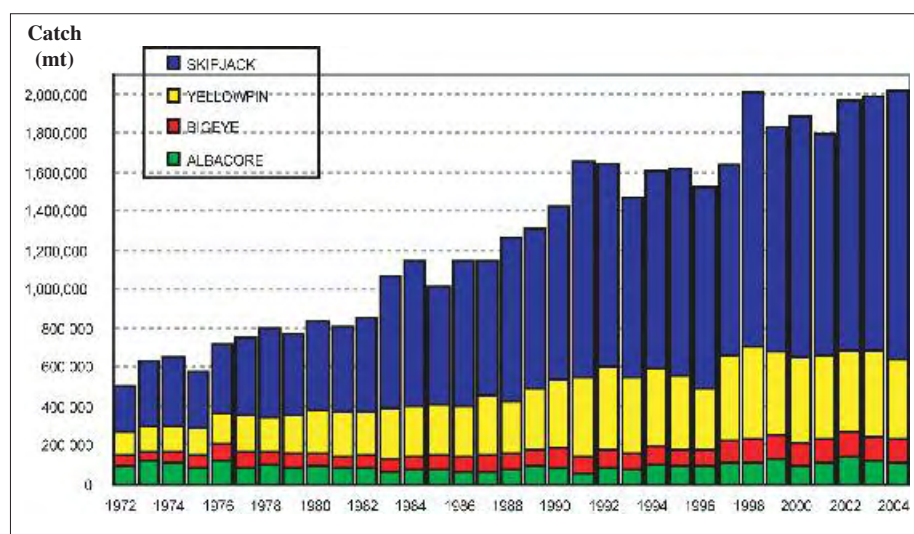


Figure 2. Catch (mt) of albacore, bigeye, skipjack and yellowfin in the WCP-CA.

The ENSO-neutral state of 2003 continued into the first half of 2004 in WCP-CA and then moved to a weak El Niño state in the second half of 2004. There was a significant westward shift in purse-seine effort during 2003 (compared with previous years) and fishing activity was again concentrated in western areas (Papua New Guinea, Federated States of Micronesia and the Solomon Islands) during 2004. Fishing activity in the first quarter of 2005 remained concentrated in this area with no significant change from the ENSO-neutral state as yet observed.

The 2004 skipjack CPUE for un-associated sets for all of the major fleets was clearly lower than in recent years (the lowest in five years for the Korean and Chinese Taipei fleets). In contrast, the skipjack CPUE for associated sets for most fleets increased in 2004, and skipjack CPUE for all set types was therefore similar to the level in 2003. The exception was the US fleet, which experienced very low skipjack CPUE for drifting FAD sets, contributing to a drop in the overall skipjack CPUE for 2004.

Yellowfin CPUE for nearly all fleets and set types dropped in 2004, and was generally on a par with the 2002 level, which was acknowledged to be a year of unusually low yellowfin catches. The exception was the yellowfin CPUE for US fleet on drifting FAD sets, which was the highest for five years. This fleet fished in a different area (farther to the east and south) than the Asian fleets during 2004 and, for one reason or another, this resulted in a different species composition (i.e. skipjack to yellowfin) in the catch taken primarily from drifting FAD sets than that experienced by the Asian fleets.

The 2004 catch estimates for most pole-and-line fleets operating in the WCP-CA have yet

to be provided, although the total catch estimate is expected to be similar to the level of recent years (i.e. 270,000–300,000 mt). Skipjack tends to account for the vast majority of the catch (84% in 2003), while albacore, taken by the Japanese coastal and off-shore fleets in the temperate waters of the north Pacific (12% in 2003), yellowfin (4% in 2003) and a small component of big eye (1% in 2003) make up the remainder of the catch. The Japanese distant-water and off-shore (152,748 mt in 2003) and the Indonesian fleets (122,820 mt in 2003) typically account for most of the WCP-CA pole-and-line catch. The Solomon Islands fleet (10,797 mt in 2003) continues to recover from low catch levels experienced in recent years (only 2778 mt in 2000), but is still far from the level (of over 20,000 mt annually) experienced during the 1990s.

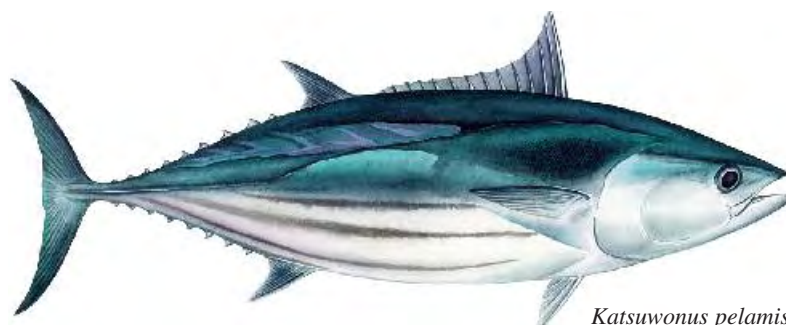
The provisional WCP-CA longline catch (225,786 mt) for 2004 was around 26,000 mt lower than the highest on record, which was attained in 2002 (231,968 mt). The WCP-CA albacore longline catch (65,865 mt; 30%) in 2004 was lower than in recent years, primarily due to a drop in catches by a number of key fleets. The provisional big-eye catch (84,394 mt; 37%) for 2004 was the second highest on record, and the yellowfin catch (70,757 mt; 31%) was the lowest since 1999. (The yellowfin catch (61,384 mt) in 1999 was the lowest for nearly 30 years, and is understood to be related to the age class showing poor recruit-

ment into the purse-seine fishery in 1996.)

The provisional 2004 troll albacore catch (4623 mt) was around 500 mt less than in 2003, although this will not be finalised until the US troll fleet catch for 2004 is made available. As has been the case in the past, the New Zealand (3373 mt) and USA (1205 mt in 2003) fleets account for most of the albacore troll catch, with minor contributions coming from the Canadian and Australian fleets.

Economic condition of the fishery

Bangkok skipjack prices remained volatile in 2004. The Bangkok price cost and freight (c&f) for 4–7.5 lb skipjack started the year at USD 820–850/mt and fell through most of the first quarter, stabilising at around USD 650/mt in mid-March. From this low, the Bangkok price then embarked on a rapid upward movement through to late August when it peaked at around USD 1170/mt, 80% higher than the mid-March level. According to Forum Fisheries Agency (FFA) data, at this level the price was the highest seen in six years. From mid-September through to end of 2004 the 4–7.5 lb price fell rapidly finishing the year marginally above its mid-March lows at around USD 680/mt. The average price for purse-seine caught skipjack at Yaizu over 2004 was JPY 93/kg (USD 862/mt), 14% higher (22% for USD prices) than the average price for 2003 of JPY 82/kg



Katsuwonus pelamis

(USD 708/mt). While Bangkok skipjack prices were volatile in 2004 the running 12-month average price of skipjack (4–7.5 lb, c&f) in Bangkok has been on a reasonably steady upward trend since mid-2003 when it stood at around USD 660/mt. In late 2004 the running 12-month average price of skipjack in Bangkok had risen to USD 890/mt and continued to rise through to mid-2005 reaching around USD 910/mt in May/June, its highest level since March 1999.

Yellowfin (for canning) prices in Bangkok rose significantly in the first half of 2004. The Bangkok price (c&f) for fish weighing 20 lb and more rose from USD 970–1000/mt in early January to USD 1450–1500/mt in late June. According to FFA data, the Bangkok price from late June to early August of USD 1450–1500/mt was the highest seen since March 1998. From August to November prices declined before increasing marginally in December but finished the year at significantly higher levels than at the start of the year. The Bangkok price for fish weighing 20 lb and more at the end of December was USD 1250/mt. Over 2004 the average Yaizu price for purse-seine caught yellowfin was JPY 142/kg (USD 1313/mt) down 14% (8% in USD terms) on 2003. After declining throughout much of the second half of 2003 and first of half of 2004 — the first time a prolonged decline has been seen since prices reached decade lows in May

2000 — the 12-month moving average price of Bangkok yellowfin (20 lb and more) trended up throughout the last three quarters of 2004 and the first half of 2005. The 12-month moving average price as at June 2005 stood at around USD 1370/mt the highest level seen since September 1998.

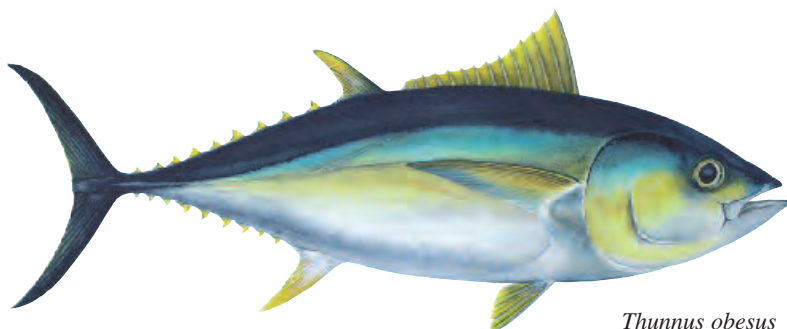
The estimated delivered value of the purse-seine tuna catch in the WCPFC area for 2004 is USD 1158 million. This represents an increase of USD 195 million or 20% on the estimated delivered value of the catch in 2003. This increase was driven a USD 245 million (35%) increase in delivered value of the skipjack catch, which was estimated to be worth USD 934 million in 2004, resulting from a 26% increase in the composite delivered price and a 7% increase in catch. This was partially offset by a USD 46 million (19%) decline in the value of the yellowfin catch, which was estimated to be worth USD 198 million in 2004, resulting from a 17% decline in catch and a 2% decline in the composite delivered price.

During 2004, the Yaizu price of pole-and-line caught skipjack in waters off Japan averaged JPY 191/kg (USD 1763/mt). The Yaizu price of pole and line caught skipjack in waters south of Japan averaged JPY 153/kg (USD 1419/mt) during 2004.

As catch estimates for the Japanese pole-and-line fleet for 2004 were not available at the time of writing this report, no

catch value estimates were derived for 2004. The estimated delivered value of the total catch in the WCPFC pole-and-line fishery for 2003 is USD 324 million. This represents a decline of USD 9 million (or 3%) on the estimated value of the catch in 2002. The estimated delivered value of the skipjack catch in the WCPFC pole-and-line fishery for 2003 is USD 243 million. This represents an increase of USD 16 million (or 7%) on the estimated value of the catch in 2002 and resulted from a 7% increase in the composite delivered price with catch levels remaining steady.

In 2004, fresh yellowfin prices at 10 major Japanese wholesale markets rose by 2% to JPY 1007/kg, while frozen yellowfin prices fell by 3% to JPY 703/kg. Longline caught yellowfin prices (ex-vessel) landed at Yaizu rose by 4% to JPY 431/kg, average fresh yellowfin prices (ex-vessel) at selected Japanese ports rose by 13% to JPY 639/kg and fresh yellowfin import prices cost, insurance and freight (c.i.f.) were steady at JPY 714/kg. While prices for imported fresh yellowfin in JPY were steady the appreciation of the JPY against the USD saw prices in USD increase by 7% to USD 6.60/kg. Following a significant rise in the price (c.i.f.) of imports of fresh yellowfin from the Oceania region in 2003 (up 8% to JPY 837/kg and in USD terms up 17% to USD 7.22/kg) prices declined by 2% in 2004 to JPY 818/kg but rose in USD by 5% cent to USD 7.56/kg.



Thunnus obesus

Prices at 10 major Japanese wholesale markets in 2004 averaged JPY 1191/kg for fresh bigeye, down marginally on 2003, and 911/kg for frozen bigeye, up 6%. Frozen bigeye prices (ex-vessel) at selected major Japanese ports rose by 5% in 2004 to JPY 652/kg while fresh bigeye prices (ex-vessel) declined by 12% to JPY 880/kg. Fresh bigeye

import prices (c.i.f) were steady at JPY 784/kg while frozen big-eye import prices (c.i.f) rose 10% to JPY 654/kg. In USD terms, frozen bigeye import prices rose nearly 18% to USD 6.05 while fresh bigeye import prices rose 7% to USD 7.26/kg. As with fresh yellowfin in 2003 there was a substantial increase in the price (c.i.f) of fresh bigeye imports from the Oceania region with prices increasing by 15%. In 2004 prices rose a further 2% to JPY 973/kg. In USD terms, prices rose by 25% in 2003 and 10% in 2004 averaging USD 9.00/kg in 2004.

In 2004 the average price free alongside ship (f.a.s.) of US imports of fresh albacore declined by 24% to USD 3.11/kg, while fresh bigeye import prices increased 3% increase to USD 7.18/kg and fresh yellowfin import prices rose 4% to USD 6.36/kg.

Bangkok frozen albacore market prices (10 kg and up, c&f)

rose steadily through much of 2004 continuing the upward trend in prices seen since March 2002 when the price of 10 kg and up sized fish stood at around USD 1700/mt. Having commenced 2004 at USD 2200–2250/mt the price of 10 kg and up sized fish increased through to the end of the third quarter reaching USD 2400–2450/mt in late September where it remained through to the end of the year.

The estimated delivered value of the longline tuna catch in the WCPFC area for 2004 is USD 1059 million. This represents an increase of USD 85 million (or 9%) on the estimated value of the catch in 2003. This increase was driven a USD 84 million (18%) increase in value of the bigeye catch, which was estimated to be worth USD 541 million in 2004, resulting from a 9% increase in the composite delivered price and an 8% increase in catch. The delivered value of the yellowfin catch was

marginally higher in 2004 at USD 367 while the delivered value of the albacore catch declined marginally to USD 147 million. For both albacore and yellowfin catch levels fell, by 14% and 5%, respectively, but this decline was offset by an increase of similar magnitude in the delivered composite price for each species.

A brief discussion ensued with regard to changes in skipjack and yellowfin targeting by the purse-seine fleets. It was noted that these shift in targeting were unlikely the result of changes in market price but the result of changes in species availability. It was also noted that the bigeye tuna catch by purse-seine vessels was not presented, but that such information would be useful to the commission to identify areas of bigeye productivity. Bigeye tuna catch was not reported since the catch is calculated as a proportion of the combined yellowfin and bigeye catch.



■ NEW COASTAL FISHERIES PROGRAMME MANAGER APPOINTED

Lindsay Chapman, currently Fisheries Development Adviser, has been recruited as SPC's Coastal Fisheries Programme (CFP) Manager. Lindsay started his new duties on 1 October 2005. The CFP Manager position provides operational leadership and coordination to the programme under the strategic leadership of the Director of Marine Resources, and is directly involved in various aspects of

the programme's work as necessary. Lindsay will continue to manage the Fisheries Development Section until alternative arrangements are made.

Lindsay's main tasks in his new position will be to:

- plan future programme activities to achieve overall programme objectives under the CFP Strategic Plan;
- identify, develop and maintain the necessary funding support to effectively implement the work programme and achieve overall programme objectives;
- supervise the work of the CFP's five sections, to ensure that the best available services are provided to clients at the national and international level;
- maintain contact and collaboration with the Forum Fisheries Agency to support mutually beneficial activities on behalf of member countries;
- maintain contact with other CROP agencies as appropriate, including attending meetings of the CROP Marine Sector Working Group as required by the Director of Marine Resources; and
- liaise with other national and international organisations to promote the work of the CFP and to ensure that the work keeps pace with international standards and best practices.



■ FISHERIES DEVELOPMENT SECTION

DEVFish (Development of Tuna Fisheries in Pacific ACP Countries) Project commences

The SPC component of the new EU-funded DEVFISH project commenced in August, with the recruitment of Mr Jonathan Manieva (Fig. 1) from Papua New Guinea to the new Fisheries Development Officer position funded under this project. Jonathan has worked as the Industry Liaison Coordinator, Industry and Provincial Liaison



Figure 1: Jonathan Manieva

Division with the National Fisheries Authority (2001–2004) and more recently as the Vessel Operations Manager with the South Seas Tuna Corporation (2004 to mid-2005). Jonathan has a strong background and good experience in the tuna fishery in the western and central Pacific Ocean, and is familiar with many of the stakeholders involved.

Jonathan's main tasks will be to assist in the establishment or enhancement of tuna fishing associations and tuna fishery stakeholder groups in the 14 Pacific ACP countries in the region. To begin, Jonathan is first researching the status of fishing associations and stakeholder groups in each of the 14 countries to establish a baseline,

which can then be used to measure future progress.

The DEVFISH project is a joint initiative with the Forum Fisheries Agency (FFA) with FFA as the lead agency. The Team Leader for this project, Mr Mike Batty, took up his position at FFA in September, while the FFA-based Project Coordinator, Mr Teriba Tabe started in August. The first planning meeting for the DEVFISH project is scheduled for early October in Honiara, so that the different components of the project can be coordinated and a work plan established for the next 12 months.



First Scientific Committee meeting for the new Western and Central Pacific Fishery Commission

Fisheries Development Officer, Steve Beverly, participated in the first Scientific Committee meeting of the new Western and Central Pacific Fishery Commission (8–19 August 2005), which

met at SPC headquarters in Noumea. He presented two reports: one covering his work on a New Caledonian longline vessel earlier in the year (see *Fisheries Newsletter* #113) at the

Fishing Technology Special Working Group session; and another on deep setting for bycatch mitigation at the Bycatch Special Working Group Session.



Technical assistance provided to Nauru

Fisheries Development Officer, William Sokimi, concluded his assignment in Nauru at the end of July. The first part of his work was with the Nauru Fisheries Corporation (NFC), training the crew of their longline vessels in gear preparation, fishing strategy and fish handling practices. These activities were reported in the previous issue of the *Fisheries Newsletter* (#113).

The second part of William's work was with the Coastal Fisheries staff of the Nauru Fisheries and Marine Resources Authority (NFMRA). This component focused on small-scale mid-water fishing methods used in combination with fish aggregating devices (FADs). William worked with the NFMRA staff to prepare for the workshop, which included both theory and practical sessions. At the start of the workshop,

William displayed the sea safety equipment that all vessels should carry and the gear that would be used during the workshop (Fig. 2).

The mid-water and FAD fishing skills workshop was a great success, with 48 local fishermen participating as well as 15 NFMRA staff. The workshop covered both night fishing (using light attraction) and daytime fishing activities. Theory

sessions were conducted with the full group (Fig. 3). Gear was made up during classroom sessions, and participants were then divided into four groups for at-sea practical fishing sessions. Lights were used at night to attract bait (scads and squids) to the boat; the bait was caught using jigs and then the live bait was used to catch larger pelagic fish. Although catches of baitfish were reasonable, the moon was too bright, which reduced the effectiveness of the technique. Vertical longlines were also used at night, although the catch was low and the cost of making up this type of equipment placed it out of the reach of many of the participants.



Daytime fishing activities were more productive than night-time activities. The methods used included deep-water snapper fishing and palu-ahi (scatter or chum bait) fishing. These activities were conducted along the coast because the weather was too rough around the FADs. For fishing, the project vessels were anchored in depths of around 200 m. Two lines on each boat were devoted to deep-bottom fishing (Fig. 4), and three to palu-ahi fishing. Catches were quite good, especially when a school of rainbow runner were chummed close to the boat on several occasions. A total of 131 rainbow runners (weighing 302 kg) were taken, with a total catch of 213 fish (weighing 472 kg) over the two days of practical fishing training.



Figure 2 (top): Sea safety equipment and fishing gear on display at the start of the workshop

Figure 3 (middle): Participants attending the first theory session

Figure 4 (bottom): Deep-water snapper fishing



Tuna longline bycatch meetings

The issue of bycatch from tuna longline activities has been highlighted over the last five years, as fisheries researchers, fisheries managers, the fishing industry, NGOs and other stakeholders work together to come up with solutions to minimise interactions. This united approach to addressing the issue has led to international meetings so that information can be shared and research efforts coordinated. In the third quarter of the year, two major international meetings on tuna longline bycatch reduction were held.

Third International Fishers Forum (IFF3)

The Third International Fishers Forum (IFF3) was held in conjunction with the International Tuna Fishers Conference on Responsible Fisheries (25–29 July 2005, Yokohama, Japan). Fisheries Development Adviser, Lindsay Chapman, attended these meetings.

The focus of the International Tuna Fishers Conference on Responsible Fisheries was on fishing vessel capacity, including flag state control over illegal, unreported and unregulated (IUU) fishing vessels. IUU fishing and ways to stop this practice were discussed several times during the meeting. The World Tuna Purse Seine Organisation (WTPO) is also fighting against IUU fishing, and has a major initiative to control tuna purse-seine effort. WTPO was established in 2001, and its membership comprises Ecuador, France, Japan, Taiwan, Korea, Philippines and Spain, although there is interest in expanding membership to include all tuna purse-seining nations. If all nations united, there would be a far better chance of addressing IUU fishing.

The development and implementation of International Plans of Action (IPOA) on sharks was also discussed. Sharks were the focus of several presentations. Target fisheries in Taiwan take around 45,000 mt/year, with a further 35,000 to 40,000 mt taken as byproduct from their tuna longline vessels. An Australian study on the blue shark estimated that in 1999,

around 200,000 mt (3.8 million animals) were landed across the Pacific. Data on the international shark trade was also presented, with an estimated ten percent of sharks being retained for meat, and the rest finned.

The focus of the IFF3 meeting was on the bycatch of seabirds and sea turtles, and mitigation methods being trialled or implemented to reduce interactions with these species. Fishermen from nine countries (Japan, USA [Hawaii], Taiwan, Peru, Korea, Ecuador, Philippines, Indonesia and China) gave brief presentations on efforts in their country to reduce seabird and sea turtle bycatch. Actions included the printing of awareness materials, using tori poles and lines to scare seabirds away during day setting of longline gear, and implementing the use of large circle hooks and mackerel bait to reduce sea turtle interactions. In most cases, it was a joint effort with industry, government, scientists, and in some cases NGOs, working together.

One interesting initiative — a hook exchange project — was being implemented in Ecuador and Peru. Local longline fishermen have been using the J hook for longlining, but they are now exchanging these hooks for circle hooks in an effort to reduce sea turtle interactions. In addition, workshops are being held to educate fishermen about releasing sea turtles alive, and the best way to handle them to increase their chance of survival.

Interesting information was presented on new nesting beaches for leatherback turtles

in Papua New Guinea, Solomon Islands and Vanuatu. These beaches were frequented by small numbers of leatherbacks, and the 1996 estimate of 700 females has now been revised to at least 2000 female leatherbacks breeding per year.

A new issue was raised at the meeting: longline interactions with cetaceans (toothed whales and some dolphin species). A small group looked at this issue, which included both the hooking or tangling of these species in tuna longline gear, and the feeding or depredation of hooked fish on a longline by toothed whales. Depredation is becoming a significant issue in the Pacific as more fishermen are recording fish losses to cetaceans.

Hook, line and bycatch

In late September, Steve travelled to Kota Kinabalu on Borneo in Malaysia, to participate in a multi-species bycatch workshop titled “Hook, Line, and Bycatch” (26–30 September 2005), which was organised and promoted by the Marine Research Foundation. The workshop gathered a diverse group of scientists, NGOs, IGOs, fishermen and consultants, with interests in reducing bycatch in longline fisheries. The aim was to share information, increase awareness of what others are doing in their fields, develop key themes for future work in multi-species bycatch assessment and reduction, and provide the outline of a document to be produced by the meeting facilitator. The workshop was organised by the Marine Research Foundation

and the World Wide Fund for Nature International. Funding was provided by the Western Pacific Regional Fishery Management Council in Hawaii, World Wide Fund for Nature International, Conservation International, and the United States National Oceanographic and Atmospheric Administration.

Two days of the workshop were devoted to presentations dealing with multi-species bycatch issues and to small group sessions concentrating on specific issues. Group sessions were aimed at developing a strategy to get stakeholders thinking about bycatch issues in a multi-species context, and to develop solutions within that context.

The main output of the workshop will be a technical report that should be ready by the end of the year.

One important disclosure during the presentations was made by Alan Bolten of the University of Florida, USA. He has been one of the major researchers and proponents of using tuna circle hooks to avoid turtle bycatch. He revealed that he now has some misgivings about supporting the use of circle hooks as research has found that, although turtle bycatch and turtle injury can be reduced significantly, the rate of capture of blue sharks rises alarmingly. The trade-off may not be worth it. Another point of interest was the fact that in Brazil

and Taiwan, blue sharks are a target species, both for their flesh and their fins. For this reason, blue sharks are considered byproduct rather than bycatch in those locales.

Steve gave a presentation on a deep setting technique to mitigate bycatch (see *Fisheries Newsletter* # 109) and also previewed a mock-up of the brochure on how to set your line deep (see Fig. 8). Brett Molony, Senior Fisheries Scientist at SPC's Oceanic Fisheries Programme, also attended the workshop and presented a paper on the Western and Central Pacific Fishery Commission bycatch data and data issues.



Training course on managing vessel condition and certification

The SPC Regional Maritime Programme conducted a two-week training course on managing vessel condition and certification in Suva, Fiji from 1–12 August 2005. This training course targeted regional maritime personnel who are shipping company managers, vessel maintenance supervisors, ship captains and deck officers, ship and shore engineers, ship surveyors, and others engaged in making vessel management decisions. William Sokimi attended the course along with 11 others from Fiji, Samoa, Papua New Guinea, Solomon Islands, Tonga, Tuvalu and Vanuatu.

This course consisted of theoretical classes and two practical

excursions: one to survey vessels under repair, and another to assess the slipway system in Suva. In the theory classes, participants were given the details of what is required of a surveyor or a ship's manager when handling vessel condition and certification. Details of ship certification and insurer issues were covered in order for participants to understand the classification systems of vessels and the category of survey certificates that apply to each vessel when insuring and registering the vessel.

The course is relevant for ship personnel and maritime managers, in order to develop their organising skills while maintaining a vessel, when preparing a

vessel for survey, and when compiling maintenance plans. This is especially useful when allocating the budget for vessel operations in the next financial year. The course also updated participants on the current issues affecting the management of vessel conditions, and certification issues internationally.

This course was especially helpful for William, as the Fisheries Development Section has been asked on several occasions to evaluate tuna longline vessels on behalf of member countries. The skills William gained will better equip him to deal with such requests in the future.



Technical assistance provided to Niue

In August and September Steve travelled to Niue where he conducted a longline fishing workshop for local fishermen. Nineteen fishermen took part in the workshop. Sea safety, rigging fishing gear, setting and

hauling longline gear, and on-board handling of catch were among the topics covered. The first sessions emphasised sea safety with a demonstration of a small, waterproof sea-safety grab bag containing a mini

EPIRB (emergency position indicating radio beacon), hand-held GPS and VHF radio, waterproof torch, batteries, all-purpose tool, signal mirror, See-Rescue Streamer and first-aid kit.



Steve then covered basic gear configuration and terminology, and explained how to set the gear, and how to find fish by using charts, seabird piles, plankton, temperature breaks and scum lines. He also discussed the line-setting depths and where different target species are found in the water column. Participants were shown how to rig floats and floatlines, and how to put together two types of branchlines using monofilament and red vinyl tarred polyester (Fig. 5).



During the second part of the workshop, trainees signed up for real fishing sessions, and were split into two groups to ensure everyone had a turn at every job involved in line setting and hauling operations. Despite the bad weather conditions, each group of trainees set and hauled 230 hooks in 40 hook baskets without mishap aided by a helpful captain and crew of F/V *Sweet Dolly* (Fig. 6), who assisted Steve in instructing trainees on baiting, snapping and coiling branchlines, and other aspects of a tuna longline operation including hauling the gear (Fig. 7).



Along with gaining practical experience, trainees had the opportunity to view several videos and DVDs including *Lindgren-Pitman's Longline Fishing*, SPC's *Handling of Sashimi Grade Tuna*, *Hawaiian Tuna Action*, and *Crossing the Line* (sea turtle handling guidelines for the longline fishing industry). Reading materials including SPC's *Horizontal Longline Fishing: a Manual for Fishermen*; brochures on sea safety equipment; and a booklet on using marine radios were also distributed.



Figure 5 (top): Rigging gear at the workshop

Figure 6 (middle): Vessel used for the training, F/V *Sweet Dolly*

Figure 7 (bottom): Workshop participants hauling the gear

Technical assistance provided to the National Fisheries College in Kavieng, PNG

William started a new three-month assignment in mid-September with the National Fisheries College (NFC) in Kavieng, Papua New Guinea. William will work with both the college and the Asian Development Bank (ADB) funded Coastal Fisheries Management and Development Project (CFMDP).

William's first task was to assist NFC's Coastal Fisheries staff in implementing the first Commercial Fishing Operations (CFO3) course. Staff were assigned specific tasks to carry out prepara-

tion for the course. The Training Guides, Assessment Guides, and Learners Guides for the course modules were organised and then printed and readied. The tutors were also assigned modules, and coached on how to deliver these effectively, and on how to prepare the assessment tasks. Based on the first course delivery, William will refine the course design and materials. The three-week CFO3 course began on 26 September.

William also worked with the NFC's Masterfisherman in car-

rying out preparations for accumulating and organising fishing gear and FAD materials for the CFMDP project. Underwater light components at the water front were repaired and stowed away, fishing gear components were identified and ordered where necessary, FAD materials were selected and quotations obtained and forwarded to the appropriate parties, vessels were readied, and fuel was ordered so that sufficient supplies would be available when the project began in October.



Update on publications

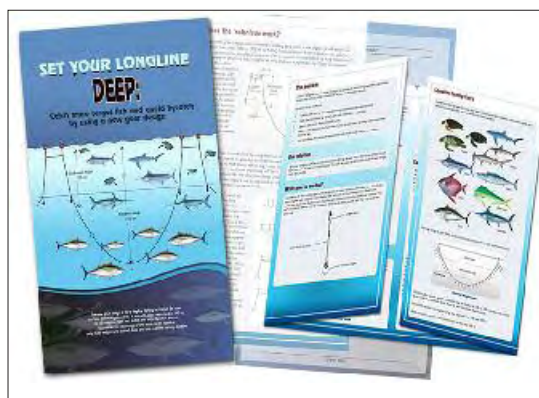
The French version of a FAD manual (*Manual on fish aggregating devices (FADs): lower-cost moorings and programme management*) was completed in July and distributed within the region.

An identification manual (*Marine species identification manual for horizontal longline fishermen*) has been expanded with the inclusion of additional species. This manual is now scheduled for completion in the fourth quarter.

A brochure (*Set your longline deep*) produced by the Fisheries Development Section in English is being printed, with a French version to be released in the fourth

quarter. This brochure summarises the new deep-setting technique developed by Steve Beverly, which won him first prize in the WWF-sponsored International Smart Gear Competition for bycatch mitigation ear-

lier this year. The brochure is targeted at tuna longline fishermen, with the aim that these fishermen will adopt the technique and reduce their interactions with bycatch species.



AQUACULTURE SECTION

Training workshop in aquacultural economics and marketing

A lack of knowledge regarding aquacultural economics and marketing has been long recognised as a constraint to the financially sustainable growth of aquaculture in the Pacific. To begin addressing this gap a short-

term regional training course on aquacultural economics and marketing was organised and funded by SPC. The one-week workshop was held in Suva, Fiji Islands, 25–29 July 2005. Workshop participants included representatives

from the Cook Islands, Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu.

Economic models can aid in predicting costs and revenues

that will be generated by a venture prior to investment, and hence can be an important tool in planning the most profitable scenario.

Proper marketing research and analysis are required to test the consumer base for a product, and to design a commodity that is responsive to consumer demands. This workshop was the first in a series of sub-regional training workshops, and also served as a testing ground to develop a more formal curriculum that SPC anticipates could become a regular training theme in the future. Some funding assistance from the Taiwanese government has been made available to facilitate such workshops.

Several organisations worked collaboratively to deliver the training, including specialists from the University of the South Pacific (USP), the Institute of Marine Resources (USP-IMR), Queensland Department of Primary Industries and Fisheries (QDPI&F), and the Pacific Islands Forum Secretariat (PIFS).

During the workshop country representatives adopted a case study based on a priority commodity of their choosing. Trainees were shown how to use the economic modelling software (jointly developed by SPC, USP and QDPI&F) to generate economic data and profit risk analysis. The economic modelling software is freely available on SPC's website at www.spc.int/aquaculture.

Trainees were also provided with theoretical principles and best practices regarding product marketing to teach them how to incorporate financial economic data and marketing strategies in the development of a business plan, which may be used to support investment ventures. The business plan is intended to serve as a model that could guide government officers or private sector investors and financial institutions.

The workshop concluded with some in-depth presentations on various commodities such as freshwater *Macrobrachium* shrimp, black pearls, mozuku seaweed, *Kappahycus* seaweed and tilapia.



Development of commercial and farm-made feeds for tilapia and *Macrobrachium* in PNG and Fiji

Introduction

There is substantial potential in Fiji and PNG for the culture of tilapia and *Macrobrachium* as an important source of protein and income for small-scale fish farmers. However, a lack of appropriate resources and capacity has contributed to low tilapia and prawn productivity in both countries. One of the key constraints is the poor quality and limited availability of supplementary feeds. The limited availability of ingredients and lack of information on cost-effective ways to make and deliver feeds often results in poor quality feed and hence reduced production and profitability. The aquaculture sectors in both countries need information about available feed resources and how these can

best be used. To address this priority a planning workshop was held as part of the Development of commercial and farm-made feeds for tilapia and *Macrobrachium* in PNG and Fiji project. The workshop was held at the University of the South Pacific (USP) and Naduruloulou Aquaculture Station, Fiji from 18–20 April 2005.¹ The meeting, organized by SPC's aquaculture section, had 18 participants: government officers from PNG's National Fisheries Authority and Department of Agriculture and Livestock, government officers from Fiji's Department of Fisheries, a Fiji Aquaculture Association representative, Dr Tim Pickering (USP), Dr Geoff Allan and Dr Carmen Gonzales (ACIAR), Cathy Hair (QDPI&F), Dr Paul Smith (University of Western Sydney), Dr Johann Bell

(WorldFish Center) and Ben Ponia and Satya Nandlal (SPC).

Objectives

The main objectives of the workshop were to review the status of and problems with feeds and feeding for tilapia and *Macrobrachium* in Fiji and PNG and to plan the project's experimental component. The workshop also presented the results of a survey of locally-available feed ingredients that may have potential as aquaculture feed, and visits to local fish farms and a government aquaculture station.

Workshop

The workshop was opened by Fiji's Acting Director of Fisheries, Mr Saimoni Tuilaucala.

¹ The feeds mini-project is being run under the auspices of the Sustainable Aquaculture Development in the Pacific Islands Region and Northern Australia project, with funding support from Australian Centre for International Agricultural Research (ACIAR). The Queensland Department of Primary Industries and Fisheries (QLD DPI&F), SPC and the WorldFish Center are all involved.

Mr Tuilaucala emphasised the challenges of improving efficiency and reducing the cost of production, along with the need to increase awareness about the benefits of farm-made feeds for use by all farmers in isolated areas.

The first day's activities began with a presentation by Drs Geoff Allan and Carman Gonzales (Consultant Nutritionist), covering the workshop objectives and survey results regarding available feed ingredients considered suitable for feeding fish and prawns in PNG and Fiji. The PNG survey was carried out by Drs Allan and Gonzales, and PNG aquaculture staff from 6–10 December 2004. A similar survey was carried out in Fiji by Dr Gonzales, Dr Peter Mather (Queensland University of Technology) and Satya Nandlal from 30 January to 5 February 2005. The survey covered all materials commonly referred to as "conventional" feedstuffs as well as so-called "non-conventional" feedstuffs, such as processed waste from the food industry. Information on quality and availability was obtained for each ingredient.

Filimone Mate (Fiji) and Jacob Wani (PNG) then provided an overview of aquaculture and the roles of Fiji and PNG in the project. Satya Nandlal provided an overview of aquaculture feeds and feeding priorities in the Pacific region. Dr Paul Smith reviewed the status of aquaculture in PNG and listed the priority feed issues. Dr Johann Bell described the WorldFish Center's interest in aquaculture feeds, and Dr Tim Pickering described the capacity for aquaculture feeds research at USP. A general discussion followed these presentations.

The second day began with a review of key issues based on presentations made the previous day. Some of the key issues were:

- Profit drives aquaculture.
- Feed constraints are limiting freshwater aquaculture in Fiji and PNG. Without adequate feeds, the potential benefits of advances in genetics and husbandry technology will not be realised by farmers.
- Ingredients for farm-made feeds were variable in composition and supply (some with unknown composition); problems included transportation difficulties as well as lack of knowledge by farmers about how to use feeds.
- Ingredients for commercial feed formulation were limited and also expensive.
- Where commercial feeds are unavailable and limited ingredients for farm-made feeds are available, farmers might be able to consider extensive farming using fertilizers to promote growth of natural food items in ponds.
- Fertilizers can be difficult to obtain as there are conflicts with users who employ fertilizers for other agricultural purposes.
- Credit problems can limit the uptake of feed technology for both commercial and farm-made feeds.
- Aquaculture associations and cooperatives can help in promoting the uptake of feed technology.
- Government policy and support (national strategic planning) are required for feed research and development.
- The following information is needed to formulate diets: 1) nutritional requirements, particularly for protein and energy (on a digestible basis); 2) availability, price and composition of ingredients; 3) digestibility of ingredients (for each species) and any restrictions regarding the use of ingredients (e.g. because of antinutrients or contaminants); 4) preferences regarding pellet size, buoyancy etc.
- Fertilization requirements for extensive culture or early non-feeding stages.

Following the review, Drs Allan and Gonzales summarised considerations for formulating diets and discussed the experimental methodology for the trials

Participants then divided into groups and discussed the specific objectives for the feed trials, including experimental methods, facilities, staff, feeds ingredients, and a schedule of activities.

Ms Cathy Hair facilitated a general discussion on ways to disseminate the results followed by brief presentation by Jacob Wani, Filimone Mate and others.

The third day began with a field visit to Monfort Fish Farm and Naduruloulou Aquaculture Station. At Naduruloulou, participants were able to observe indoor facilities (such as the feed making facilities, prawn and carp hatchery) but were not able to visit the other facilities due to continuous rainfall at the time.

The day ended with a meeting in the conference room on experimental design and an outline of the responsibilities of the various staff that were to be involved in the trials. The workshop ended with closing remarks by Filimone Mate.



Conclusions

- Participants left with increased knowledge about the importance of feeds and feeding practices, an understanding of the major nutrients required by aquaculture species, how different ingredients are used in formulated feeds to supply these requirements and how feeds are made.
- Participants learned about the types of ingredients that might be available in Fiji and PNG and how these might be combined in simple formulated feeds.

Two experiments were designed to compare four formulated feeds (made from locally available ingredients) with a currently available (although expensive) commercial steam-pelleted feed.



Deep in discussion on feed making at Naduruloulou feed room.

From left to right: Johnny Soranze (PNG), Dr Geoff Allan (ACIAR), Jacob Wani (PNG), Satya Nandlal (SPC), and Peter Minimulu (PNG)

SPC joins INGA — an international genetics network organisation

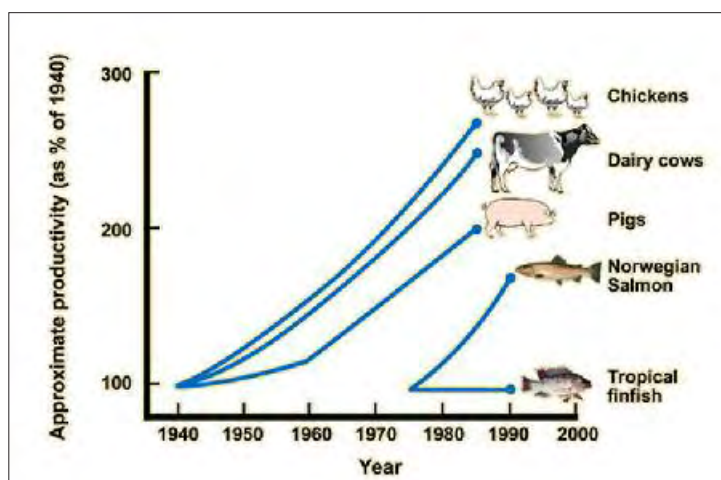
In September, SPC's Aquaculture Adviser, Ben Ponia, went to Shanghai, China to participate in the steering committee meeting of an international genetics network — the International Network on Genetics in Aquaculture (INGA) — and to lodge a submission for membership.

INGA is coordinated by the WorldFish Center and includes membership from 13 developing countries in Asia, Africa and the Pacific (Bangladesh, China, Egypt, Fiji Islands, Ghana, India, Indonesia, Ivory Coast, Malaysia, Malawi, Philippines, Thailand and Vietnam) and 15 advanced scientific institutions and regional and international organisations.

The objectives of INGA are to: 1) foster regional and international cooperation in aquaculture genetics research; 2) assist in developing strategies for national breeding programs;

3) contribute, through collaborative research, to the domestication of tropical finfish; 4) strengthen national capacity in genetics research; and 5) facilitate exchange of germplasm and information.

The application of genetics to the areas of fisheries and aquaculture is an emerging field of science, one that promises significant benefits. The focus of INGA on the needs of developing countries is aligned with challenges facing the SPC.

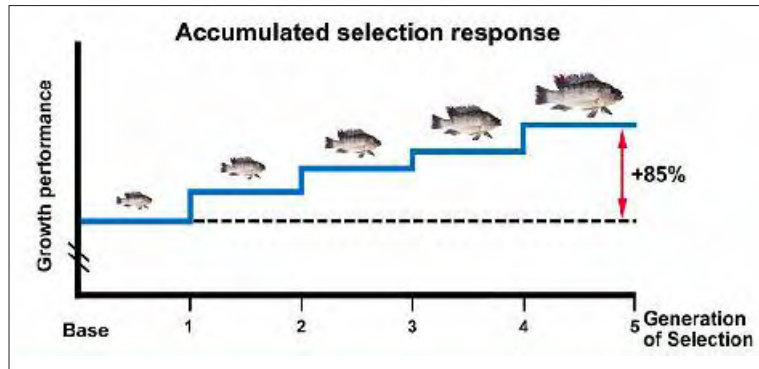


Graphs outlining improvements in productivity from genetic selection programmes. Compared to terrestrial farming there have been few advances in aquaculture of tropical finfish

Membership provides an opportunity for the Pacific region to access improved genetic strains, and to access experts in the field of genetics, and is a step forward in conserving genetic resources.

The success of the GIFT (genetically farmed improved tilapia) tilapia project confirmed the practical application of genetics. It generated a lot of interest amongst Asia, Africa and the Pacific and was partially responsible for the eventual formation of the INGA network in 1993.

Through a process of genetic selection the GIFT project produced a strain of Nile tilapia from indigenous strains in different countries. The GIFT tilapia had 77 per cent faster growth and 66 per cent higher survival rates compared with tilapia commonly farmed in the Philippines.



GIFT tilapia demonstrated significant improvement in growth response with each generation of breeding

One project concept discussed at the INGA meeting was to use the GIFT experience to selectively breed a high performance strain of the giant freshwater prawn *Macrobrachium rosenbergii*. There is interest in Fiji to review the performance of the current strain of *M. rosenbergii*, which was introduced about a decade ago.

The steering committee accepted SPC's application for membership in the organisation, noting the constructive role SPC might play, particularly as an extension agent for the region and in disseminating products. Also present at the meeting was a national representative from Fiji Islands, the only Pacific Island member of the network.



GIFT tilapia in Fiji

Tilapia farming manuals completed

A two-volume field manual for tilapia hatchery techniques and tilapia pond growout, co-authored by Satya Nandlal (SPC) and Tim Pickering (USP), has been published by SPC.

Although many booklets and training materials for tilapia farming are available, they are written primarily for Asian readers. This manual is written for inhabitants of the Pacific Islands, and is based on practical experience with what works in the varied environmental and cultural conditions found in the Pacific region.

Volume 1 (**Tilapia Hatchery Production**) covers breeding and fry-rearing up to pond stocking size (fingerlings). It is intended for use by fisheries extension officers, staff of rural community development projects, school teachers, or other people with some basic knowledge of biology, and is designed to help them impart fish-culture

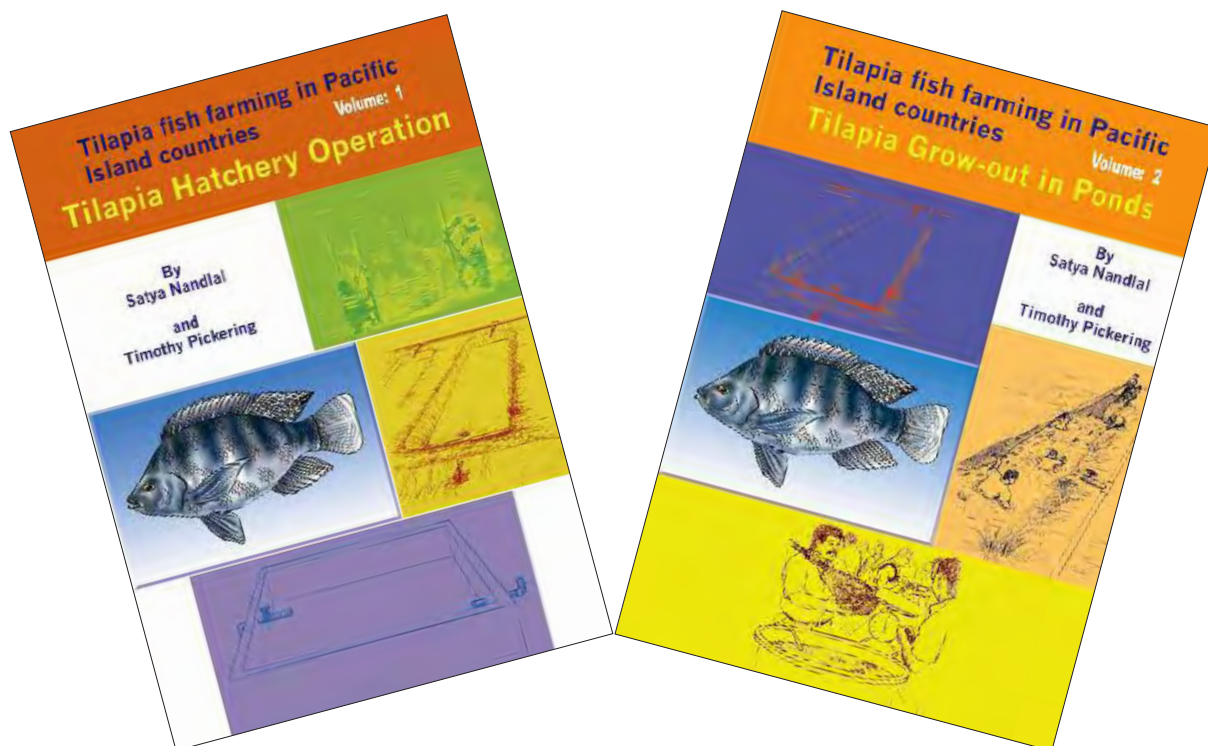
practices to people directly engaged in tilapia fingerling production. It can also be used by more advanced fish farmers who want to further improve their skills and self reliance by producing their own tilapia fry and fingerlings. The document is available in hard copy, but can be downloaded from SPC's website:

<http://www.spc.int/aquaculture/site/publications/documents/TilapiaFishFarmingVol.1.pdf>

Volume 2 (**Tilapia Growout in Ponds**) is intended for fish farmers at the subsistence or small-scale commercial level, and can be used as a training textbook by Fisheries Department officers, staff of rural com-

munity development projects, school teachers, or others responsible for imparting good fish-culture practices to people engaged in tilapia fish farming. This volume assumes less biological knowledge than does Volume 1, and has greater emphasis on practical techniques for raising tilapia in ponds. This makes it more suitable for people who are new to fish farming, or who only want to be involved in the grow-out of tilapia. The document is available in hard copy, but can also be downloaded from SPC's website:

[http://www.spc.int/aquaculture/site/publications/documents/TilapiaGrowoutVol\[1\].2.pdf](http://www.spc.int/aquaculture/site/publications/documents/TilapiaGrowoutVol[1].2.pdf)



Consultancy to review tilapia control techniques completed

Professor Romeo Fortes (University of the Philippines, and consultant to SPC) has completed a review of techniques and practices for controlling tilapia populations, and identification of methods that may have practical applications in Nauru, including a national tilapia plan. The following is an extract of the executive summary of his report.

The Mozambique tilapia (*Tilapia mossambica* Peters = *Oreochromis mossambicus* Peter = *Sarotherodon mossambicus* Peters) was introduced in Nauru in 1960, primarily to feed on mosquito larvae and as a food source. Instead, it rapidly became abundant in what are considered in Nauru to be lagoons (sunken pools surrounded by mangroves) and ponds (depressions created by bomb craters). It also became an aggressive competitor with milkfish (*Chanos chanos* Forsskal), leading to the collapse of milkfish aquaculture. Through FAO, the Republic of Nauru implemented a Tilapia eradication program (in 1979 and 1980) in which rotenone was used as the toxicant.

When tilapia were introduced in other areas (in the 1950s to 1970s) similar problems were experienced as in Nauru; however, most countries (e.g. the Philippines) continued to regard it as source of food. In the early 1970s techniques to control tilapia reproduction were developed and applied to aquaculture production. Today, most species of tilapia are used in aquaculture. The experience of other countries that have addressed similar problems may be instructive in developing a means of controlling tilapia in Nauru.

The most important tilapias used in aquaculture are the Nile tilapia (*T. nilotica*), Mozambique tilapia (*T. mossambica*), and the blue tilapia (*T. aurea*), plus a number of mouth brooding tilapia hybrids used in aquaculture (red *T. mossambica* hybrids) with *T. aurea*, *T. nilotica*, and *T. urolepis hornorum*, including *T. galilea* and *T. melanotheron*.

These species account for 99.5% of global tilapia production. Nile tilapia now dominate global tilapia aquaculture, accounting for 72% or 474,000 mt in 1995. Total world tilapia landings from capture and culture have been estimated at 1.16 million mt, with cultured tilapia accounting for 57% of the total (659,000 mt). Cuba is the world's largest producer of blue tilapia, but overall the largest tilapia producing nations are in Asia. China is the world's largest tilapia producer (315,000 mt), accounting for 48% of global production, followed by the Philippines, Thailand, Indonesia and Egypt. The USA is the world's largest tilapia consumer. In some countries (e.g. Australia, Nauru, Fiji and Palau) complete eradication of tilapia was undertaken.

Failure of tilapia culture in the past has often been due to uncontrolled spawning, and control measures were consequently developed. There are basically seven methods for controlling tilapia populations, which have been carried out for aquaculture or simply for eradication purposes. These include:

- 1) periodic harvesting of fry and fingerlings;
- 2) monosex culture by which single-sex fish are obtained through: manual separation of sexes, hybridization, hormone augmentation and genetic manipulation methods such as androgenesis, gynogenesis, polyploidy and transgenesis;
- 3) culture in cages;
- 4) high density culture;
- 5) biological control;
- 6) sterilization; and
- 7) eradication by means of fish toxicants.

While tilapia has tremendous potential as an economic commodity, it also has the potential to significantly affect environmental biodiversity and impact economic activities, as has been experienced in a number of countries, such as Nauru, Australia, Fiji and Palau. As a result, various actions have been taken to prevent the infestation of undesirable species (including tilapia) into a given country. In general, the principles behind the control and management of pests and nuisance species may be considered when controlling tilapia populations.

The preferred approach involves preventive measures, careful surveillance and monitoring coupled with a regular procedure to prevent entry into other water bodies. The general methods of control are: physical/mechanical, chemical and biological control, genetic engineering, and environmental management and cultural control.

The complete report can be downloaded from SPC's website:

<http://www.spc.int/aquaculture/site/publications/documents/Tilapia.pdf>



Nauru aquaculture development plan

SPC's Aquaculture Section has assisted the Nauru Fisheries and Marine Resources Authority in holding a planning workshop and formulating a national aquaculture development plan. The final document was completed, following a recent attachment with the section by Mr Peter Jacob, Acting CEO, earlier this year.

The economy of Nauru was for many years dominated by the phosphate mining industry. The fisheries sector, and in particular the aquaculture sector, was largely neglected because other sectors had priority.

Today, however, the fisheries sector is receiving greater attention, particularly in attempts to alleviate the food security situation, and aquaculture has a role to play. Milkfish is the national fish of Nauru, and fish farming of milkfish was an important traditional activity. The introduction of Mozambique tilapia, however, had a detrimental effect on milk-

fish farming. Fortunately there are now improved species of tilapia that are gaining popularity worldwide, and these may co-exist with milkfish aquaculture and also provide a more acceptable short-term solution as a food source.

The Nauru Aquaculture Development Plan is a five-year strategic plan that takes a significant step forward in outlining Nauru's aquacultural requirements. It addresses capacity-building, research and development, and awareness-raising programmes.

The plan maintains a focus on the subsistence needs of the people of Nauru. A research facility is proposed to help farmers with technical requirements such as conducting experimental trials, maintaining fish broodstock, producing fish fingerlings and providing training.

The document is available online from SPC's website:

http://www.spc.int/aquaculture/site/publications/documents/Nauru_Portal.pdf



Model import risk analysis (IRA) framework developed for the Pacific Islands

A team of consultants, led by Dr J. Richard Arthur, and including Melba Bondad-Reantaso, Edward Lovell, David Hurwood, and Peter Mather, were engaged by the Aquaculture Section to undertake two import risk analyses (IRAs) involving the proposed introduction of aquatic species. These risk analyses were developed to serve as models for consideration by other Pacific Island countries for future translocations. The IRA process can significantly reduce the risks associated with translocation, as might occur from a poorly planned and executed introduction or some unanticipated result. This is a valuable tool for implementing proper biosecurity measures and constitutes a best practice approach for quarantine and translocation.

The IRA process formulated for the Pacific has two approaches.

Prawn farm located in Navua, outside of Suva, Fiji Islands

Unlike the traditional approach, which focuses on pathogenic diseases, the model framework for the Pacific includes both a pathogen and an ecological risk analysis. The ecological component recognises the high value

attributed to biodiversity in the Pacific.

The pathogen risk analysis examines the potential risks due to pathogen introduction along with the movement of the com-





Larval *Macrobrachium rosenbergii* culture at the Ministry of Fisheries and Forestry Aquaculture Center, Naduruloulou, Fiji.

modity, identifies hazards (pathogens) requiring further consideration, and recommends ways to reduce the risk of introduction to an acceptable level. The pathogen risk analysis was

conducted using a qualitative approach with six risk categories (i.e. high, moderate, low, very low, extremely low, negligible).

The ecological risk analysis focuses on the invasiveness and “pest potential” of the species to be translocated and considers the likelihood of its escape and/or release into the natural environment and the nature and extent of any potential ecological impacts that could stem from escape or release. To assist in assessing the ecological risks, a questionnaire and decision making process was used.

The first risk analysis concerned the introduction of blue shrimp (*Litopenaeus stylirostris*) from Brunei Darussalam to Fiji.

This document is available from SPC’s website:

http://www.spc.int/aquaculture/site/publications/documents/Stylirostris_BruneiFiji.pdf

A second separate report analysed the risk associated with the proposed introduction of giant river prawn (*Macrobrachium rosenbergii*) from Fiji to the Cook Islands. The document is available from SPC’s website:

<http://www.spc.int/aquaculture/site/publications/documents/MacrobrachiumRosenbergii1.pdf>



■ REEF FISHERIES OBSERVATORY

Towards a regional reef fisheries data repository

One of the main objectives of the European Union-funded PROCFish/C project, implemented by SPC’s Reef Fisheries Observatory is to conduct a regional comparative assessment of reef fisheries in the Pacific. During the last four years, a considerable amount of socioeconomic and ecological data has been collected by the project and is currently being analyzed by PROCFish researchers.

To support this large data set, a Structured Query Language (SQL) Server 2000 database has

been established, and is used with a customized data entry and retrieval application called RFID (Reef Fisheries Integrated Database) and linked with a geographic information system (GIS) based on MapInfo and MapXtreme (MapInfo engine).

While this central database is hosted at SPC, a stand-alone version (using SQL Server Desktop Engine – MSDE), is routinely used in the field and by national attachments to enter and extract data for their own

country. The purpose is to provide Pacific Island countries a standardized system for assessment of their reef fisheries (using PROCFish/C or similar methodology), which can be used to extend the initial baseline assessment to other areas of interest with a comparable analysis for sound resource management.

The use of a standardized system ensures that countries benefit from future improvements to the SPC software, and eases

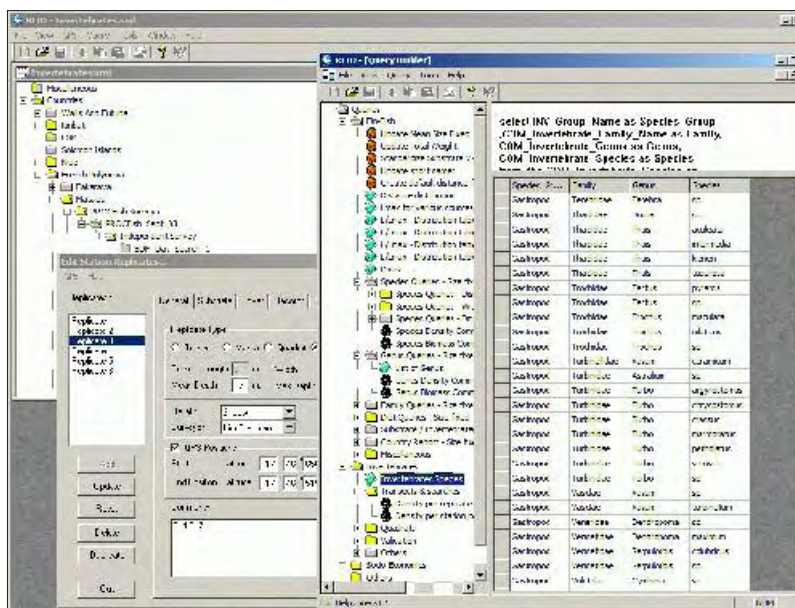


Figure 1: RFID Application

data exchanges between countries and the Reef Fisheries Observatory. Moreover, the system can be extended and customized to accommodate the special needs of the country, such as additional types of surveys and historical data.

A typical setting like the one depicted in Figure 2 has been recently installed in Tonga. It contains data collected under PROCFish/C in Tonga and the master copy of Tonga Fisheries data. The database is accessed through the local network by

fisheries workstations and is installed as a local stand-alone database on field work laptops and on a remote workstation. Data are synchronized with SPC using an import/export tool that produces a file which can be eventually transmitted by email. A similar system will be installed in Fiji in the near future.

Maintaining consistency between remote databases and software is a challenging issue in the Pacific especially because online updates through Internet are often not possible. We are cur-

rently tackling this problem by developing asynchronous tools that can use any available medium for updates, gradually improving the system according to user's feedback.

The replication of fisheries data at SPC has several objectives: it is an additional backup in case the master database is destroyed (hardware failure, natural disaster, human error, etc.), but is also an opportunity for SPC and in-country scientists to study together national fisheries data in conjunction with PROCFish/C data for a more thorough analysis and to better advise resource managers.

While the PROCFish/C project is innovative and ambitious in its scope (17 countries and territories are directly targeted), we recognise that considerable work by others has already been done, and previous or parallel studies are quite important for understanding Pacific fisheries. We have, therefore, begun inventorying existing research papers and reports, creating an electronic repository that can be redistributed.

The PROCFish web portal (http://www.spc.int/coastfish/Sections/reef/PROCFish_Web/) provides an interface for searching and

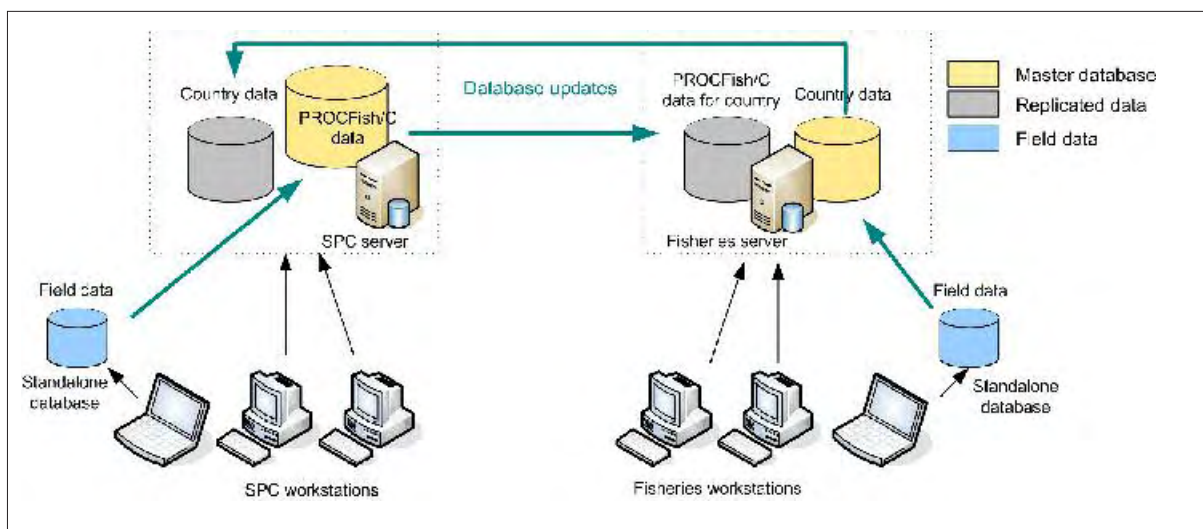


Figure 2: SPC and in-country databases

retrieving already digitized documents, which can be searched by metadata fields and/or in full text, as all documents are searchable. The digital library currently contains primarily SPC-produced documents, but the intent is to extend the pool of documents through collaborations and authorizations of copyright holders.

The portal also provides GIS data, either as ready-to-use MapInfo files or indirectly through links to other repositories.

For example, LandSat 7 satellite images released under the Millennium Coral Reef Mapping project are indexed by country on the portal and each image has a direct download link to the raw GeoTIFF image, which can be re-imported in most GIS and remote sensing software. We will continue to extend the portal according to feedback received from Pacific reef fisheries stakeholders.

In conclusion, PROCFish is gradually building a regional reef fisheries repository contain-

ing a large data set as well as reports and documents for the benefit of Pacific Island fisheries departments. Through the dissemination of standardized database and software, the project tries to ensure the sustainability and broad use of methodologies proposed by PROCFish/C, as well as facilitating the exchange of data and sharing of experience for the purpose of better managing reef resources.

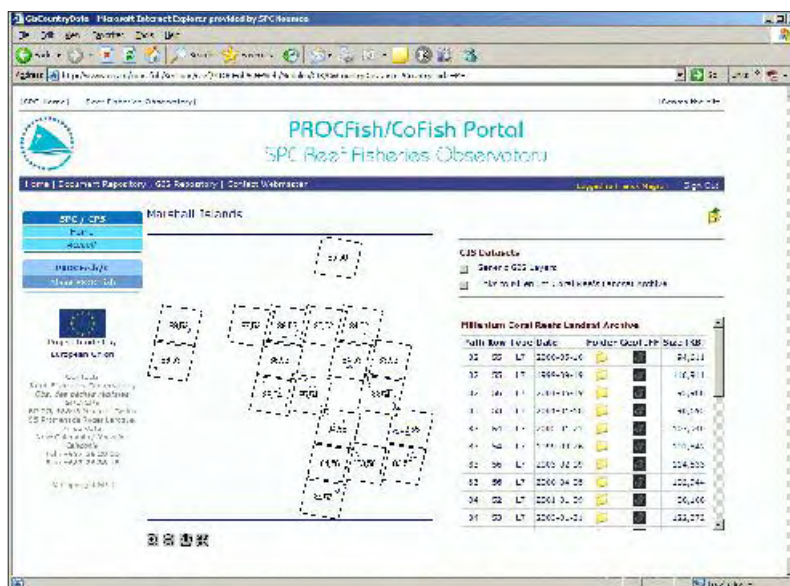


Figure 3. PROCFish/C web portal – GIS repository

■ SEAWEED YIELDS NEW COMPOUNDS WITH PHARMACEUTICAL POTENTIAL

Researchers have discovered 10 new molecular structures with pharmaceutical potential in a species of red seaweed that lives in the shallow coral reef along the coastline of Fiji in the South Pacific Ocean.

Some of these natural compounds showed the potential to kill cancer cells, bacteria and the HIV virus, according to research at the Georgia Institute of Technology. In fact, two of them exhibit anti-bacterial activity towards antibiotic-resistant *Staphylococcus aureus* at concentrations worth pursuing, though researchers don't know yet whether the concentrations of the compounds required to kill the bacterium would be harmful to humans.

The compound that was isolated in the greatest abundance — named bromophycolide A by the researchers — killed human tumor cells by inducing programmed cell death (called apoptosis), a mechanism that is promising for development of new anti-cancer drugs, researchers noted.

The findings on three of these compounds — called diterpene-benzoate natural products — are reported in the October 12 online issue of the American Chemical Society journal *Organic Letters*. Information on the other compounds will be published later. The research, which is part of an environmental conservation, economic development and drug discovery project in Fiji, was primarily funded by the Fogarty International Center at the National Institutes of Health. Georgia Tech Professor of Biology Mark Hay leads the project, which also aims to benefit the Fijian government and villages, which own their local natural

resources and will benefit monetarily if these natural resources become marketable drugs.

"We're only at the test-tube level so far," explained Julia Kubanek, a Georgia Tech assistant professor of biology, chemistry and biochemistry, who is the lead author on the paper. "The next step is to discover how these compounds work and then to study them in a more complex model system."

The US pharmaceutical company Bristol Myers Squibb is collaborating with Georgia Tech researchers to determine how some of these 10 compounds kill cancer cells. Meanwhile, Georgia Tech has filed a provisional patent to protect the discovery of these structures and small variations of them.

"These molecular structures are curious in the way carbon atoms are attached," Kubanek said. "It's

very unusual. They represent a new category of organic molecules. It's exciting as a biochemist to observe that living organisms have evolved the ability to synthesize such unique and exotic structures compared to other molecules typically produced by seaweeds."

The source of these new molecular structures is a red seaweed (*Callophycus serratus*) collected from four Fijian sites. Among the sites, researchers found variations in the molecular structures produced by the species.

"There are chemical differences among populations of this seaweed species, even though two of the sites where it was collected are only about 2 kilometres apart," Kubanek noted. "... this shows us there are small, but valuable differences within species, and this genetic biodiversity is important to protect as a resource for the future."



Researchers have discovered 10 new molecular structures found in a species of red seaweed along the Fijian coral reef. Some of these chemical compounds showed the potential to kill cancer cells, bacteria and the HIV virus.

Photo Courtesy of Julia Kubanek



Researcher Julia Kubanek and her colleagues collected baseball-sized samples of Fijian coral reef species that exhibit unusual growth and/or behavioural phenomena. Among their collection were soft corals, marine sponges, slugs, and green, red and brown seaweeds.

Photo Courtesy of Mark Hay.



Researchers explored the coral reef ecosystem and collected plant and invertebrate animal species samples near the Dravuni village in Fiji, along with several others.

Photo Courtesy of Julia Kubanek

Researchers have been analyzing extracts from about 200 marine plant and invertebrate animal samples they collected from the Fijian coral reef in June 2004 with the permission of the Fijian government and local resource owners.

"Marine organisms make molecules for their own purposes that we might co-opt for our own use as pharmaceutical agents," Kubanek explained. "The organisms' purposes include defence against predators, the ability to fight diseases,

and the production of chemical cues, such as those used for sex recognition."

Hay, Kubanek, and their colleagues collected baseball-sized samples of reef species that exhibit unusual growth and/or behavioural phenomena. Among their collection were soft corals, marine sponges, slugs, and green, red and brown seaweeds.

In the lab, researchers extracted these organisms using mixtures of organic liquids, which opened up the cells and dissolved the natural products. The organic liquids were then removed from the extract by evaporation, and small quantities of each extract were tested against a battery of pharmaceutical drug targets, including malarial parasite, tuberculosis-causing bacteria, and several cancers.

Typically, these tests involve exposing live, disease-causing cells — parasites, bacteria or cancer cells — to an extract and then assessing cell death compared to cells that were not exposed to extracts. Georgia Tech scientists then prioritized further study of extracts that had strong effects on these disease-causing cells.

The *Callophycus* red seaweed was one of the first five species that researchers investigated to identify the compounds within extracts that caused strong effects against disease-causing cells. Anne Prusak, a former Georgia Tech student and research technician, separated the new molecules from other components of the extract by a process called chromatography, which takes advantage of the different chemical characteristics of compounds.

Finally, researchers used X-ray crystallography (work done at Emory University in Atlanta), nuclear magnetic resonance

spectroscopy and mass spectral analyses to determine how carbon, oxygen, bromine and hydrogen atoms connected to make up the molecular structures of the 10 new natural products.

Much research is left to do before any of these compounds are used to formulate a drug available on the market,

Kubaneck said. It typically takes at least a decade from the discovery of a compound to the marketing of a new drug. If that does happen in this case, Fijian villagers and the Fijian government would benefit financially from the discovery because of an agreement that is already in place, she added. Because of the long timeframe in getting a drug to market, the project in

Fiji provides other immediate conservation and economic development benefits to villagers and the government.

(Source: Jane M. Sanders, Georgia Institute of Technology Research News, <http://gtresearchnews.gatech.edu/> 12 October 2005



■ MORE ON EATING MORE FISH

For anyone that cherishes good health and values straight facts, the oft-cited statistics of 630,000 American babies born every year with elevated levels of mercury in their blood and potentially damaged brains, if true, ought to be mind-boggling. These American babies are said to have been poisoned before birth when their pregnant mothers consumed fish with trace levels of mercury, and after birth when they were breastfeeding.

The most disturbing aspect of this dangerous environmental mythmaking is that fish is known to be good not only for developing brains but also pregnant women. Scary news is turning women and children away from nutritious fish meals. *[Editor's note: Fish has several apparent health benefits that easily outweigh any risks from mercury in fish; the American Heart Association, for example, has concluded that the benefits of eating fish far outweighs the risks for middle-aged men and post-menopausal women and suggests that people consume two servings of fish weekly given the proven benefits.]*

In 2003, a study found that 8% of women ages 16–49 in a CDC (Centers for Disease Control and Prevention) nutrition and health survey during 1999–2000 had blood mercury levels above the so-called "safe" mercury ref-

erence dose established by the US EPA (Environmental Protection Agency). Since there are over 4 million births in the U.S. annually, the environmentalists and several government scientists were quick to conclude that at least 320,000 babies born in the US each year are in harm's way because of "unsafe" mercury levels in their mothers' blood. Then, in a January 2004 conference presentation, a senior EPA scientist went further, suggesting that there may instead be about 630,000 American babies at risk of brain damage and learning disabilities because earlier estimates neglected to take into account that mercury concentration in cord blood is about twice that measured in body blood by the CDC survey.

In the latest survey of over 5,900 Japanese, 87% of the sample, including 74% of the women of childbearing age, had mercury concentrations above EPA's "safe" level. Another new survey found 56% of Inuit cord blood samples exceeded the EPA's safety standard. Logically, one must either conclude generations of Japanese and Inuits are "brain-damaged" victims suffering from severe and permanent learning deficits or that EPA's "safe" mercury dose is simply arbitrary and extreme.

There are other reasons why mercury alarmists' emotive cries

are neither justified nor credible. For example, children in fourth and eighth grade in Hong Kong outperformed US students on international math and science tests despite having mercury levels in their blood some ten times higher. Postpartum depression rates are known to be low in pregnant mothers eating a lot of fish in Japan, Singapore, Malaysia, Hong Kong, and Chile. The latest controlled trial of dietary supplementation with nutritious fish oils for school children of ages five to twelve in Durham, UK, also found significant improvements in reading, spelling, and behaviour.

The "safe" level of mercury set by EPA is recognized to be the most stringent in the world and is known to be at least ten times higher than any actual levels of concern or harm established by other medical experts. No women in the CDC 1999–2000 survey had blood mercury above actual levels of harm, not by a very wide margin. Furthermore, while in the process of deciding upon a "safe" mercury exposure level in 2001, the EPA had already accounted for the difference in mercury concentrations in cord versus body blood.

Every concerned citizen must also be informed that the "safe" mercury level decided by the EPA was based on a controversial study that would be appli-

cable only to someone who consumes whale meat and blubber with a high concentration not only of mercury but also a host of other toxic chemicals like PCBs. The chief physician of the Faroese Hospital System, Dr Pal Weihe commented in a 2004 letter to the Boston Herald that:

The Faroese children are not exposed to [mercury] by eating fish. They are exposed to mercury by the traditional consumption of pilot whale meat. Fish normally consumed in the Faroes, e.g. cod and haddock, are low in mercury and do not, in my opinion, constitute any threat to the health of the Faroese children. On the contrary, the fish consumption most likely is beneficial to their health.

In sharp contrast, no adverse neuro-developmental problems were found in a more appropriate study of infants and children in a population — with consumption rates as high as twelve to fourteen meals per week — that ate a wide variety of ocean fish as Americans do.

Indeed, numerous benefits have been reported, such as superior eyesight, higher child mental development scores, less hyperactivity, good heart and brain function, and improved intelligence at four years of age.

The warnings by Dr Robert Goyer, chair of the 2000 US National Research Council's

Committee on the Toxicological Effects of Methyl-mercury, were largely ignored until now but deserve a more careful reading:

The offspring of those mothers are exposed to mercury levels that are not considered safe, and, therefore, the committee considered them to be "at risk." [However,] the number should not be interpreted as an estimate of the annual number of cases of adverse neuro-developmental effects. The committee does not believe it is possible to estimate a meaningful number of children that might be affected within the "at risk" population.

The point is that the EPA's mercury safety factor is stringently derived to protect people on the grounds of extreme precautions, and one cannot simply argue that someone is being harmed by mercury when the exposure levels are above that hypothetical "safety" level. In other words, while mercury exposure at or below the EPA limit is unlikely to pose a risk given built-in safety factors, it is not accurate to say that absolutely any exposure above the EPA limit is likely to pose a risk.

There is perhaps even more "bad" news for the mercury scaremongers. The CDC has just recently released its 2001–2002 health survey results. Instead of showing 8% of the 1,709 women surveyed in 1999–2000 to be above EPA's "safe" mercury

level, the latest CDC result reports only 4% of the 1,928 women surveyed in 2001–2002 to be "at risk." One can hardly find any media outlets rushing to report these important updates; instead, there was more hasty extrapolation, for example by Senator Susan Collins, who said that "600,000-plus American children are born each year" at risk of "birth defects, including mental retardation and problems with motor skills."

What about the children? The CDC survey actually carried out blood mercury measurements for young children ages one to five. The 1999–2000 survey documented seven out of 705 (or 1% of) children with blood mercury above the EPA's "safe" mercury dose, while the 2001–2002 survey found only four out of 872 (or 0.5% of) children above it. More importantly, even the highest mercury level measured in this four-year survey still has a safety cushion of more than 500% of the lowest exposure level of concern. Since EPA's "safe" mercury dose is far removed from levels where actual harm could occur, no US children are being dangerously exposed to mercury that could lead to brain or developmental damage.

(Source: American Council of Science and Health
www.acsh.org
www.HealthFactsAndFears.com
18 August 2005)



■ PACIFIC MARINE EDUCATORS CONFERENCE

Marine educators from throughout the Pacific will gather in Suva, Fiji, in January 2007 to share resources and build a network aimed at ensuring the health of the ocean. Web conferencing will allow educators who are unable to travel to Fiji to participate.

The Pacific Marine Educators Conference is an outcome of the One Ocean Marine Forum (OOMF), held in July 2005 at Kahului, Maui, Hawaii. This meeting focused on building an international network of marine educators. The upcoming conference will further that goal by piloting the Pacific.

Pacific islands are early warning indicators of problems, changes and issues facing our ocean. These small, sensitive and fragile islands are microcosms where the interplay of issues such as sustainability, stewardship and climate change becomes readily apparent. Marine educators — using the

widest sense of the word — are invited to participate in this conference focused on the Pacific.

The conference will be held at the University of the South Pacific and is being sponsored by local, regional and international organizations, including the Council of Regional Organizations of the Pacific.

The conference Organizing Committee includes representatives from the Western Pacific Regional Fishery Management Council (USA), University of the South Pacific (Fiji), Marine Education Society of Australasia (Australia), National Marine Educators Association (USA), University of Hawaii (USA), Howard County Public School System (USA), Oregon

Statue University's Hatfield Marine Science Center (USA), Kamehameha Schools (USA) and College of Exploration (USA).

For more information, contact Sylvia Spalding at:

info.wpcouncil@noaa.gov



■ OCEAN INVADERS IN DEEP TIME

Much has been made of the economic impacts of recent biological invasions, but what are the implications of invasions in deep time? Luiz Rocha leads geneticists who time travel through ocean environments. The results of their travels, published online in *Molecular Ecology*, tell us that during warm, interglacial periods, reef-associated fish (goby genus *Gnatholepis*), leapt around the horn of Africa into the Atlantic, where their range expanded as the world warmed.

"We found that global warming events correspond clearly with major range expansions of gobies from the Indian Ocean into the Atlantic Ocean and subsequently into the Eastern Atlantic," summarizes Rocha. A chilly Antarctic current — the Benguela upwelling system — surges up along the western coast of Africa acting as a natural barrier, and has prevented most warm water organisms from the Indian Ocean from making it in to the Atlantic for the last 2 million years. But when the world warmed about 150,000 years ago, gobies slipped around the corner of the continent.

Researchers at the Smithsonian Tropical Research Institute, Scripps Institution of Oceanography, Hofstra University and the University of Hawaii, sequenced goby DNA (774 pb of the mtDNA of cytochrome b, to

be exact) from the western, central and eastern Atlantic Ocean. They also sequenced DNA from gobies in the same genus from South Africa, from the Cocos Keeling Islands in the eastern Indian Ocean, and from the Cook Islands in the South Pacific. They calculate the approximate amount of time that isolated groups of fish have been separate based on the differences in the DNA between groups.

What evidence do they have that makes them think that Atlantic gobies are invaders? "The Atlantic goldspot goby certainly is a prime candidate—it's the only species of the genus in the Atlantic and there are eight species and subspecies in the Indo-Pacific. It's really similar to a sister taxon in the Indian Ocean," Rocha continues. "We nailed down the timeline of the invasion by sequencing—the last time there was tropical ocean connecting these two areas was 2 million years ago. We calcu-

late that these fish invaded the Atlantic Ocean during a warm period about 150,000 years ago and arrived in the eastern Atlantic only 30,000 years ago."

What future effects of climate change might we expect in the marine realm? "Genetic analysis told us that fish from the Indian Ocean breached the Benguela barrier in the past, and this barrier seems to open intermittently. It would be reasonable to expect that other organisms limited by cold water barriers will continue to expand their ranges during warm periods."

Rocha, L.A., Robertson, D.R., Rocha, C., Van Tassell, J.L., Craig, M.T., Bowen, B.W. 2005. Recent invasion of the tropical Atlantic by an Indo-Pacific coral reef fish. *Molecular Ecology* online.

(Source: Smithsonian Tropical Research Institute, www.stri.org, 13 October 2005)



Gnatholepis sp.

■ STUDY FINDS GOVERNMENT ADVISORIES ON FISH CONSUMPTION AND MERCURY MAY DO MORE HARM THAN GOOD

Eating one fish meal per week gives significant nutritional benefit

A comparison of the risks and benefits of fish consumption suggests that government advisories warning women of childbearing age about mercury exposure should be issued with caution. The study warns that if advisories cause fish consumption in the general public to drop out of fear about the effects of mercury, substantial nutritional benefits could be lost. The study will appear as a series of five articles in the November issue of the *American Journal of Preventive Medicine*.

"Fish are an excellent source of omega-3 fatty acids, which may protect against coronary heart disease and stroke, and are thought to aid in the neurological development of unborn babies," said Joshua Cohen, lead author and senior research associate at the Harvard Center for Risk Analysis at HSPH. "If that information gets lost in how the public perceives this issue, then people may inappropriately curtail fish consumption and increase their risk for adverse health outcomes."

Fish are a major source of mercury exposure, a neurotoxin that may cause subtle developmental effects *in utero*, like the loss of a fraction of an IQ point, even at the modest exposure levels typical of the American population. As a result, the US Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) have issued advisories warning women of childbearing age about mercury in fish.

Because fish are also a good source of omega-3 fatty acids, the advisories have had to walk a fine line. The most recent US

government advisories emphasize that other adults need not worry about mercury in fish. They even advise women of childbearing age to keep eating fish, although they caution that group to keep away from some species (shark, swordfish, king mackerel, and tilefish) likely to contain more mercury and to limit total fish intake to about two meals a week.

The Harvard project looked at whether the benefits of lower mercury exposure to pregnant women justified the loss of omega-3 fatty acids from decreased fish consumption. The project also went one step further, asking what would happen if the public did not follow the government's recommendations exactly as they were intended. Although evidence on how people actually react to advisories is limited, one study found that pregnant women cut their fish consumption by one-sixth following a 2001 government advisory. Nor is it difficult to imagine that other adults, not targeted by the advisory, cut back on fish based on misperceptions about the risks.

In order to synthesize the available evidence, the Harvard project convened a panel of experts, chaired by Steven Teutsch, a medical epidemiologist formerly with the US Centers for Disease Control and Prevention and now at Merck and Company. Other panel members included David Bellinger (Harvard University), William Connor (Oregon Health Sciences University), Penny Kris-Etherton (Pennsylvania State University), Robert Lawrence (Johns Hopkins University), David Savitz (University of North Carolina), and Bennett Shaywitz (Yale University). The panel identified important health effects to consider, assessed the

dose-response relationships between fish consumption (or its constituents) and health outcomes, and developed an overall health effects model. In addition to Joshua Cohen, Harvard scientific staff included Colleen Bouzan and Ariane König, and principal investigator, George Gray, executive director of the Harvard Center for Risk Analysis.

The study found that if pregnant women were to eat the same amount of fish but replace fish high in mercury with fish low in mercury, cognitive development benefits, amounting to about 0.1 IQ points per newborn baby, could be achieved with virtually no nutritional losses. However, if pregnant women were to decrease their fish consumption by one-sixth, the loss of omega-3 fatty acids during pregnancy would cut the nutritional benefit by 80%. If other adults were to also decrease their fish intake by one-sixth, then risks from coronary heart disease and stroke would increase. For example, among 65 to 74 year old men, the annual mortality risk would increase by nearly 1 in 10,000.

The study also found that increasing fish consumption among individuals who were not going to become pregnant would substantially decrease stroke and coronary heart disease risks. Much of this benefit appears to be associated with getting people to eat at least some fish (e.g. one meal a week), rather than no fish at all.

Cohen explained that the problem with fish advisories is that we do not know what their overall impact on the population might be. "Depending on how the population reacts, that impact could very well be nega-

tive." Because of the potential downside, Cohen urges the government to carefully evaluate the pros and cons. He concluded, "Before the government issues advisories, it needs to gather data on how people actually will react, how those changes in behavior will influence nutrient intake and exposure to contaminants, and how those changes in intake and exposure will translate into changes in health. In other words, before we put an intervention into action, we need to estimate its real world impacts — both its benefits and its countervailing risks."

The work was funded by a grant from the National Food Processors Association Research Foundation (now the Food Products Association Research Foundation) and the Fisheries Scholarship Fund.

The five articles and the introductory article from the American Journal of Preventive Medicine will be available as PDFs shortly.

"A Quantitative Analysis of Fish Consumption and Stroke Risk" by Colleen Bouzan, MS, Joshua T. Cohen, PhD, William E. Connor, MD, Penny M. Kris-Etherton, PhD, George M. Gray, PhD, Ariane König, PhD, Robert S. Lawrence, MD, David A. Savitz, PhD, and Steven M. Teutsch, MD

"A Quantitative Analysis of Fish Consumption and Coronary Heart Disease Mortality" by Ariane König, PhD, Colleen Bouzan, MS, Joshua T. Cohen, PhD, William E. Connor, MD, Penny M. Kris-Etherton, PhD, George M. Gray, PhD, Robert S. Lawrence, MD, David A. Savitz, PhD, and Steven M. Teutsch, MD

"A Quantitative Analysis of Prenatal Methyl Mercury Exposure and Cognitive Development" by Joshua T. Cohen, PhD, David C. Bellinger, PhD, and Bennett A. Shaywitz, MD

"A Quantitative Analysis of Prenatal Intake of n-3 Polyunsaturated Fatty Acids and Cognitive Development" by Joshua T. Cohen, PhD, David C. Bellinger, PhD, William E. Connor, MD, and Bennett A. Shaywitz, MD

"A Quantitative RiskBenefit Analysis of Changes in Population Fish Consumption" by Joshua T. Cohen, PhD, David C. Bellinger, PhD, William E. Connor, MD, Penny M. Kris-Etherton, PhD, Robert S. Lawrence, MD, David A. Savitz, PhD, Bennett A. Shaywitz, MD, Steven M. Teutsch, MD, and George M. Gray, PhD

(Source: Harvard School of Public Health

<http://www.hsph.harvard.edu/>
19 October 2005)



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DIET OF FOUR TUNA SPECIES OF THE WESTERN AND CENTRAL PACIFIC OCEAN

Introduction

Assessing the impact of fisheries and environmental variability on an ecosystem — in order to develop ecosystem approaches to fisheries management — requires a good comprehension of the elements of this system. Fish predation induces mortality in the ecosystem that is often higher than fishery mortality, and determining trophic interactions between species is a major step towards a better understanding and modelling of dynamics of this ecosystem.

A large sampling programme, involving the collection of samples and determining the diet of top predators, has been implemented in the western and central Pacific Ocean in order to develop a better understanding of the pelagic ecosystem. Based on stomach content data, this paper (presented during the first regular session of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean; see article on p. 2) discusses the diet of four tuna species of the warm pool area, where most tropical tuna fishing occurs. The classification

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of prey according to their vertical distribution and migration provides information on tuna behaviour.

Methods

Sampling programme, sampling protocol

Stomach samples are collected from target fish (tunas) and bycatch species by observers from the different national observer programmes in the area. Since the beginning of the programme in January 2001, 81 sampling trips have been made: 54 on longline boats, 17 on purse-seine vessels, and 10 on other boats. Sampling trips were organised as follows: French Polynesia (20), New Caledonia (13), Federated States of Micronesia (2), Papua New Guinea (6), Solomon Islands (12), the FSM Arrangement programme (10), Marshall Islands (1), SPC (2), Wallis and Futuna (1), ships of opportunity (12), Cook Islands (2).

Stomach examination

Prey were sorted by species or group, and identified at the lowest taxonomic level. A digestion state was attributed, from 1 (fresh) to 4 (bones), the development state determined when possible (larvae, juvenile, adult), and prey were counted, weighed and measured. Forage species prey were classified according to their depth distribution and vertical behaviour (from epipelagic to mesopelagic and bathypelagic, with night-surface migrating

components) and to the degree of association with reefs (data compiled from literature).

Sample characteristics

This study presents only data from samples collected in the warm pool: 173 yellowfin (YFT), 119 bigeye (BET), 300 skipjack (SKJ), and 12 albacore tuna (ALB). Most of the fish collected were caught by purse seine but a significant proportion of the YFT and BET were caught by longline, as well as all the ALB. Mean length of the fish examined are: YFT and BET, about 77 cm, SKJ 54 cm and ALB 94 cm. Fish smaller than 80 cm were generally caught by purse seine and larger fish by longline.

Nearly all the SKJ and ALB examined were considered to be adults, while all BET were juveniles, as were more than two thirds of the YFT.

Results and discussion

Diet description

Prey groups

The most important prey groups (see graph below) found in the stomachs (measured by weight) were identical for all four tuna species: fish (64–88%), molluscs (6–25%) and crustaceans (0.2–9%). The most piscivorous species was SKJ, while ALB presented the lowest proportion of fish and the highest of molluscs. YFT had the highest crustacean content.

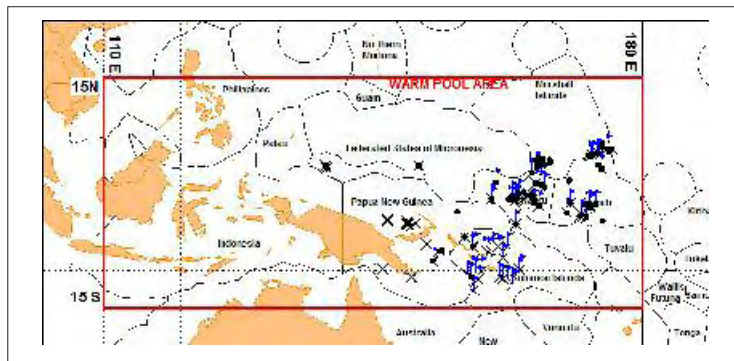
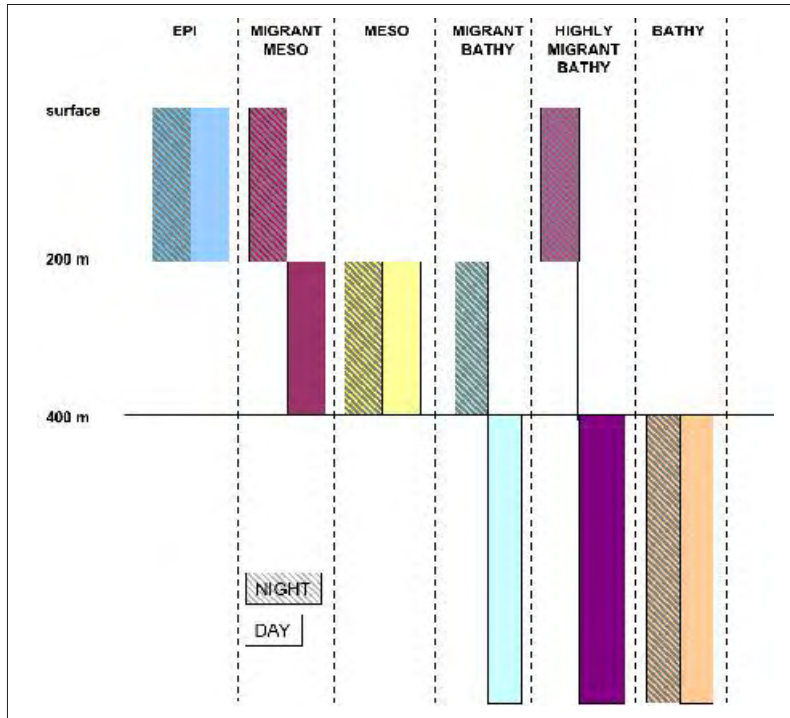
SKJ is a true piscivore while YFT and ALB have a more diversified diet, including crustaceans and molluscs; BET has an intermediate diet composed mainly of fish and molluscs.

Prey items

BET: Not taking into account the undefined items, the most important prey group in terms of



Prey from the stomach of a tuna: fish, squid and shrimp



Top: Vertical distribution and migration of forage species
Bottom: Locations of the tuna sampled for the study in the warm pool. BET (flag), SKJ (circle), YFT (cross)

weight is the mesopelagic class (36%), particularly Paralepididae (barracudinas; 22.3%), Sternoptychidae (hatchetfish; 7%) and the squid *Moroteuthis* sp. (2%). The second prey group is the deep bathypelagic, including a Paralepididae (*Magnisudis indica*; 10%) but also Diretmidae, Scopelarchidae and Chiasmodontidae (3%, 2% and 1%). Epipelagic prey and surface migrating prey represent 5, 5 and 7% of the diet with SKJ specimens (2%), the squid *Stenoteuthis oualaniensis* (3%) and Myctophidae (4%).

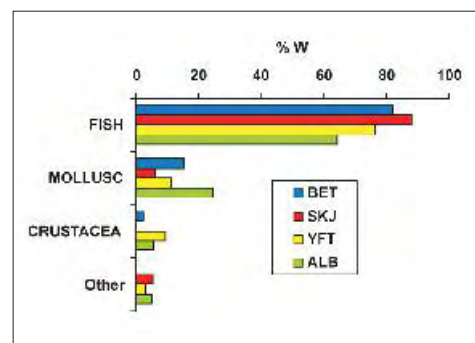
This diet composition is in agreement with the vertical

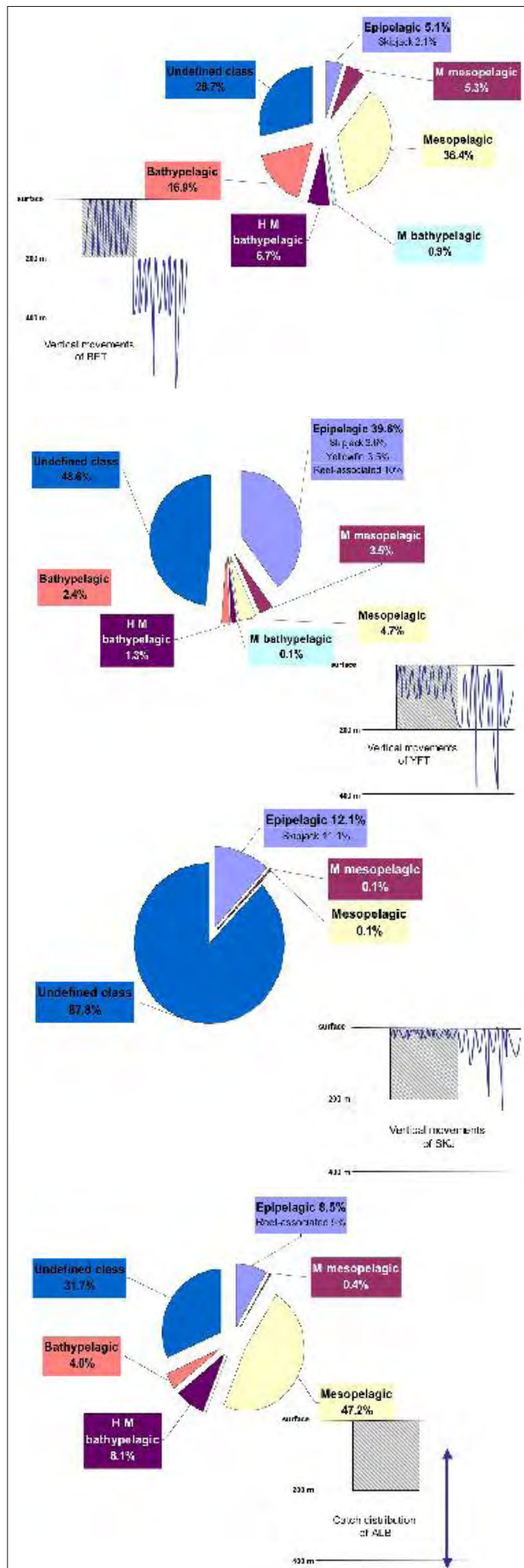
behaviour of BET, as determined through electronic tagging: at night they stay between the surface and 250 m, while during the day they dive to depths of 200–500 m, and on rare occasions as deep as 900 m (Allain et al. 2005; Musyl et al. 2003). This suggests that this species eats during the day and at night at all depths. This is in agreement with its eye characteristics, which makes BET an efficient visual hunter even in dim light (Fritsches and Warrant 2001).

YFT: A large portion of the YFT diet is composed of epipelagic prey (40%), particularly *Elagatis bipinnulatus* (rainbow runner; 7%), Exocoetidae (flying fish; 4%), SKJ (4%), YFT (3%), juvenile reef fish, including Acanthuridae (surgeon fish; 2%), Balistidae (trigger fish; 3%), Tetraodontidae (puffer fish; 2%) and small crustacea (megalopa, Amphipoda, Stomatopoda, and Phronima). The reef-associated prey species represent 10% (by weight) of the YFT diet. YFT also consumes deeper prey species: mesopelagics (5%) including Paralepididae (3%), bathypelagic species (Chiasmodontidae; 2%), and migrant deep prey (the squid *Stenoteuthis oualaniensis*; 2%) and Myctophidae (lanternfishes; 1%).

It is interesting to note the presence of juvenile tuna in the YFT diet, demonstrating predation pressure on SKJ (4%) and cannibalism (3%). It also appears that YFT can have an important impact on the mortality of juvenile reef-associated fish; this predation is opportunistic and depends on the area and the presence of islands (Allain 2004). The predominantly epipelagic diet is in agreement with what is known regarding the vertical distribution of YFT, which stays between the surface and 200 m (both during the day and at night), and dives to 500 m depths on rare occasions (Dagorn et al. 2001).

SKJ: Because of the large portion of highly digested and unrecognizable prey, for which the vertical class could not be





defined, less than 13% of the prey (by weight) could be classified; a total of 12% of prey were epipelagic. The most important prey is SKJ (11%), with other prey collectively representing less than 1% (these include Bramidae, Acanthuridae, Pomacanthidae, and Stomatopoda). Deeper prey species accounted for less than 0.1%.

On the basis of the prey items identified, SKJ is exclusively an epipelagic predator and shows significant cannibalism. It will be important to try to improve the percentage of identified prey to validate this high rate of cannibalism. Genetic techniques coupled with examination of hard parts is a promising technique in identifying highly digested prey (Smith et al. 2005) and could be applied to the case of SKJ to obtain a more accurate estimate of cannibalism. SKJ is an epipelagic predator that stays between the surface and 100 m during the day and night, diving on rare occasions to depths of up to 250 m (Ogura 2003); the fact that no deep prey that migrate to the surface at night were found in their stomach contents suggests SKJ feed exclusively during the day. This is in agreement with the fact that all SKJ caught early in the morning around FADs have empty stomachs; however, the hypothesis of exclusively daytime feeding needs to be confirmed by analysis of an increased percentage of identified preys. In addition, the effect on FADs on SKJ feeding strategy needs to be clarified (Musyl et al. 2003)

ALB: The most important prey group in the ALB diet consists of the mesopelagics (47%), particularly Paralepididae (25%), the squid *Ancistrocheirus lesueuri* (9%), the squid *Moroteuthis* sp. (7%) and the fish *Scombrobrax heterolepis* (black mackerel; 3%). Epipelagics and surface migrating bathypelagics both represent 8%, including the cephalopoda Sepiida (1%), small crustacea (megalopa 1% and Stomatopoda 1%), Acanthuridae (1%) and Myctophidae (8%). Reef-associated prey species represent 5% of the ALB diet. ALB also consumes deep bathypelagic

Prey items for the four different species of tuna; from top to bottom: BET, YFT, SKJ, and ALB

prey (4%) such as Chiasmodontidae (3%) and *Sternoptyx* sp. (hatchet fish 1%).

The ALB diet is similar to that of BET, but ALB do not appear to dive as deep, relying more on mesopelagic and epipelagic prey (including reef-associated species), or surface migrating prey. Deep prey species (bathypelagics) are less important for ALB than they are for BET (4% and 17%, respectively). Few data are available on the vertical movements of ALB, but diet data are in agreement with depth distribution inferred from catch data.

Prey size distribution

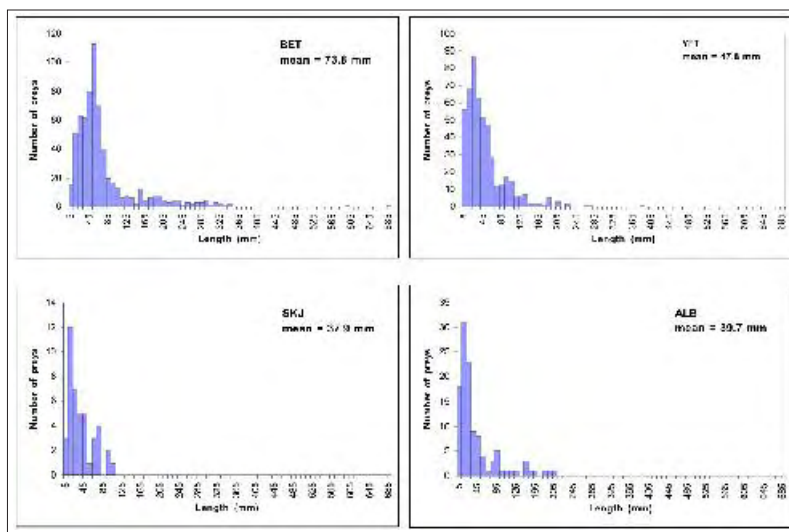
BET ingests prey between 0 and 690 mm, with most in the 50–60 mm length class. Other tuna species eat smaller prey: SKJ, prey length ranged from 0–109 mm, with most in the 10–20 mm class; YFT, 0–387 mm and 20–30 mm; ALB, 2–203 mm and 10–20 mm.

Conclusion

Examination of tuna stomach contents provides important information on feeding strategies. It appears that to balance its high metabolism SKJ eats more and digests faster than the

other tuna species. Due to their vertical distribution and behaviour, the four tuna species have access to different depth strata, and this is noticeable in the composition of their diet. SKJ, which stays closer to the surface, eats only epipelagic prey (mainly fish), with a very high cannibalism rate, and shows a low diversity in prey. YFT eats also mainly surface preys but also deep water organisms. BET and ALB have a high percentage of deep preys in their diet. While the diets of these pairs of species (SKJ and YFT, and ALB and BET) show similarities, there are differences in the size of the prey consumed. The diet of the four tuna species shows relatively low overlap.

Diet studies provide information on basic biology and behaviour of the fish, but are also an important part of the parameterization of ecosystem models such as Ecopath/Ecosim (Allain 2005). Information such as prey diversity, prey size, and diet composition can be used in conjunction with other ecosystem indicators to detect changes in the ecosystem (Kirby et al. 2005).



Length-frequency distribution of the prey consumed by the different predators

References

- Allain V. 2005. Ecopath model of the pelagic ecosystem of the WCPO. WCPFC-SC1, EB-WP10. Noumea, New Caledonia, 9–18 August 2005.
- Allain V. 2004. Diet of yellowfin tuna in different areas of the western and central Pacific Ocean. SCTB17 – BIO1. Majuro, Marshall Islands. 9–18 August 2004.
- Allain G., Lehodey P. and Kirby D. 2005. The influence of the environment on horizontal and vertical bigeye tuna movements investigated by analysis of archival tag records and ecosystem model outputs. WCPFC-SC1, BI-WP3. Noumea, New Caledonia, 9–18 August 2005.
- Dagorn L., Josse E. and Bach P. 2001. Association of yellowfin tuna with tracking vessels during ultrasonic telemetry experiments. Fishery Bulletin 99:40–48.
- Fritsches K. and Warrant E. 2001. New discoveries in visual performance of pelagic fishes. PFRP Newsletter 6(3):1–3.
- Kirby D., Allain V. and Molony B. 2005. Potential ecosystem indicators for the WCPO. WCPFC-SC1, EB-WP5. Noumea, New Caledonia, 9–18 August 2005.
- Musyl M., Brill R., Boggs C., Curran D., Kazama T. and Seki M. 2003. Vertical movements of bigeye tuna associated with islands, buoys, and seamounts near the main Hawaiian islands from archival tagging data. Fisheries Oceanography 12(3):152–169.
- Ogura M. 2003. Swimming behavior of skipjack, observed by the DST at the NW Pacific. SCTB16–SKJ7. Mooloolaba, Australia. 9–16 July 2003.
- Smith P.J., McVeagh S.M., Allain V. and Sanchez C. 2005. DNA identification of gut contents of large pelagic fishes. Journal of Fish Biology 67:1178–1183.



DEVELOPMENT OF COMMERCIAL AND FARM-MADE FEEDS FOR TILAPIA AND *MACROBRACHIUM* IN PAPUA NEW GUINEA AND FIJI

Introduction

The development of tilapia and freshwater prawn *Macrobrachium rosenbergii* culture in Papua New Guinea (PNG) and Fiji has been rather slow due to a lack of expertise and the absence of appropriate resources and technology. One of the key constraints has been the poor quality and limited availability of supplementary feeds. Although feed manufacturers in both countries have recognized that fish and prawn feeds are potential new product lines, the development of effective fish and prawn feeds has not occurred. This is due to low demand by farmers, in part because of the small size of the tilapia and prawn industries.

Since the cost of feed represents the major expense in semi-intensive tilapia culture and aquaculture, feeds and feeding must be cost-effective in order to maintain or increase profit. A limited range of formulated aquafeeds are available locally in PNG and Fiji. These have been shown to provide better tilapia growth than single-ingredient feeds but are very costly and sometimes limited in availability. Consequently, a lower-cost compound diet for semi-intensive production of tilapia and prawns, formulated from locally available ingredients, must be developed if aquaculture is to expand. Fisheries authorities in both Fiji and PNG recognize the need for cheaper compound feeds, and provided the impetus for a mini-project on the development of commercial and farm-made feeds for

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tilapia and *Macrobrachium* in PNG and Fiji.

This research is part of the larger Sustainable Aquaculture Development in the Pacific Islands Region and Northern Australia project, which receives funding support from the Australian Centre for International Agricultural Research (ACIAR). The Queensland Department of Primary Industries and Fisheries (QDPI&F), Secretariat of the Pacific Community (SPC) and the WorldFish Center are collaborators in the project. This mini-project involves Fiji's Ministry of Fisheries and Forests and PNG's National Fisheries Authority. Following a planning workshop held in Suva in April 2005 (see article in this issue), two experiments were designed to evaluate cheaper, formulated feeds that are produced using locally available ingredients. The experiments commenced at Naduruloulou Aquaculture Station on 3 August 2005 after two weeks of preparatory work.

Research design

Experimental objectives: to develop a better, lower cost diet for tilapia and Macrobrachium culture in Fiji.

The experiments (one for tilapia and one for *Macrobrachium*) are being conducted at Naduruloulou Aquaculture Station, 7 km north of Nausori town on the island of Viti Levu, Fiji.

Tilapia

Twenty hapa (9 m²) have been installed in two earthen ponds (600 m²). Each hapa was stocked with 200 tilapia fingerlings (av. wt. 1.74 g). The stocks were reduced to 100 juveniles per hapa after 42 days of rearing. (a hapa is an enclosure of fine mesh net used for breeding fish and nursing fry)

Macrobrachium

Fifteen plastic tanks (1000 L each) have been set up under a shelter (shade screen and supplied with running water and aeration). Each tank was stocked with 10 juvenile prawns (av. wt. 5 g). Both experiments will run for a period of 120 days with sampling carried out every 21 days.

Four experimental feeds were formulated, containing: 1) approximately 20% crude protein (CP) with a vitamin/mineral mix (VM); 2) 20% CP without VM; 3) 32% CP with VM; and 4) 32% CP without VM. The feeds have similar composition with varying amounts of mill mix bran, fishmeal, coconut meal, rice pollard, and wheat flour and vitamin mineral mix. The feeds have been processed into pellets (3 mm) using a mechanical mixer and extruder, then broken down into suitable sizes and dried to a moisture content of about 10%. Local tilapia feed (containing approximately 29% CP) is being used as a control feed. Each of the five feeds is being fed to tilapia in four different hapas (resulting in 20 tilapia hapas in total) and to *Macrobrachium* in three different tanks (15 *Macrobrachium* tanks in total).

Tilapia are fed twice daily, once in the morning and once in the afternoon, at a daily rate of 10% of body weight (this will be reduced to 5% by end of the experiment). At least 30% of the total number of tilapia stocked in each hapa will be sampled every 21 days to determine the average weight and adjust the feeding rates.

Macrobrachium are also fed twice daily, with 30% of the ration in the morning and 70% in the evening. The initial feeding rate is 15% of the body weight and this will be adjusted to around 5% by end of the experiment. All the prawns in each tank will be sampled every 21 days to determine the average weight and adjust the feeding rates. Feed is delivered onto feeding trays in each tank using a PVC pipe to ensure feeds get onto trays while minimizing pellet disintegration. All uneaten feed is siphoned out of each tank every morning. The feed is filtered through plankton net mesh to retain solid matter and discard water. The solid matter of each tank is kept separate and dried in an oven to calculate the amount of feed actually eaten by prawns.

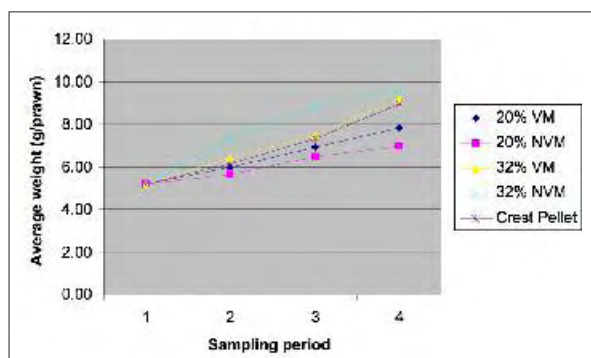
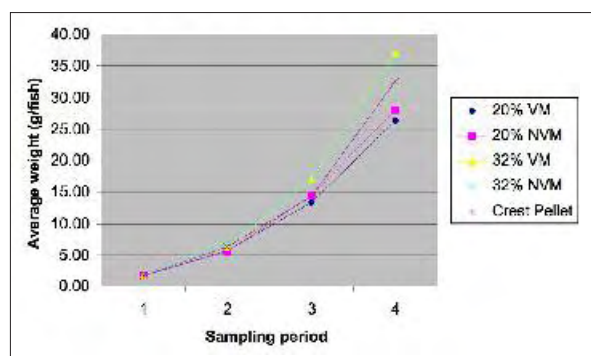
Water temperature is recorded twice daily (at 0900 and 1600 hours, using a mercury thermometer) and pH, dissolved oxygen (using meters) and NH_3 (using test kits) are measured weekly.

The composition and proximate analysis of the feeds, including response variables (survival, weight gain, specific growth rate, feed intake and food conversion ration), will be calculated after the final sampling, which is due on 7 December 2005.

Results to date (after third sampling period) are presented on this page.

Acknowledgements

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Tilapia (top) and *Macrobrachium* (bottom) growths on different diets



Hapas set up in pond for tilapia trials





Top: Shalini (left) and Shirleen (right) emptying trays of dried feed
Middle: Shalini weighing feed ingredients, feed mixer and feed grinder on the left
Bottom: Tanks under shade screen for prawn trial