BREAKING NEWS

The Philippines has just approved its first-ever official protection of spawning aggregations. Two spawning aggregations have been included within year-round protected areas, with strong community support, in Taytay, northeastern Palawan.
For more information, see Newsletter.

A spawning aggregation of grey mackerel, *Scomberomorus semifasciatus*, is reportedly being overfished by commercial netters in Australia, according to fisher records. The Queensland State Government is looking at the issue in its review of inshore net fisheries
Cairns Weekend Post. Sept. 9-10, 2006, p. 8

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SCRFA

SOCIETY FOR THE CONSERVATION OF REEF FISH AGGREGATIONS

NEWSLETTER • NUMBER 9 • AUGUST 2006

WORDS FROM THE CHAIR

Welcome to SCRFA Newsletter issue No. 9 which provides another snapshot of what is happening globally, and facilitates a network of communication on fish spawning aggregation issues.

The first Breaking News item is a very exciting outcome for SCRFA, WWF and the Philippines. The strong community support for the protection of spawning aggregations in the Philippines is another clear indication of the gradual shift we are seeing in awareness of the need to protect fish spawning aggregations throughout the tropics. Yvonne is following up on this at a national Marine Protected Areas Summit for Mayors in Cebu in October.

The SCRFA Board will hold its annual Board meeting in San Diego on 13-14 November 2006. We will be preparing for another year of outreach, and management and research initiatives.

We have a new Board member. I am very pleased to welcome Janet Gibson to the SCRFA Board of Directors. Janet is a Belizean who has spent most of her career working in marine conservation. She is currently the Wildlife Conservation Society's marine programme coordinator for the Mesoamerican region and one of the team that worked so successfully to manage Belizean spawning aggregations. Janet replaces Ken Lindeman on the Board. I would like to take this opportunity to thank Ken for all his valuable and stimulating contributions to SCRFA over the past few years, and for his continued support for the Society.

Enjoy the newsletter.

Martin Russell
Chair, SCRFA

SCRFA NEWS

It is a pleasure for me to pull together the various articles submitted for this Newsletter. Not only because they are diverse and cover a wide range of issues and a fair range of species, but also because, as a community interested in fish spawning aggregations, we really seem to be making some progress. The articles include several reports of recent or planned protection (USVI, Fiji, Philippines), a growing number of species attracting attention (mojarras, croakers), as well as follow-up work and research after measures have been put in place (Bahamas,

Belize, Pohnpei; also see the Publications listing for the, Grouper Moon Project). The articles reflect the remarkable growth of activity in spawning aggregation research, management and conservation since 2000, when this aspect of fisheries and fish biology began to attract much overdue interest and when SCRFA was formed. They also show how the real work begins after management is put in place.

Since Newsletter No. 8, we conducted a workshop, in July, in Suva, Fiji, to summarize our interview and outreach work to government, NGOs and communities, and to discuss follow-up actions. This workshop, the first in Fiji on reef fishery management and co-organized with the Fisheries Department, was very well received. I will include a report, in our next newsletter. One clear message that arose during the workshop was that, as long as traditional (i.e. for special or ceremonial events) uses of aggregations in Fiji could be maintained, their protection was likely to have a lot of community support. While this may seem obvious, it is easy to forget subtleties in conveying messages that can mean the success or failure of a proposed management initiative; in this case a blanket seasonal protection of spawning aggregations would have precluded rare traditional use (such as the death of a Chief); certainly not the intention.

We continue to work closely with the WWF in the Philippines and are delighted to report on a very recent success; the first legally protected spawning aggregation in the country (for article, see below). We discovered an aggregation from exploratory interviews, verified it by diving and now it has legal protection. A particularly interesting spinoff from this work is that the focus on marine resources brought about by attention on aggregations (the importance of which is easy to understand) has snowballed into a much broader discussion and consideration of cooperative coastal management in the area. The lesson learned is that success in something small and readily understood, can be an excellent way to lay the foundation for wider debates on more complex but intimately related issues.

We continue to work closely with the WWF in the Philippines and are delighted to report on a very recent success; the first legally protected spawning aggregation in the country.

After months of hard work, the GIS component of the SCRFA database is ready for inspection (**http://www.scrfa.org:8888/website/scrfa/viewer.htm**). This enables you to make specific searches by country or species, as well as allowing access to various GIS layers such as coral reef areas and socio-economic data. I hope that this is a useful addition to the reference database and would welcome feedback and comments.

Meetings that will include sessions or case studies on spawning aggregations later this year, and that we plan to participate in include: ITMEMS3 which will be running a Fisheries and Aquaculture theme (**http://www.itmems.org/agenda.htm**) as part of its agenda; the 59th Gulf and Caribbean Fisheries Institute, in Belize **http://www.gcfi.org/Conferences/59th/Belize59.htm** , which, for years has included an active spawning aggregation session; and a National Mayor's Summit on Marine Protected Areas in Cebu, Philippines, where we will run a special session on spawning aggregations.

Finally, I continue, in this issue, with the *Perspectives* theme we introduced in the last newsletter. This time I will be talking about several of the biological considerations needed when determining the management of species that aggregate to spawn. As before, I would welcome feedback from your own experiences or research.

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Director, SCRFA scrfa@hku.hk

Bahamas

Bahamas
Nassau grouper news

In support of the 2006 seasonal protection of the Nassau grouper (see last newsletter), the Bahamas Reef Environment Educational Foundation (BREEF) conducted a large public relations campaign in the Bahamas. This included a request to restaurants not to serve Nassaus during the closed season (the regulation prohibited purchase and sale of the species). While some restaurants complied, others continued to sell the species, sometimes at increased prices. Some even advertised 'fresh Nassau grouper specials'! According to the regulation, groupers should be landed whole but some on sale were found to be filleted. BREEF's experience illustrates yet another complexity of making management work.

Casuarina McKinney (BREEF) casuarina@breef.org

Belize

Belize
Update on the Belize Spawning Aggregation Working Group

Following a national survey of many of Belize's Nassau grouper, *Epinephelus striatus*, spawning sites conducted during the 2000 – 2001 aggregation period and spearheaded by the Green Reef Environmental Institute, the drastic decline in numbers of spawning groupers was dramatically brought to the attention of many concerned organizations at a historic workshop held in July 2001 in Belize City. An outcome of this meeting was the formation of a special working group, tasked with developing actions to stem the decline which met on several occasions during the following year. No concrete protective measures, however, were taken and the group met less and less frequently.

A coalition of NGOs established in late 2002 decided that urgent action was essential if the spawning banks were not to be lost.

A coalition of NGOs established in late 2002 decided that urgent action was essential if the spawning banks were not to be lost. The members implemented a campaign that led to the passing of legislation that provided full protection to 11 sites and introduced a closed season for Nassau grouper. The coalition realized that this action marked only the beginning of a process and that monitoring, education and public awareness needed to continue in the longer term. This core group therefore revitalized the original committee formed the previous year, and it has been meeting every two months, or more frequently, ever since.

The Working Group is composed of members from the Fisheries Department, the marine reserves, NGOs and reserve co-managers, and fishermen. It recognizes, though, that the representation of fishermen needs to be strengthened, a factor that the Group intends to address in the coming year. The Group's goal is 'to manage spawning aggregation sites and gather data that can be used to develop strategies to maintain these as viable sites for the protection, conservation and sustainable use for the fishery.' Its main earlier efforts included the monitoring of sites using an agreed protocol, training in the monitoring method, promotion of dive safety, and public awareness and education. The latter program has led to the production of a television advertisement, posters, and newsletters that report on the monitoring results. Many of the monitoring teams also hire former spawning bank fishermen to assist with the research and data collection.

The success of the Group has been noticed within the region and members have shared their experience with Mexican authorities which are interested in starting a similar Group for their spawning aggregation sites within the Mesoamerican reef region.

The Group subsequently turned its attention to establishing a web-based database to house the monitoring data. This is a major project, which will take a great deal of care and work and which is still under development. It has received valuable advice from SCRFA in this endeavour. The organizations involved in the monitoring and data collection are signatories to a data-sharing agreement that will govern the use of the database. Preliminary results of the monitoring of priority sites over the past four years indicate that at least three sites have more or less maintained or slightly increased their counts of spawning Nassau groupers. Further analysis of the data needs to be conducted, however, and this aspect will be incorporated in the database project.

The Working Group members are presently preparing their work plan for July 2006 – June 2007 and hope to have a web site up and running before the end of 2006. It plans to continue and strengthen its core programs of monitoring and data management, training, and public awareness. The success of the Group has been noticed within the region and members have shared their experience with Mexican authorities which are interested in starting a similar Group for their spawning aggregation sites within the Mesoamerican reef region.

Janet Gibson (Wildlife Conservation Society) jgibson@btl.net

Editor's note: during the 2006 spawning season, a Nassau grouper aggregation site at Glover's Reef, Belize, was surveyed and had 3,000 groupers in January. The site was fully protected in 2002 and has shown promising changes, from 1,700 fish in 2004 to 2,240 fish in 2005. Longer term work is needed to conclude a real increase, given natural variability that occurs in spawning fish numbers, but the results to date are extremely encouraging.

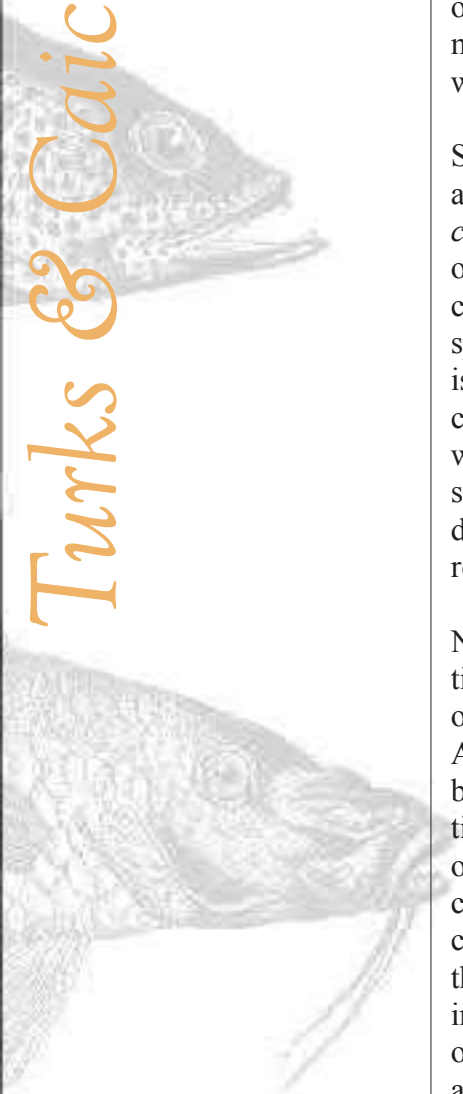
Turks & Caicos

Turks and Caicos
Spawning aggregation of yellowfin mojarras

From July to August in 2005 and 2006, a massive aggregation of this mojarra, consisting of individuals from many schools, was found gathering on a specific shallow reef area.

The yellowfin mojarra, *Gerres cinereus*, is usually found in schools of up to several thousand individuals on shallow banks associated with seagrass and mangrove areas around South Caicos, Turks and Caicos Islands. This species is occasionally seen in shallow coral reef areas, but seldom in large numbers. However, from July to August in 2005 and 2006, a massive aggregation of this mojarra, consisting of individuals from many schools, was found gathering on a specific shallow reef area. Estimating the size of this aggregation was difficult, but there appeared to be over 100,000 individuals that covered the substratum like a carpet, with densities sometimes exceeding 20 individuals m^{-2}. Only preliminary information on this aggregation is presented herein, as research is ongoing.

During the day, the aggregation rests over an area of patch reef in a sheltered channel inside a harbour lying about 100 m leeward of where the waves break on a fringing reef crest. However, about one hour before sunset, the whole aggregation moves from this relatively protected area, following a consistent path along the fringing reef around the exposed side of a series of small islands and into an exposed channel 300 m wide and with a maximum depth of 7 m at the mouth of the harbour roughly 150 m away from its daily resting location. Fifty individuals were collected during this migration in 2006. In order to limit



The yellowfin mojarra is not a highly sought-after food fish in the Turks and Caicos Islands, although on the docks and other areas of coast where a small number of locals (mainly children) cast hand lines, catches of large numbers of mojarras have been observed during the first week this aggregation was documented in 2006.

disturbance of the aggregation, small numbers of individuals were colleted over successive days. Through analysis of gonads, all females were found to have ripe ovaries, all males released sperm, and the sex ratio of the catch was more than 3 males to each female. In addition, the mean standard length of females caught was significantly larger than that of males.

Spawning has only been observed within the exposed channel. The actual spawning act was observed daily over 14 separate days, occurring around dusk. *Gerres cinereus* appears to be an egg-scatterer. Smaller groups of several thousands break off the main aggregation and move out into the deeper water in the middle of the channel at around 4 to 7 m depth. Often moving in a circular pattern, eggs and sperm are released within 1m (usually < 30 cm) of the substratum. Gamete release is not associated with any behaviour, such as spawning rushes, and gamete release can only be confirmed by the increasing milkiness of the bottom layer of the water. These gamete clouds never appeared to rise much above 1.5 m from the substratum. Occasionally, individuals would stop within these aggregations, but due to the lack of light it was unclear whether this was associated with gamete release. Following spawning, the groups return to the main aggregation.

Neither the substratum type over which spawning occurred nor the currents at the times of spawning appeared to be consistent. Substratum types included; areas of coarse sand, hard limestone substratum, rubble, gorgonians, and stony corals. Although the channel where spawning occurs is subject to strong tidal currents both into the shallow harbour at rising tide and out into deeper water at falling tide (sometimes too strong for observers to swim against), spawning appears to occur regardless of the currents, having been documented at times of strong currents both into and out of the harbour, as well as at times with no discernible current at all. Presently, it is not clear whether there is any lunar periodicity to this aggregation. However, the aggregation has remained since it was first seen in July, and spawning appears to occur on a daily basis, having been documented on every day that weather has permitted observation. These observations include a period of over 10 consecutive days and include days around all four lunar quarter phases.

Two species of surgeonfishes also spawn in aggregations in the late afternoon in areas that overlap the mojarra spawning area. As part of a study on these surgeonfishes, data were collected on the presence of large predatory fishes in this area from early afternoon until dusk. Comparing these data to observations of predatory behaviour around the mojarra aggregation, the presence and activity of barracudas, jacks, large groupers and sharks appears to be enhanced and numerous predatory attacks by jacks and barracudas have been witnessed.

The yellowfin mojarra is not a highly sought-after food fish in the Turks and Caicos Islands, although on the docks and other areas of coast where a small number of locals (mainly children) cast hand lines, catches of large numbers of mojarras have been observed during the first week this aggregation was documented in 2006. Unfortunately, it was not possible to analyse the characteristics of these catches (sizes and presence of eggs or sperm). These catches suggest that the mojarras migrate following the coast from their usual foraging areas in mangroves and seagrass. A number of fish/lobster traps were illegally placed along the area where the mojarras migrate from their daily resting area to their dusk spawning site. However, it is more likely that grouper were being targeted and no mojarras were found in these traps when they were removed; it is also unlikely that this

More Information

For further information or materials, see www.SCRFA.org, or contact SCRFA@hku.hk

aggregation is known by local fishermen.

More research is being conducted on this aggregation of mojarras. In particular, a tagging program is planned to determine the area from which individuals migrate to spawn, as well as to look for other spawning aggregations of this species in similar locations around the Turks and Caicos Islands.

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United States – Virgin Islands

*Fishing at Grammanik Bank, St. Thomas, U.S. Virgin Islands was shut down for the 2006 spawning season of Nassau (**Epinephelus striatus**) and yellowfin groupers (**Mycteroperca venenosa**).*

Turbe, a local fisherman and conservationist who assists with the studies, has dived on spawning aggregation areas since the 1970s and has seen Nassau and yellowfin grouper numbers plummet in the last 20 years because of overfishing. He called the partial-year closure of Grammanik Bank "a super decision."

United States – Virgin Islands
Spawning season closures for groupers

Fishing at Grammanik Bank, St. Thomas, U.S. Virgin Islands was shut down for the 2006 spawning season of Nassau (*Epinephelus striatus*) and yellowfin groupers (*Mycteroperca venenosa*). In St. Thomas, the Grammanik Bank area seven miles south of St. Thomas now has a seasonal closure in place, since last year, to protect species of fish that spawn: the closure runs through April 30.

The National Marine Fisheries Service first closed the 6.88 square nautical mile Grammanik Bank for part of 2005 after University of the Virgin Islands (UVI) researchers documented that yellowfin grouper migrated there to form aggregations for spawning. "I was happy to see this now in law - I think it's going to improve the fish populations there," Dr. Richard Nemeth, director of UVI's Center for Marine and Environmental Studies.

Nemeth and his UVI team monitor Grammanik Bank and nearby Red Hind (*Epinephelus guttatus*) Bank - an area that has been closed to fishing seasonally since 1990, and permanently since 1999 to protect spawning red hind - each week between December and May, tagging and counting fish at the sites. The researchers have found tiger grouper (*M. tigris*), cubera snapper (*Lutjanus cyanopterus*) and dog snapper (*L. jocu*) along with Nassau and yellowfin grouper at Grammanik Bank.

Catching from spawning aggregation sites can be lucrative because so many fish are gathered there. But the practice harms populations because the large numbers of eggs that female fish carry during the season are eliminated along with the adult fish. "The spawning fish are future fish - all the fish are full of eggs. You're catching the babies with the parents," said Kenny Turbe, a local fisherman and conservationist who assists with the studies, has dived on spawning aggregation areas since the 1970s and has seen Nassau and yellowfin grouper numbers plummet in the last 20 years because of overfishing. He called the partial-year closure of Grammanik Bank "a super decision."

In addition to the spawning season closure, fishing with pots, traps, bottom longlines, gillnets and trammel nets is prohibited year-round in the area under the new laws. That move likely was made in order to protect the coral reefs from being damaged if traps hit them, Nemeth said, but UVI did not advocate for that change.

Extracted and adapted from an article written by Lynn Freehill (Virgin Islands Daily News January 28, 2006)

INDO-WEST PACIFIC

Australia

Black jewfish aggregation, fishery and tagging studies

The black jewfish (*Protonibea diacanthus*) is Australia's largest tropical sciaenid. These fish reportedly attain sizes of up to 180 cm in length and 45 kg in weight. From a resource management perspective, there is a dearth of information on Northern Australia's black jewfish life history and biology, or the demands made on those stocks by the various fishery sectors. The biological basis and importance of the annual aggregations of black jewfish is yet to be demonstrated, as is the location and period in which black jewfish spawn in Australian waters (Phelan, 2003).

In 2000, a recreational fishing survey conducted in the Northern Territory of Australia confirmed the importance of black jewfish to the recreational fishing sector accounting for approximately one third (140 tonnes) of the estimated total recreational catch of 450 tonnes of reef fish. Likewise black jewfish dominate the Coastal Line Fishery catch of the Northern Territory, accounting for over 250 tonnes landed in 2004.

Concerns over target fishing of black jewfish aggregations have resulted in a collaborative project between the Northern Territory Fisheries Group, the Tasmanian Aquaculture and Fisheries Institute (TAFI), the Fisheries and Research Development Corporation (FRDC), and the Australian Institute of Marine Science (AIMS). The research is aimed at understanding the nature of large black jewfish aggregations and applying this information to ensure the species is managed in an appropriate manner.

Concerns over target fishing of black jewfish aggregations have resulted in a collaborative project .....aimed at gaining an understanding of the nature of large black jewfish aggregations and applying this information to ensure the species is managed in an appropriate manner.

With assistance from the Coastal Line Fishery and fishing tour operators, Northern Territory Fisheries staff collect biological information from around 70 black jewfish per month. These data will provide vital information on the age, sex composition and reproductive patterns of black jewfish in Northern Territory waters.

AIMS and NT Fisheries staff will conduct habitat mapping at several aggregation sites near Darwin using state of the art oceanographic technology aimed at providing valuable information on the features and environmental conditions that attract black jewfish to aggregation sites.

TAFI and NT Fisheries staff are using innovative acoustic technology to determine black jewfish movement patterns around the Northern Territory coastline. Over 50 acoustic receiver listening stations have been deployed around key aggregation sites. At each site black jewfish are being caught and surgically tagged with acoustic pingers in their abdominal cavities before being carefully released. The receivers record individual black jewfish movement to, from and around each aggregation site.

Key aggregation sites in the vicinity of Darwin were identified with the assistance

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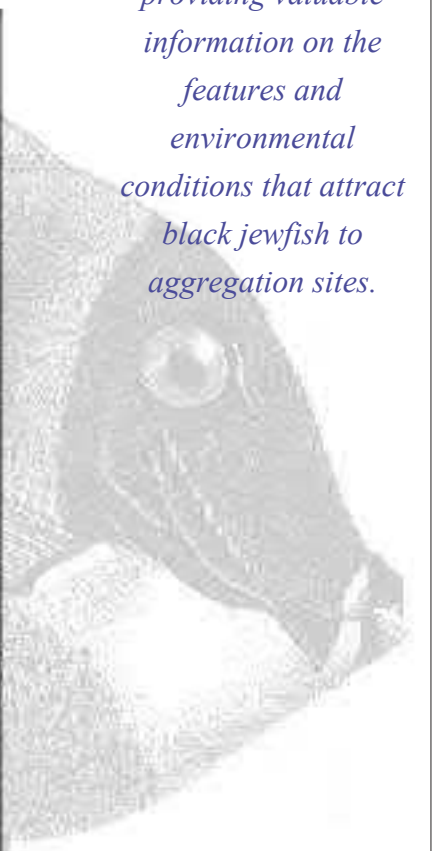

of commercial and recreational fishers. Two primary study sites, one at Channel Point near the Peron Islands south-west of Darwin and the other out from the mouth of Sampan Creek in Chambers Bay north-east of Darwin, were subsequently chosen to be the focus of the tagging work and listening station array. Secondary study sites placed strategically along the coast between the two main sites were also selected for the listening station array.

Eighty-four black jewfish have been tagged both externally and internally with 44 being tagged out from the mouth of Sampan Creek and another 40 at Channel Point. These fish were caught using heavy hand-lines and landed in waters generally less than ten metres in depth. A sling was constructed to support and contain these large fish while being lifted on board. A specially designed cradle was required to hold the fish in a supported position while being tagged.

The process of tagging involves making a small incision with a scalpel in the abdominal region of the fish, inserting the tag (which is the size of a small adult finger), and closing the incision with a needle and suture. A dose of antiseptic cream is applied to prevent infection. This tagging process takes two people around five minutes to complete.

Phelan, M.J. (2003). Sciaenid aggregations in Northern Australia: an example of successful outcomes through collaborative research. Putting fishers' knowledge to work conference proceedings, August 27-30, 2001. Fisheries Centre Research Reports, University of British Colombia, Canada 11910:100-109

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Editor's note: Jeff Kinch in SCRFA Newsletter 8 reported on a similar fishery of this species in Papua New Guinea and concerns over aggregation-spawning. It is good to see this and other croakers gaining more attention

Fiji

Catching fish from an aggregation site fifty years ago was usually conducted for household consumption; fish were caught only for the meals of the day. But, as the demand for cash increased, the fishing of spawning aggregations was increasingly conducted for commercial purposes.

Fiji
Identifying the Gaps in Local Community Knowledge in Fiji

In Fiji, traditionally, the gathering or aggregation of fish in large numbers and the associated increase in landings have long been recognized by local fishermen (called 'gonedau') and is commonly described as the 'cabe ni ika' meaning that fish are rising to the water surface. When speaking to the older people in many communities around Fiji, which I did as part of the fisher interview surveys I have done for SCRFA and for community outreach work I am involved in with the Wildlife Conservation Society (WCS), it is clear that they were well aware that the times of aggregations were important for the fish as spawning periods. They knew the fish had eggs (known as 'via') and occasionally liked to eat them.

As the demand for cash has increased over the years, fishing intensified and became an easier and quicker means of getting cash compared to farming. Partly as a result, detailed knowledge of, and interest in, fish behavior and patterns is slowly being lost. The traditional importance and meaning of the 'cabe ni ika' event is no longer associated with a 'spawning' event; rather, it is viewed more as an opportunity for easily catching large numbers of fish compared. For example,

Recently, the government introduced an ice-plant in the area. Without management, the ice-plant, intended to help the fishing community, will, instead, encourage overfishing of spawning aggregations and ultimately will harm the fishery if not managed.

After conducting studies in Fiji on the status of spawning aggregations, SCRFA provided feedback and assistance to local NGOs and the Fiji Fisheries Department to identify management approaches for the protection of spawning aggregation sites.

when questioning middle-aged and young fishermen whether they directly knew what a spawning aggregation was, most would respond with blank looks. However, if asked whether they had ever experienced catching fish in large numbers as compared to any other times of the year, they would often respond readily. These responses were quite different from those of more knowledgeable, older, fishers. Younger fishers generally referred to the 'cabe ni ika' event as the fish being 'in season' in fishery terms, and would seek to catch as much as possible because they were available in large numbers.

Spawning aggregations have been targeted for many years in many areas, and because of this, spawning aggregations are beginning to decline. Studies conducted by SCRFA (see Newsletter No. 8), in Fiji, showed that many aggregating sites of reef fish have declined in the last 10-20 years, based on fisher interviews and preliminary validation by diving. There are many reasons for this. For example, catching fish from an aggregation site fifty years ago was usually conducted for household consumption; fish were caught only for the meals of the day. But, as the demand for cash increased, the fishing of spawning aggregations was increasingly conducted for commercial purposes. Also, many local fishermen now have access to boats with motor engines, more efficient fishing gears and freezing technologies that have allowed them to travel greater distances, catch more fish and at the same time be stay out longer, compared to the past. Most importantly, knowledge of spawning site locations are not only known to communities within its vicinity, but, increasingly, to people outside of the community, leading to increasing problems of poaching.

Vanuabalavu is an interesting example of problems of sustainably fishing and managing spawning aggregations. In Vanuabalavu (northern Lau group of islands), groupers ('kawakawa') were preferably caught by fishermen during its spawning period because many people liked to consume the gonads of the gravid female fish as a delicacy. Many people even preferred the ovaries to the fish flesh. Marketing opportunities are still not good in this relatively remote location. Sometimes if fish were caught in excess numbers, they were either sent to relatives in Viti Levu, or were discarded because there were no facilities to freeze and store the fish for later use. Recently, the government introduced an ice-plant in the area. Without management, the ice-plant, intended to help the fishing community, will, instead, encourage overfishing of spawning aggregations and ultimately will harm the fishery, if not managed. This is just one example of the difficulties of achieving proper resource use. Indeed, a representative of the community who attended a workshop on fisheries in July in Suva, Fiji's capital, reported that several aggregations in the area had been producing much reduced catches recently.

The Fiji Fisheries Act 158 recognizes the importance of protecting 'female fish having eggs to spawn attached to them'. This means that catching fish during its reproductive months are prohibited. One of the greatest problems faced, however, is the poor compliance of communities and the public with this regulation. Poor compliance has been the result of lack of enforcement of the regulations of the Fisheries Act by the government, as well as a general lack of awareness and education programmes provided to the public and local communities on the significance of spawning aggregations and the importance of protecting them. SCRFA and WCS are trying to fill some of these information gaps, through the interview surveys, educational materials, workshops and other outreach activities. Also, since the Fisheries Act is currently under revision, there is a good chance

that the updated version may better address spawning aggregations.

Traditional knowledge obtained by semi-structured interviews conducted in local communities on fish spawning events has been very useful for understanding the status of spawning aggregations in Fiji. The interview surveys have also been important opportunities for education. Evidently the knowledge of the 'cabe ni ika' event relating to its time and locations are still well known to many local fishermen, although the relevance of the event for the fish population is becoming lost. The apparently growing knowledge gap needs to be filled with information on the importance of aggregations to the fishery to encourage communities to protect spawning aggregations by better understanding their importance. It would be good to include education on reef fishes and fisheries in primary and secondary schools.

After conducting studies in Fiji on the status of spawning aggregations, SCRFA provided feedback and assistance to local NGOs and the Fiji Fisheries Department to identify management approaches for the protection of spawning aggregation sites. Also, educational and awareness materials were developed and distributed to communities where research on spawning aggregations (mainly through interviews) was conducted, such as Yasawa, Tailevu, Macuata, Vanuabalavu, Rakiraki and Serua. Information is also being provided in areas where the Wildlife Conservation Society has long-term projects, and SeaWeb in Fiji is developing other outreach plans. On the positive side, the protection of spawning sites has now been explicitly incorporated into some of the marine protected areas being established in Fiji. However, there is still a need to strengthen protection of aggregating fish through seasonal closures and by banning the sale of fish during their reproductive months.

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Philippines

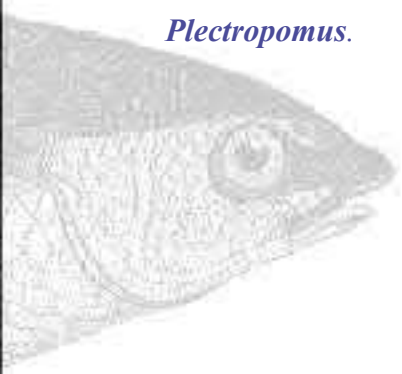
Philippines
The Philippines protects its first spawning aggregation

Very little was known of spawning aggregations in the country at the time, despite, or maybe even because of, its vast shallow coastal area, so planning the initial fishery interview surveys was quite a challenge.

In 2003 SCRFA initiated the first of a series of 4 interview survey trips to the Philippines to learn about and raise awareness on spawning aggregations. Very little was known of spawning aggregations in the country at the time, despite, or maybe even because of, its vast shallow coastal area, so planning the initial fishery interview surveys was quite a challenge. Yvonne recalls looking at a map of the Philippines and wondering where to begin! Early on in this work, WWF-Philippines was approached for collaboration, and through good fortune Dr. Jose Ingles (Jingles) then became involved. This article reports on one of the successes of this collaboration; the first protected spawning aggregations in the Philippines.

One of the fisher interview survey trips focused on Palawan, specifically from Puerto Princesa up the eastern coast to Taytay. In 2004 interviews were conducted with a fisherman who reported to us an area where he remembered seeing, on a regular and predictable basis, concentrations of groupers. Our visit coincided with the end of one of these gatherings and allowed us to confirm the actual

*Underwater surveys subsequently verified the presence of small spawning aggregations of several species of **Plectropomus**.*



An exciting spin-off from this work is that it has triggered seven local Barangays to cooperate with each other in coastal resource management.

location, spot a few wary groupers and look at the topography of the site; very promising with lots of hiding areas for large fish. Other possible sites were also suggested. In 2006, more trips were conducted, one to validate the site as an aggregation area and others to raise awareness at Municipal and Barangay (local administrative unit) levels about spawning aggregations and, in the Taytay situation, the need to protect them. The area is heavily fished for groupers as part of the live reef food fish export trade; many of these fish end up in, or passing through, Hong Kong.

Underwater surveys subsequently verified the presence of small spawning aggregations of several species of *Plectropomus*. Four sites were visited at the time of year noted by local fishers for higher catch rates and ripe fish. At several sites, small groupings of *P. leopardus* were seen with many fish heavily swollen with eggs. This species was the most common, with approximately 30 seen within one small area. Other species of *Plectropomus* occurred in smaller numbers but ripe females were also seen of *P. polyphekadion*, and *P. oligacanthus*. A few ripe *Anyperodon leucogrammicus* were also visible. Groups of ripe fish were seen for several days and then most animals disappeared immediately after the presumed day of spawning.

Following these observations, one spawning aggregation site was protected at the Barangay level, with Municipal protection anticipated to follow shortly. Another site has also been given legal protection. In both cases, the sites are protected year-round. An exciting spin-off from this work is that it has triggered seven local Barangays to cooperate with each other in coastal resource management. WWF and SCRFA continue to contribute to progress in the area.

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Pohnpei

Strong evidence for a reproductive migratory pathway and for sex-associated differences in residence times at an aggregation were indicated.

Pohnpei
Coralgrouper tagging studies

A17-month acoustic and conventional (spaghetti-style Floy) tagging survey of squaretail coralgrouper (*Plectropomus areolatus*) at a fish spawning aggregation (FSA)-based marine protected area (MPA) (Kehpara Marine Sanctuary, KMS) provides strong evidence for a reproductive migratory pathway (RMP), skewed sex ratios at capture, differential behaviour by sex at aggregation sites, and spawning site fidelity. Support for the existence of a RMP between Peleng Channel and the KMS is provided by the recapture of 83% of all conventionally tagged fish (not recaptured at the KMS) in the vicinity of Peleng Channel (8 km to the north of KMS). We also noted directional movement by 6 acoustically tagged fish between KMS and Pehleng. All but one of the 59 returned tags came from a 12-km radius of the FSA, suggesting a localized 'catchment' area proximate to the FSA site The speed of travel averaged 2.1 km hr^{-1} (range=0.6- 5.4 km hr^{-1}).

Sex differences were noted in catches and residency times at the aggregations. Using hook and line, a 4:1 male: female sex ratio (n=647) was obtained at KMS, and using spear, a 3.4: 1 (M: F) sex ratio was obtained in the fishery as a whole, i.e. not just at KMS, during the 17-mo study. Males appear to stay longer at an

To best protect spawning biomass, management for squaretail coralgrouper at the KMS (and likely elsewhere) should incorporate reproductive migratory pathways into fish spawning aggregation area closures and strongly consider complete bans on catch and sales during reproductive periods to assist enforcement.

FSA within the annual spawning season (3.0±1.1 month for males; 2.6±1.0 month for females); this was also true within spawning months (16.2±2.0 day for males; 10.1±9.2 day for females). Spawning site fidelity was exhibited by some tagged individuals, both within and between years; 51% of acoustically tagged individuals returned to the FSA more than 2 months of the spawning season, and inter-annual site fidelity was demonstrated by some individuals. Only 2 tagged males and 1 female were present in all five spawning months in either 2005 or 2006, demonstrating that FSAs are likely composed of a sub-set of the reproductive population and that the entire adult population is likely never present at the FSA site during any single reproductive month. This latter finding clearly has a bearing on how estimates of population abundance are measured, as well as how changes in abundance are gauged. To best protect spawning biomass, management for squaretail coralgrouper at the KMS (and likely elsewhere) should incorporate RMPs into FSA area closures and strongly consider complete bans on catch and sales during reproductive periods to assist enforcement.

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PERSPECTIVES

The appropriate management of fish species that aggregate to spawn will depend on a number of factors. From a biological perspective, an important question that needs to be asked is whether fishing activity on, or other human disruptions of, a spawning aggregation, could have a negative impact on reproductive behaviour or egg output, and, therefore, whether aggregations themselves need to be protected. There are a number of reasons for asking whether aggregations need protection in addition to, or perhaps instead of, other forms of management. In this newsletter, I only address some biological perspectives: practical, social and other considerations will be examined later. Note that this column does not necessarily reflect the opinion of us at SCRFA; rather it is intended to stimulate discussion, provoke thought, and, hopefully, encourage feedback.

There are several possible ways in which fishes gathered for spawning could possibly be directly or indirectly affected by human activities. These include physical disturbance of spawning or courting fish by fishing activity, or impacts on social systems by selective removals of fish by sex, size or genotype. It is also possible that the presence of divers during research, acoustic impacts or tourism activities might affect aggregated fish. Whether such effects do occur as a result of aggregation-fishing (as opposed to from fishing activity outside of the aggregation period) or other activities, and whether they affect reproductive output of the population in the short or long term is largely unknown. However, it is of interest to look at the general fish literature (i.e. not just reef fishes) for indications of possible impacts, as pressures to fish or otherwise focus on aggregations increase.

Stress in fishes can affect their reproduction. There is some evidence in Atlantic cod (*Gadus morhua*) that the physical act of trawling through aggregated fishes disturbs reproductive activity. Cod have quite complex reproductive behaviours (e.g., Hutchings et al., 1999) and the physical passage of trawl nets can disrupt these for extended periods of time in the field (Morgan *et al.*, 1997). A laboratory study on the potential effects of stress, such as due to trawl avoidance, showed

that courtship and other behaviours were reduced by disturbance, but that this did not appear to affect egg production, fertilization rates or hatching success. On the other hand, stressed fish produced abnormal larvae more frequently (Morgan *et al*., 1999).

In other species, including common snook (*Centropomus undecimalis)*, pink snapper (*Pagrus auratus)* and red gurnard (*Chelidonichthyes kumu)*, stress in captivity is known to cause changes in hormone levels, fecundity, egg size and development, and egg survival (examples cited in Morgan *et al.,* 1999). Snook and pink snapper (a sparid) both aggregate to spawn: a recent histological study on common snook showed that females caught using hook and line from a spawning aggregation did not interrupt or finish spawning, or exhibit egg breakdown. While there are indications that stress can affect reproduction, the extent to which fishes might be stressed in exploited or disturbed spawning aggregations, is not known.

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Disruption of spawning or courting behaviour by fishing (removals of fish), due to the presence of divers, or from acoustic impacts, we likewise know little about. It may be that nothing ultimately inhibits the biological imperative to spawn; that the fish just wait until intrusions go away. Lobel and Neudecker (1985), for example, found that a hamlet (pair-spawner), disturbed by divers, did not abort spawning but did change their behaviour, continuing clasps later into the night or moving closer to the substrate. Nonetheless, we do not understand what occurs in other species or in aggregated fishes when disturbed. We know that the social structure within aggregations can be quite specific, that males and females may have different patterns of arrival and departure, and that there is intense courtship, and, presumably, mate selection. I am not aware of any literature on the possible impacts of the presence of divers or fishers on social and mating behaviours in such cases, but this is one area that merits scrutiny. Field biologists suspect that some species respond to divers and others much less so; they also know that the presence of lights can interrupt or possibly prevent spawning. The possible acoustic impacts on fish spawning aggregations are largely unknown; one study on a croaker suggested little impact on drumming behaviour among assembled fish, while other studies on fish have shown negative effects on behaviour (Jeremy Hall Memorial University Newfoundland) (**http://web.mit.edu/seagrant/aqua/cfer/acoustics/exsum/collins/extended.html)**.

A number of aggregating species are known to change sex, among these both protogynous (female to male) and protandrous (male to female) sex-changers. For all such species studied, sex change appears to be controlled by aspects of the social environment or mating group ranking rather than by absolute size or age, or genotype. For many species, their spawning aggregations are the only times that large numbers of conspecifics are likely to come together. For sex-changers, therefore, important cues relevant to sex ratios and sex change may be communicated only at this time (e.g., Shapiro *et al*., 1993). If larger (mostly male) fish typically live deeper than smaller (more likely to be female) fish, or if the sexes are widely dispersed for most of the year, as they probably are for many larger reef species, then they may only be able to assess adult sex ratios in the population while gathering to spawn. This could have implications for subsequent sex change schedules. Fishing on aggregations could, conceivably, disrupt information availability or its transfer relevant for sex change.

In conclusion, biological studies and theory suggest that certain biological attributes of fishes could predispose some species to negative impacts on reproductive

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of fishes could predispose some species to negative impacts on reproductive outputs from aggregation-fishing or other disturbances, either directly or indirectly. What little evidence there is, however, is inconclusive and focused studies are needed to test hypotheses of possible impacts. What is clear is that a precautionary approach is needed. For example, in the case of activities such as dive tourism, precautionary guidelines should be developed that include no lights, divers remaining in one place and not approaching aggregated fish too closely. Refer to our SCRFA Methods Manual, Colin *et al*., 2003, for a brief discussion on diver disturbance and how to reduce it.

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The Grouper Moon Project **http://www.reef.org/data/groupermoon.html**

Fishery Management and Spawning Aggregations work by NOAA (USA) **http://www.nmfs.noaa.gov/habitat/ead/spawnaggs.htm**