SCRFA

SOCIETY FOR THE CONSERVATION OF REEF FISH AGGREGATIONS

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BREAKING NEWS

Nassau Grouper Gets More Protection

Another ban has been put on Nassau Grouper, *Epinephelus striatus,* **in the Bahamas. The ban will be in effect from mid December 2005 until mid February 2006. The Minister of Fisheries, V. Alfred Grey, made the announcement and officials are taking a zero tolerance approach to compliance.**
The Bahamian 26 December 2005

New Caledonia Protects Spawning Fish

A new regulation was introduced in 2005 in New Caledonia that protects reef fishes during their spawning season. From October to March each year, an important section of the barrier reef of the southwest lagoon, off Noumea, is protected.
Claude Chauvet, University of New Caledonia

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EDITORIAL

We are gradually seeing a succession of management initiatives to protect fish spawning aggregations throughout the world. The breaking news items in this newsletter are both very good examples of this. SCRFA congratulates and supports the Governments of the Bahamas and New Caledonia for making important moves to protect reef fishes during spawning (see ‘Breaking News’).

This edition of the SCRFA newsletter has been expanded to include articles from various authors that provide an update on the latest management and research on fish spawning aggregations in the Caribbean, Atlantic, Western Pacific and Indo-Pacific. Its large size is an indication of the rapidly expanding management and research focus that countries are placing on this important issue.

To prepare for another year of outreach, and management and research initiatives, the SCRFA Board held its annual Board meeting in November 2005 during the Gulf and Caribbean Fisheries Institute (GCFI) annual meeting in San Andres, Colombia. 2006 will be another busy year for SCRFA. Dr Yvonne Sadovy will be continuing work with the Government of Fiji and local Fijian communities to research and provide information in relation to the management of spawning aggregations. SCRFA Board members will be presenting at various conferences and meetings. The spawning site database will be expanded, and we will continue to contribute to the refinement of management arrangements for spawning aggregation protection in several areas, including the Great Barrier Reef, and the Caribbean.

Enjoy the newsletter.

Martin Russell
Chair, SCRFA

SCRFA NEWS

We have been quite busy since our last Newsletter in May 2005. Work has focused on Fiji, where we carried out a preliminary validation of reef fish spawning aggregation sites identified in previous fisher interviews in the country (see section on Fiji below for more details). We are also working with SeaWeb in Fiji on an information/outreach campaign.

Fisher interviews continued in southeast Fiji (Lakeba) and in Mindanao, Philippines, in collaboration with the Fiji government fisheries research office and the Sulu-Sulawesi Marine Ecosystem project of Philippines WWF, respectively.

Production of educational and outreach materials has continued. In August 2005, Dr Andy Cornish updated the summary of the SCRFA database (available on our website) which identifies patterns from 557 reported aggregations. Note, however, that while we carefully check the data we enter, we cannot guarantee its accuracy, so care should be taken when using data, and original sources should be checked as necessary. We are also having our foldout pamphlet translated into pidgin for use in Papua New Guinea and the Solomon Islands; several other language projects are in the pipeline and we will upload pamphlets as they become available. Copies can be obtained by contacting us (scrfa@hku.hk). A simple educational poster is now available (see website) to help to illustrate what spawning aggregations are and we are developing an educational module, mainly for teachers and fishery managers.

SCRFA has linked up with a Caribbean-based, bilingual (Spanish/English), weblog to further spread the message of good science in spawning aggregation work (see below) and we continue to update our website and reference materials.

Board members have been active at international meetings and conferences over the last six months with presentations, displays and SCRFA member meetings, variously at the Indo-Pacific Fish Conference in Taiwan, International Marine Protected Area Congress (IMPAC1) in Australia, the Gulf and Caribbean Fisheries Institute in Colombia, and at the Coral Reef Task Force meeting in Palau. We also participated in a small community workshop in Lakeba, Fiji.

About Newsletter No. 8

Those of you who have been reading our newsletters will see that this issue is considerably longer than those we have produced to date. This is a reflection of the increasing amount of work that is going on and a growing awareness of aggregations and their exploitation. The issue is also larger because I have included a few non-reef fish examples (the croakers for example) because the problems they share and the techniques that can be used to study them have many commonalities.

Several points emerge from the articles in this issue that I would like to highlight. The first is to emphasize how important it is, when concluding that a gathering of fish is a probable spawning aggregation, to ensure that there is evidence of both **spawning** (by observations, gonad samples, etc.) and significant **aggregation** behaviour (we cover this in our manual but many times the evidence is not reported even when collected). The second is to point out how often interviewing outcomes are being used to identify sites and times of spawning. This is a very valuable approach, and, if carefully conducted by knowledgeable people, can be extremely valuable. Wherever possible, however, it is best to validate information by in-water work or sampling. I would also strongly advise that interviewers are not only familiar with the species likely to be reported, but also knowledgeable about both the fishery and local social context. If not, interviewers will not be respected by their interviewees, and much time and money can be wasted in non-productive interviews.

Finally, at the end of this Newsletter, please note that I have started, on behalf of our Board, an occasional column, which we have called '**Perspectives**'. The purpose of this column is to highlight topical issues raised by communications or comments that we receive. To start the ball rolling, I have compiled a list of questions that any thoughtful manager or fishery biologist might ask his or herself if faced with the challenge of managing fish species that aggregate to spawn. Note that, in this issue, I am merely *identifying key questions*. What I hope, in subsequent issues, is that we discuss and compile answers to each question from your opinions and experiences. I would be delighted to receive feedback for a lively debate. Are there any other questions to add to the list? I look forward to hearing from you.

Best of wishes for 2006, and for the Chinese New Year of the Dog.

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Regional weblog joins forces with SCRFA.

The weblog 'Agregaciones Reproductivas de Peces: Caribe y Golfo de Mexico (Fish Spawning Aggregations: Caribbean and Gulf of Mexico' is an initiative of the Centro Interdisciplinario de Estudios de Litoral (Interdisciplinary Center for Coastal Studies: http://www.amp-pr.org/ciel) of the University of Puerto Rico – Mayagüez Campus - to serve as a bilingual forum for promoting advances in research in the region in the fields of ecology, sociology, anthropology, socio-economics, and fisheries management. It is also intended to promote exchange of information, access to documents, and improvement of networking among researchers. The initiative for creating the weblog is part of a wider project entitled "Strategies for Implementation and Development of Marine Protected Areas in Puerto Rico".

The project is supported by the Caribbean Coral Reef Institute, a NOAA-funded Institute based on the Department of Marine Sciences, University of Puerto Rico – Mayagüez Campus. SCRFA and the Caribbean spawning aggregation weblog are now linked at the hip, providing information to a broader audience than ever before, especially in Latin-America. [See SCRFA website for link]

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Bahamas

Nassau grouper, Epinephelus striatus, protected in the Bahamas.

By virtue of an amendment to Section 35 of the Fisheries Resources (Jurisdiction and Conservation) Regulations, a closed season for the Nassau grouper, *Epinephelus striatus*, was established for the period 13 December 2005 to 12 February 2006. This is a continuation of the protection in place during the previous spawning season of this species, and has the support of NGOs and the general public. Given that the Bahamas is one of the few remaining places where this endangered (IUCN Red List) species is known to persist in reasonable numbers, the country is likely to be an important key for the future of viable populations.

Colombia

SEFSC surveys possible fish spawning aggregation sites of black grouper, Mycteroperca bonaci, in Columbia.

In February 2005, NOAA (National Oceanographic and Atmospheric Administration) Fisheries/Southeast Fisheries Science Centre (SEFSC) scientists led an expedition to Providencia, Colombia, to investigate the spawning behaviour and spawning habitat of black grouper (*Mycteroperca bonaci*). Over 60 dives were conducted by team members, in collaboration with scientists and fishermen from CORALINA, the environmental authority within the San Andres archipelago. Unusual, probable, courtship behaviour (including colour changes) was seen, as well as behavioural interactions never before described. Habitat descriptions were recorded, and habitat associated with black grouper was photographed by the team. The team participated in outreach programmes, interviewing and educating fishermen about spawning aggregations and otolith (earbone) removal, and was interviewed by several members of the local media.

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Mexico

In 2001, Comunidad y Biodiversidad, A.C., (COBI, www.cobi.org.mx), a grass-roots, non-profit conservation group from Guaymas, Mexico, began conducting reef surveys in Loreto Bay National Park to evaluate the effect of no-fishing in two small no-take zones (1.5 km^2) and three control sites. For the selection and design of their experiment, the COBI team started to assess populations of reef fishery species of groupers and to search for their spawning sites. Particular species of concern were *Epinephelus itajara* (goliath grouper), *Mycteroperca jordani* (Gulf grouper), *Mycteroperca rosacea* (leopard grouper), *M. prionura* (broomtail grouper), and *M. xenarcha* (sawtail grouper). As an offshoot of this longterm project, Michele Buckhorn started her PhD. Dissertation project entitled: "*Enhancing fishery management of leopard grouper (Mycteroperca rosacea) using life history characteristics to design no-take zones in Loreto Bay National Park, Gulf of California, Mexico*."

Daytime surveys during several spawning seasons of the leopard grouper indicated several areas that could be potential spawning sites and finally, in 2004, spawning was directly observed at one site (Site A) on the afternoons and evenings of the full and new moons in May (May 4 and May 18, respectively). Leopard grouper abundance at this site was in the 1000s and spawning rushes to the surface consisted of 50-300 animals per rush. The day of the full moon in June, leopard grouper abundances had dropped dramatically (down to the 20's of fish) at this site and the abundances of yellow snapper (*Lutjanus argentiventris*), another fishery target, was in the 100s. No direct observation of yellow snapper spawning was observed but their behaviour suggested (Sala *et al*., 2003) possible pre-spawning activity. This may indicate that this site is a multi-species spawning site, an important consideration for a no-take zone.

Leopard grouper, Mycteroperca rosacea, spawning aggregations in Mexico.

In 2005, direct observation of daily spawning at Site A took place during the afternoon from 16:30 Pacific Standard Time until last light on April 20-25 (full moon April 23), May 6-10 (new moon May 8), and May 23-26 (full moon May 23). Surveys were also conducted in the mornings, but no spawning was observed. Leopard grouper abundance overall at the site was ~1,000 fish and spawning rushes were in somewhat smaller groups consisting of 10's to 100's of individuals per rush. This indicates that, although there may be some variation in numbers of individuals participating in spawning, particular sites may be predictable from year to year. Brad Erisman, from Scripps Institute of Oceanography, collaborated on the project in the spring of 2005 collecting gonad samples daily from sport fishing catches April through June and participating in surveys.

At a second spawning site (Site B), the abundances and average size of leopard grouper were considerably smaller in comparison to Site A, but it was encouraging to directly observe spawning activity at this, another, site within the park.

Currently, COBI and Loreto Bay National Park personnel are continuing the evaluation of the no-take zones and control sites; in the past, some of these areas were important spawning aggregations for large groupers, such as the Gulf grouper (Saenz-Arroyo *et al*., 2005). Unfortunately, these spawning aggregations have evidently not recovered yet. The leopard grouper is a prized target species for both local artesenal fishers and international sport-fishers who visit the area. It is hoped that this current research will provide the data needed for the Park to continue introducing effective no-take zones to sustain this valuable natural resource.

Saenz-Arroyo, A., Roberts, C. M., Torre, J., Carino-Olvera, M., and Enriquez-Andrade, R. R. (2005). Rapidly shifting environmental baselines among fishers of the Gulf of California. Proceedings of the Royal Society B, 272:1957-1962

Sala, E., Aburto-Oropeza, O., Paredes, G., and Thompson, G. (2003). Spawning aggregations and reproductive behaviour of reef fishes in the Gulf of California. Bulletin of Marine Science 72:103—121.

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Puerto Rico

Possible grouper aggregations at Mona Island, Puerto Rico.

Underwater visual surveys were conducted in December 2004 and in January, February and March, 2005, to search for possible grouper spawning aggregations in Mona Island, Puerto Rico (72 km west of Puerto Rico). The months were selected because several grouper species have their spawning seasons at this time of year. We documented the presence of at least 6 grouper species (*Epinephelus striatus*, *E. guttatus*, *E. adscensionis*, *Mycteroperca tigris*, *M. venenosa*, *M. interstitialis*) off the southern coast of the island. However, only 3 species were sighted with evidence of spawning aggregation formation (*E. guttatus*, *M. venenosa* and *M. tigris*); multiple individuals were noted with distended abdomens in all species, small concentrations of fish were seen in *M. venenosa* and *M. tigris*, and changes in coloration pattern occurred within small groupings of *M. tigris*. Since no gonad samples were taken, however, the reproductive condition of the fish could not be confirmed. In addition to underwater surveys, fishers were interviewed to identify possible aggregation sites, either still existing or known in the past. In the case of the Nassau grouper (*E. striatus*), fishers reported that aggregations had existed in the 1960s, although our underwater surveys gave no indication of their existence.

Due to severe declines of grouper populations by fishing, we believe that locating and protecting their spawning aggregations should be a conservation priority. Mona Island is a place where spawning aggregations of Nassau grouper have possibly “disappeared.” Information recorded from both fishers and our surveys suggests that its spawning aggregations were once heavily exploited but no longer form at traditional sites; diving revealed no evidence of aggregating Nassau groupers during their likely spawning period. In October 2000 and during the 2005 visits, surveys conducted at southern areas of Mona Island confirmed that, while spawning aggregations were not found, small juveniles (of about 100 mm TL) of *E. striatus* were seen in shallow sea-grass areas. These fish could have come from spawning at Mona Island or from spawning elsewhere, either from aggregations or from non-aggregating fish.

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United States – Atlantic

Spotted seatrout (croakers, family Sciaenidae) spawning aggregations in Tampa Bay, USA.

Spotted seatrout (*Cynoscion nebulosus*) are aggregate broadcast spawners, spawning multiple times over an extended spawning season in nearshore and estuarine waters. Male spotted seatrout produce species-specific courtship sounds associated

More Information

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

with spawning that can be used to identify spawning sites. Because spotted seatrout spawn in relatively accessible and identifiable areas, this species is ideal for studying spawning aggregation dynamics. The objectives of our research are to determine: (1) how many aggregation sites occur within a given estuarine system; (2) the habitat associated with these sites; (3) whether reproductive output differs between spawning sites; and (4) how individuals behave/use a given spawning site.

We have been using a multiple methods approach to try to meet our objectives. From 2000 to 2002 we conducted a fecundity study in the lower portion of Tampa Bay, Florida. We sampled four estuarine "zones" in the lower bay and a 'pass' spawning site discovered in 2001. Spotted seatrout fecundity varied both temporally and with age/size. But, surprisingly, it also varied over a small spatial scale, with relative fecundities and percentage of active spawners being much higher at the pass site than in estuarine zones. The 'pass'spawning site appears to be a "true" spawning site, where fish aggregate only to spawn. In contrast, estuarine sites were used for multiple purposes and active spawners did not occur in large concentrations (i.e., many non-spawning individuals were also collected).

From 2003 to 2005 we conducted an acoustic survey to map spotted seatrout spawning sites throughout Tampa Bay and at nearby passes. We used the presence of aggregation courtship sounds as our measure of spawning activity. Although spawning aggregation sites (58 sites) occurred throughout the estuary, the greatest number were in the lower bay, associated with shoreline habitat and sea-grasses. However, none of these sites produced the sound level we consistently observed at the 2001 pass spawning site. In addition, of the nine other nearby passes sampled, only two had spotted seatrout spawning aggregations; these were smaller than those at the 2001 pass site and did not occur throughout the spawning season.

Because the 2001 pass site appears to be the most active spotted seatrout spawning site in the Tampa Bay area, we are now developing a small-scale, high resolution research project to better understand it. This project includes a telemetry array covering the spawning area integrated with multiple long-term acoustic recording systems (LARs). Telemetry is being used to determine site fidelity and site-specific spawning frequency. The LARs are used to monitor spawning activity (based on courtship sound production) daily over the spawning season and to correlate this information with when and where implanted fish are relocated. From 2000 to 2004, we worked on protocol development: evaluating whether implanted fish would spawn, mapping the boundaries of the spawning site (based on sound production), and determining the minimum tag range so that we could calculate the number of receivers necessary to cover the spawning site. In the spring of 2005, ultrasonic receivers were deployed and 32 fish were implanted in May 2005 (19 F:13 M). Twenty-eight of the 32 fish returned to the spawning site multiple times. Three fish were relocated only at two estuarine receivers (approximately 700 m into the estuary from the spawning site). One fish was not relocated. All relocations ended mid-July, apparently due to a heavy red tide in the area. Courtship calls also ceased at this time. Analysis of these data is ongoing.

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Australia

Spawning season closures of coral trout, Plectropomus leopardus, on the Great Barrier Reef.

The second year of spawning season closures for reef fishes occurred on the Great Barrier Reef in 2005. The closures, managed by the Queensland Government over the new moons in October, November and December, are based on the peak spawning period for common coral trout (*Plectropomus leopardus*). Although it is likely that some reef fishes, including common coral trout, spawn outside these times, these closures are precautionary and fully consistent with the Statement of Concern and Recommendation of ITMEMS2 and IUCN's recent Fourth World Conservation Congress, respectively, regarding spawning aggregation protection.

There is, currently, debate by managers regarding the refinement of these closures to better protect a wider range of aggregating fishes on the Great Barrier Reef. More information is needed on the timing of aggregations of other key target species such as large *Epinephelus spp*., blue spot trout (*Plectropomus laevis*) and emperors (*Lethrinus spp*.).

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Fiji

Validating camouflage grouper, Epinephelus polyphekadion, aggregations in Fiji.

As part of an attempt to validate fisher interviews conducted by SCRFA in parts of the western Pacific and Southeast Asia, a preliminary field validation was carried out in Fiji during the summer of 2005. Specifically, we wanted to confirm species, timing and locations of spawning aggregations of reef fishes identified in interviews conducted since 2003.

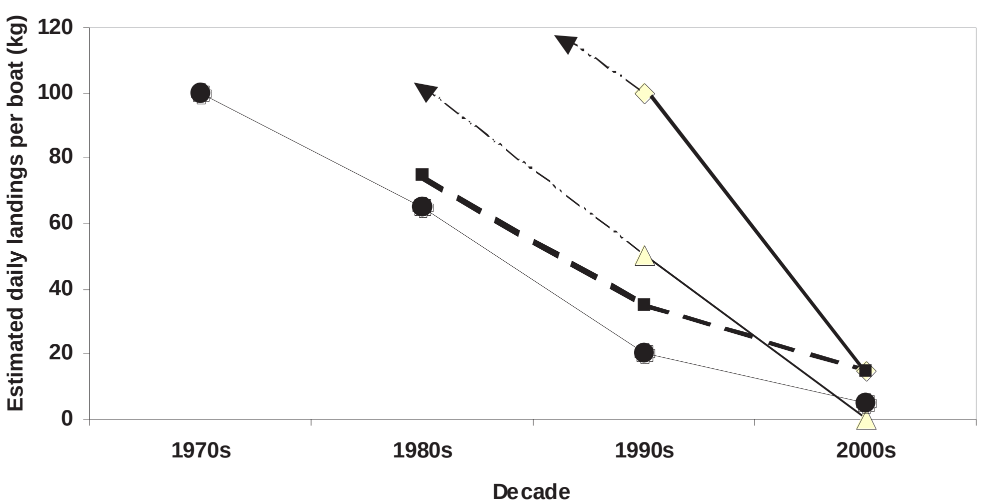
Several fish species aggregate in large numbers in, or near, the channels and passes of Fiji's outer reefs for just a few months each year, although the timing for each species appears to vary substantially across the country. These species include several groupers, camouflage grouper, *Epinephelus polyphekadion* (locally *Kesala*), squaretail coralgrouper, *Plectropomus areolatus* (*Batesai*), brown-marbled grouper, *E. fuscoguttatus* (*Delabalea*), and the speckled blue grouper, *E. cyanopodus* (*Raravuya*), as well as several other species such as a sweetlips, *Plectorhinchus chaetodontoides* (*Sevaseva*), and emperors (Lethrinidae). The sweetlips, in particular, has been reported to spawn in large numbers close to passages, and indications are that is has become severely reduced in the fishery as a result. Between 2003 and 2005, interviews were conducted in a widely dispersed set of communities throughout the country to examine current status, species and history of exploited aggregations (see also the SCRFA database: http://www.scrfa.org/server/database/dbaccess.htm).

The validation study was conducted by interviewing fishermen and then by diving at four identified aggregation sites during part of the identified spawning season; catches on site were inspected and gonads examined, while fish traders in nearby urban areas were also interviewed. In 2003, interviews were conducted in fishing communities in Vanua Levu. In 2005, the same area was revisited during the reported spawning aggregation season and divers visited aggregation sites. The work was conducted in close collaboration with the Fiji Fisheries Research Department, and allowed us to confirm species identifications, aggregation condition, catch levels and gonad status at four aggregation sites during a key reported aggregation period.

The results of the 2005 summer visit suggest that the most important species in these aggregations are the camouflage grouper and squaretailed coralgrouper (relative importance to individual fishers depend on what fishing gear is used), with smaller numbers of other grouper species, such as *E. howlandi* and *E. cyanopodus*. The observations confirmed many aspects of the interviews although *E. howlandi* (*Varavara*) had not previously been reported and was found to be taken in shallow waters by spear; it is possible that our earlier interviews had not included this fishing sector. All groupers inspected were ripe and close to spawning, with the exception of *Plectropomus leopardus*, which is not reported to spawn in large aggregations, nor at the channels.

Overall, the results show classic signs of overfishing of aggregations and supported the earlier interviews. From both the interview information as well as from the on-site dives and catch inspections, it was clear that several of the aggregations of **camouflage grouper**, for which we had most information overall, had probably been too heavily fished. Presently, numbers of fish at aggregation sites are low, despite the time being a reproductive period; ripe fish, bulging with eggs, were seen at some of the aggregation sites and inspections of catches revealed many ripe gonads. Underwater observations of groupers at aggregation sites were fully consistent with the low numbers of fish being caught (i.e. low catch rates) by fishers during our visit, and with previous interviews. It is clear that there have been steady declines in catches of camouflage grouper at all aggregation sites surveyed, since at least the 1980s (see figure below). Capture rates are now very low compared to catch rates in the 1980s, sometimes with declines of 70% or more noted. One site (white triangles in figure) in particular, previously productive for this species, had no fish, and no boat was on the site despite the excellent weather. Indeed, the nearby community was so concerned over declines in recent years that they had recently banned fishing at the aggregation site, which was located in their traditional fishing area (marine tenure system, known as *qoliqoli*).

Camouflage grouper landings from four different aggregations in Fiji according to fisher interviews (2003-2005) and preliminary validation in 2005



The declining trends are also fully consistent with the information provided by two major traders/middlemen based in a nearby urban area. About 200 boats now fish commercially for grouper along the Great Sea Reef during the aggregation season, according to middlemen, and this is at least 10 times more boats than 15 years ago. Moreover, to maintain catches to meet demand, boats now travel further and spend more time out at sea. All indicators are that the reef fish fishery, in general, is considerably more heavily fished compared to a decade or so ago, and that current levels of fishing pressure have caused serious declines in at least one species, the camouflage grouper, at all four studied aggregation sites.

Because a large proportion of annual landings of camouflage grouper is believed to be taken at spawning aggregation time, several recommendations were submitted to the government:

- Community management of *qoliqoli's* to protect aggregation sites from overfishing (e.g. reduce fishing effort on aggregations by community regulations; reduce number of licenses issued, etc.), with government assistance for development of management plans and enforcement;
- No commercial use of fish from spawning aggregations, including no purchase by government ice plants of fish from aggregations;
- Educational initiatives to explain to communities why fish numbers are declining;
- Incorporate spawning aggregation sites in on-going marine protected area designations;
- Prohibit night-diving, or diving with compressed air, on aggregations.

Yvonne Sadovy
SCRFA

New Caledonia

Closure of Dumbea Pass introduced in New Caledonia protects the spawning site of several reef fish species.

New Caledonia is an island of about 18,500 km^2, surrounded by 1,600 km of barrier reef that encloses a lagoon of almost 24,000 km^2. Many passes punctuate the reef, linking the lagoon to the open ocean, and their varying orientation to the wind and tides mean that the passes differ substantially in their hydrodynamic properties. From the end of August to February of each year, these passes are the gathering sites of a range of different species that assemble in small or large numbers, according to each pass and its specific physical and oceanographic characteristics.

Lying to the north of the southwest lagoon, Dumbea Pass is particularly dynamic; the current is almost constantly flowing outwards to the open sea, even at the rising tide. This Pass, more than any other in the lagoon, attracts a wide range and large number of reef and lagoon fish species. Since 1992, data on the aggregating activity of a wide range of species have been collected by divers at Dumbea Pass. Spawners that reside in the Pass, and that spawn in groups, include many pomacentrids, some labrids (e.g. *Thalassoma*), scarids (e.g., *Scarus microrhinos*), and several small to medium size groupers, among them *Epinephelus caeruleopunctatus*, *E. fasciatus*, *E. howlandi*, *E. maculatus* and *E. merra*.

To date, 56 different species that visit the Pass to spawn have been noted, although many are also known to spawn elsewhere, as indicated by extensive diving at the Pass, along the outer reefs and in the lagoon by many people and over many years. Outside of the Pass, the Napoleon fish *Cheilinus undulatus*, the bumphead parrotfish, *Bolbometopon muricatum* and several carangids (e.g., *Caranx ignobilis, C. sexfasciatus*, and *Trachinotus blochii*) spawn along the barrier reef, while in other areas of the lagoon, aggregation spawning has been seen by the groupers *E. malabaricus (Mere loche), E. maculatus (Loche grisette)*, the coral trout, *Plectropomus leopardus (Truite de corail)*, and the enormous giant grouper, *E. lanceolatus (Loche carite)*.

A number of species are only known to reproduce in the Pass; they have not been noted spawning elsewhere. Examples include the little scarid, *Scarus sordidus*, sweetlips *Plectorhinchus lineatus, P. picus, P. obscurus*, unicornfishes, *Naso unicornis, N. tuberosus, N. brevirostris*, and other surgeonfishes such as *Acanthurus blochii*, and *Ctenochaetus striatus*, snappers (*Aprion virescens, Macolor niger, Lutjanus bohar, L. gibbus, L. rivulatus, Symphorus nematophorus*), lethrinids such as *Lethrinus nebulosus*, and also the baraccuda *Sphyraena qeni* and sea chub *Kyphosus vaigiensis*.

Several large species of grouper appear to spawn exclusively in the Pass environment, including the speckled blue grouper *E. cyanopodus (Loche bleue)*, the brown-marbled grouper, *E. fuscoguttatus (Loche marron)*, the camouflage grouper, *E. polyphekadion (Loche crasseuse)*, the humpback grouper, *Cromileptes altivelis (Loche truite)*, and the blacksaddled coralgrouper *Plectropomus laevis (Grosse saumonee)*. Spawning has been directly observed in *E. polyphekadion, Cromileptes altivelis* and *Plectropomus laevis*, and collections have been taken by spear to confirm sexual status in other cases.

For these grouper aggregations, the number of individuals assembling (as determined either by total counts or by point counts and known areas) has varied annually from 1992, especially in the case of the speckled blue grouper. After 1998 a steady decline in numbers was noted for this species; numbers fluctuated annually but clearly showed a strong downward trend. Over the last three years, numbers of this species declined by a factor of more than 20, compared to the 1992 to 1998 period. The lowest numbers of all were in 2005, the last year for which there is information.

Fluctuations in aggregating fish numbers between years appear to be correlated with water temperature, which is closely related to the arrival time of fish at the spawning site. Typically, the first individuals arrive with an inter-tropical water mass of more than 23^{o}C as it reaches the south of New Caledonia at the end of August. In combination with the timing of the full moon, this water mass determines the number of spawning months each year (usually 2 or 3 and rarely 4, as in 1995 or 1, as in 2005). Hydrodynamics, especially in relation to the intensity of storm activity in the Coral and Tasman Seas, and massive swells that pass over the barrier reef, also seem to play an important role in determining numbers of aggregating fish.

Given that year to year changes in fish numbers correlate with coastal water temperatures and the hydrodynamic characteristics of Dumbea Pass, the overall reduction in numbers noted in this area between 1998 and 2005, is likely due to other factors. A study of the speckled blue grouper stock, based on captures from the south lagoon between 1996-2001, did not suggest obvious overfishing, although the importance of the strong recruitment years, 1996 and 1997, was clear. Possibly several causes, acting synergistically, have resulted in overall declines in recent years noted in this species at the aggregation site. These include: poor recruitment since 1997; reduction in springtime swells over the last few years; the progressively later arrival of inter-topical waters to the south of new Caledonia; and disturbance of spawning aggregations by fishing activity (itself possibly related with poor recruitment).

The large island of the archipelago supports about 200,000 people with more than 150,000 living in Noumea and its outskirts. Dumbea Pass is the closest pass to Noumea and access to the reef by fishers is easy and uncontrolled. In some years, captures of speckled blue grouper, one of the favoured targets of fishers (especially recreationally) during the three full moons of the austral spring, exceed those taken throughout the remaining 9 months of the year in the entire southwest lagoon. For this species, a record aggregation catch was 112 fish (about 0.5 tonnes), in one night by just one boat.

After six years of lobbying the President of the Southern Province (in New Caledonia, each Province is responsible for environmental matters), the Provincial Assembly finally voted, in 2005, to close fishing in a specified area on all fish during the reproductive season (October through end of February). Prior to protection, fishing pressure on the passage was between 10 and 30 boats nightly at the height of the season. As well as protecting the groupers, which finish spawning around Christmas at the very latest, the new regulation will also protect other species that spawn in the area during the regulated period, including the Napoleon wrasse.

This newly protected zone is an extension of the *Grand Recif Abore* that was protected in September of 1996, bringing to 150 km^2 the extent of the protected barrier reef.

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[Translated from French by Y. Sadovy.]

Papua New Guinea

Traditional management of mullet, Crenimugil crenilabis, aggregations in Papua New Guinea.

Many individuals in coastal communities in Manus Island, Papua New Guinea (PNG), have detailed local knowledge on the aggregating and spawning behaviour of the fringelip mullet (*Crenimugil crenilabis*). Experienced fishers often know of the locations of mullet pre-spawning and spawning aggregation sites and the migration corridors that schools of mullet travel along when moving between pre-spawning and spawning sites. For generations, Manus Island fishers have used their local knowledge of both where and when aggregations of mullet form to capture this prized food fish, with the ripe eggs of female mullet being a particularly sought-after delicacy.

In the past four decades many mullet aggregations in Manus have declined markedly (Hamilton, 2003) or completely disappeared (Manuai Matawai, personal communication, 2005) as a direct result of fishers dynamiting and gill-netting mullet at aggregation sites and along known migration corridors. The mullet are reported to only spawn at the outer reef site at night. That is, they aggregate at the pre-spawning aggregation site in the passage environment over several days, migrate along set corridors to the outer reef spawning site, then spawn there at night (fishers report hearing them splashing on the surface of the water at night). Few known mullet aggregations in Manus are currently managed, but one exception is a large pre-spawning mullet aggregation site and its associated migration corridors, which have been managed by the Loniu community on the south coast of Manus for decades.

In the Loniu community the management and harvesting of aggregations of mullet, or *kanas* as it is known locally, is the responsibility of the *kanas* clan. In PNG Pidgin the Loniu *kanas* clan is referred to as "*haus boy bilong kanas*", which means 'the group of people (under one roof) who look after this fish'. Within this clan is a head figure, known as "*papa bilong kanas*", the father of *kanas*. The *kanas* clan has a meeting-house (*kanas haus*) where the fishing equipment used to capture *kanas* is stored, and where fishers from this clan can meet to organise fishing trips and relax.

The Loniu mullet aggregations are known to occur in every month of the year, with pre-spawning aggregations forming in a large passage environment that intersects two large islands. Pre-spawning aggregations build up over a three to four day period following the full moon. Approximately four days after the full moon the mullet will depart the pre-spawning aggregation site in the early morning, migrating along a ten-kilometre migration corridor until they reach their spawning aggregation site on the outer reef. Part of the migration corridor the mullet travel along takes them over shallow sandy sea-grass flats, and females sighted here are extremely gravid and can be seen 'dragging their stomachs in the sand' (Loniu fishers, 2003). The migrating mullet form densely packed schools, apparently for predator defense, with local fishers stating that trevally will periodically attack schools of slowly moving mullet. The lips of mullet that are yet to spawn are known to be bright red, which Loniu fishers refer to as their 'lipstick'. Spawning at the spawning aggregation site is believed to occur at night. Post-spawned mullet migrate back to the pre-spawning aggregation site the following morning via the same migration corridor in smaller faster moving schools, and fishers have observed that post-spawned fish 'no longer have their lipstick on', jokingly saying that 'the *kanas* honeymoon is now over'.

In order to manage their mullet aggregations, the Loniu community enforces a complete capture ban at the Loniu pre-spawning aggregation site, and only allows their clan the rights to conduct limited traditional subsistence fishing along the known mullet migration corridor. These customary bans are strictly enforced by the Loniu tribe. For example, fishers from a nearby community who dynamited the Loniu pre-spawning aggregation of mullet at night in 1999 were confronted by members of the Loniu community the next morning while selling the bombed fish at the provincial headquarters market. The Loniu tribe opened a case against them through the Provincial court, with the poachers eventually settling out of court by paying a large amount of compensation and preparing a customary feast for the Loniu tribe.

The Loniu *kanas* clan only fishes for mullet on one day of each month, and fishers may only use traditional *kupen na kanas* nets to capture the mullet. The *kupen na kanas* nets are large open-mouth handheld nets that require two men to operate. *Kupen na kanas* fishing occurs as follows. Four days after the full moon the *papa* of the *kanas* clan will send several men to the pre-spawning aggregation site at around midnight. These men will remain at the site all night, and when they see the mullet aggregation beginning to move out of the passage in the early morning they will quickly travel back to Loniu village and inform everyone that it is time to move.

Loniu fishers report that poachers who bombed their pre-spawning aggregation site in 1999 destroyed the entire pre-spawning aggregation of mullet that was made up of over 2000 fish.

Fishers report that, whereas in the past the largest aggregations would be in the order of approximately 10,000 fish, today they did not exceed 3,000 fish in any one month.

Up to ten canoes with 30-40 individuals in total will travel to the shallow sea-grass areas where *kanas* are known to pass through on their migration to their spawning grounds. The man who first sees the *kanas* pre-spawning aggregation migrate is responsible for telling fishers where to base themselves in preparation for capturing migrating fish. He is also responsible for using customary chants to call the mullet migrations over to the site that he has picked. Once a potential capture site has been selected, fishers will enter the shallow water, and use their canoes and bodies to make two parallel 'fences' in the water that are separated by a width of 10-15 m. Between four to six fishers who are not part of the human fences are responsible for capturing the mullet with the traditional *kupen na kanas* nets. These fishers place the nets side by side across the 10-15 m of water that separates the two parallel lines of canoes and people, with the mouth of the nets facing in the direction that the *kanas* will be coming from. Schools of densely aggregated and slow-moving mullet that swim into this trap quickly end up with nowhere to go but straight into the nets.

When *kanas* schools have entered the net, fishers shut the net by turning the wooden frame of the net down into a vertical position, hereby preventing the fish from escaping. Fishers report that, to this day, one scoop of a net can capture up to 200-300 fish if the school is well intercepted. Fishers also report that the size of migrations varies quite considerably from month to month. If a very large migration event occurs, fishers say *kanas* will come past in four to five 'waves', with each migration being so large that the surface water at the front of the aggregation breaks. In other months, only a single migration will occur. *Kanas* hold considerable customary significance to Loniu people and, when captured, this fish is considered a blessing. Captured *kanas* are never sold, instead being shared between everyone in the village.

Despite the management measures in place, the Loniu *kanas* aggregation is reported to have decreased in size by over 50% in the past three decades, in part at least as a result of poaching at pre-spawning aggregation sites. Dynamiting is the most destructive practice that poachers use. Loniu fishers report that poachers who bombed their pre-spawning aggregation site in 1999 destroyed the entire pre-spawning aggregation of mullet that was made up of over 2000 fish. Fishers report that, whereas in the past the largest aggregations would be in the order of approximately 10,000 fish, today they did not exceed 3,000 fish in any one month. It seems intuitive that without customary management the Lonui aggregation would have been seriously overfished some time ago. But it remains to be seen whether the current customary management measures will be sufficient to conserve this aggregation in the long term.

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The black jewfish (*Protonibea diacanthus*) is a giant croaker species of the family Sciaenidae. It primarily inhabits coastal waters on the continental shelves throughout the Indo-Western Pacific, and enters estuaries and rivers seasonally to spawn in large aggregations. Maximum standard length in adults can reach

Targeting of a croaker (Protonibea diacanthus) spawning aggregation in Madang Province, Papua New Guinea.

150 cm, but the species is more commonly found to 100 cm. It is a highly fecund fish and feeds on small crustaceans, fishes, and benthic organisms (Trewavas, 1977; Sasaki, 2001).

In early 2004, the European Union, through the Rural Coastal Fisheries Development Programme (RCFDP), started a loan programme for nine village-based fisher groups in Madang Province, Papua New Guinea, to acquire outboard-operated dinghies and fishing gears to target deep-water snapper species. For a variety of reasons, the targeting of deep-water snapper species was not financially viable (Kinch *et al.*, 2005) and one fisher group in particular concentrated on catching the black jewfish in its seasonal spawning at the Gogol River mouth, one of the major estuaries that feed into the Astrolabe Bay. The main spawning period is during the months of June to December.

Since fishing began under the RCFDP (i.e. fishing seasons of 2004 and 2005), 1,327 black jewfish have been taken by three fisher groups, with a total weight of 7,078.4 kg (on average 5.3 kg per fish). One of the three groups took approximately 90 % of the total catch of black jewfish due to its close proximity to the spawning ground, the Gogol River mouth. Time spent fishing for black jewfish averaged around 7.5 hr/day for this group and usually occurred from mid-morning to late afternoon. No particular lunar phase or time of the month during the seasonal run was preferred. The black jewfish may exist in other rivers along the Madang Coast, but no catches from such areas have been reported.

Although many croakers are broad on their geographic distribution, there are indications that these fishes are particularly vulnerable to over-fishing due to their large size and aggregating behaviour, making them easy to find both temporally and spatially (Sadovy and Cheung, 2003). Sedimentation loading in spawning rivers can be a problem in this habitat, as well as changing substrates due to sediment discharge; the Gogol River too has been affected (Kinch *et al*, 2005). The status of the black jewfish elsewhere is either unknown, or the fishery has already disappeared, and several other species of croaker have dwindled severely (Sadovy and Cheung, 2003). The giant yellow croaker, *Bahaba taipingensis* is considered to be threatened on the IUCN Red List.

At present, there is little information available, or being collected, on the black jewfish in Madang Province, but, given its restricted known distribution to the Gogol River, closer attention to its monitoring and management is strongly warranted, particularly now as the species is considered to be of increasing monetary value to RCFDP fisher groups.

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Pohnpei

Squaretail coralgrouper, Plectropomus areolatus, movements and aggregation: research and management in Pohnpei.

Acoustic and conventional (Floy) tagging techniques are being used in Pohnpei to investigate the effectiveness of the Kehpara Marine Sanctuary (KMS) in protecting a spawning aggregation and susceptibility to fishing activity of squaretail coralgrouper. By examining patterns of movement of spawning individuals relative to an existing fish spawning aggregation (FSA)-based MPA and surveying catch locations during a 12-month period, the study seeks to identify ways to improve existing conservation approaches. Currently, 51 of 647 conventionally tagged individuals have been recaptured. Approximately 37% of those were recaptured at the KMS spawning site during the tagging exercise, with the remainder taken within or along what are presumed to be migratory pathways for spawners between aggregating periods during the reproductive season.

Evidence of migratory pathways comes from two sources: (1) acoustically tagged individuals repeatedly using common pathways within the spawning season to reach sites, and (2) a high percentage of conventional tags recovered by fishers in areas adjacent to channels and proximate to the spawning site between spawning months. All tag recoveries occurred 0-8 months after tagging and within a 10-km radius of the site. Within a 12-month period, twenty-three percent of all recaptures taken outside KMS within the spawning season were by subsistence fishers during the annual February-March grouper sales ban period. Tag returns waned following the spawning season, but have continued for 11 consecutive months. Results suggest that squaretail coralgrouper in Pohnpei are most vulnerable to fishing during reproductive months at spawning sites, or in areas close to them.

The current results, together with findings from previous research (1998-1999) and from 2000-2005 KMS monitoring of spawning serranids, support a combination of spawning site protection as well as the need for a combined sales and catch ban that match the spawning seasons of individual serranid species. Results clearly highlight shortcomings in the current sales ban: subsistence fishers continue to catch reproductively active fish outside of the protected area but during their reproductive season. To be more effective, therefore, sales bans could be combined with a simultaneous ban on catches during the spawning seasons of individual species. If effectively enforced, the sales and catch bans could be better management tools than an FSA-based MPA for this fishery.

As an alternative to a sales and catch ban during the spawning season, large marine protected areas to protect reproductively active squaretail coralgrouper within and between spawning periods in Pohnpei could be introduced. However, this option is evidently politically and culturally unacceptable because of the high number of currently known spawning sites surrounding Pohnpei: the (presumed) wide spatial distribution of reproductively active individuals relative to each spawning site would require a very large MPA, enclosing approximately 50% of Pohnpei's surrounding barrier reef.

In 2006, we will initiate a NOAA-funded market survey to determine the number and volume of reproductively active serranids entering markets in reproductive months not covered by the current February-March sales ban on groupers. This survey also seeks to determine the number of juveniles entering the market, and whether a shift in fishing pressure to other species occurs as a result of the current sales ban. The study will also examine details of squaretail coralgrouper life history that include age at maturity, age and growth, fecundity and sexual pattern that can be incorporated into future studies of possible life history parameter responses to fishing pressure.

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PERSPECTIVES

To protect aggregations or not: questions that challenge.

Many larger, exploited, reef fishes conduct part or all of their reproduction in aggregations. However, it is not always clear whether their management should involve controls on fishing of aggregating fish instead of, or in addition to, more conventional management controls. Examples of conventional approaches include annual catch quotas, size and bag limits, etc. Assuming (a) that management is needed, and (b) that aggregations are targeted, what factors need to be considered when devising suitable management and monitoring plans for aggregating species?

In this, new, 'Perspectives' column I identify, aided and abetted by the SCRFA Board, *biological and practical questions* that could, perhaps should always be considered. Obviously, each case depends on the local social and economic contexts, as well as on the species and fishery involved. However, in many different cases, several or more of the following questions might have to be considered. In subsequent newsletters, and, hopefully with the help of feedback from readers' own perspectives and experiences, SCRFA will try to supply answers to each question, as well as illustrative examples. In the first instance, I would welcome feedback on the *Biological considerations.*

Biological considerations

1.Is a high proportion of annual catch taken during the aggregation period, as opposed to the non-aggregation period? For some species, like the Nassau grouper, for example, most annual landings are, or were, taken from spawning aggregations in several countries.

2. Does the species form relatively few, large, aggregations within its geographic range, or many smaller ones? In the former case, aggregation protection may be particularly important.

3. For fish species that change sex (such as groupers or emperors), is it possible that important social information is exchanged when fishes gather to spawn? In some species, for example, aggregations are the only times that large numbers of fish come together.

4. How do young fish learn where their conspecifics aggregate to spawn? Is it possible that sexually immature fish need to follow reproductive adults to find spawning aggregation sites?

5. For species that depend on critical habitat for spawning, or where the habitat itself is threatened, are special protective measures advisable for the habitat?

6. Is catchability of spawning fish different from that when they are not spawning? Catchability of aggregating fish can be higher or lower compared to catchability of non-aggregating fish, depending on the species and fishing method(s) used.

7. Could removal of fish from aggregations affect their spawning behaviour, or negatively impact reproductive output? Is reproductive potential influenced by fishing activity during the reproductive season either by the presence of fishers, or because of high removals of spawning fishes?

8. Does fishing on aggregations truncate size/age structure or reduce genetic diversity? For some species, the largest individuals may live in deep water for much of the year, becoming accessible to a shallow-water fishery only at spawning, while maximum size or age may be partly determined by genetics.

Practical considerations

1. Is aggregation management and enforcement of regulations easier than for non-aggregating fishes? Ease and expense of enforcement and implementation must be important management considerations.

2. Do the public understand aggregation management? Public perception of the taking of spawning fish, which are visibly full of eggs (=future babies), should not be undervalued.

3. Do fish prices vary between spawning and non-spawning seasons? In some areas, the glut of fish produced by fishing aggregations can lower unit market prices such that more fish have to be taken for a given level of income than during the non-aggregation season.

4. Does aggregation protection lead to higher fishing effort before and/or after the protected period as part of 'derby' fisheries.

5. Is there wasteful mortality associated with aggregation-caught fish? This could occur when fish are taken live (as for the live reef food fish trade of Southeast Asia and the western Pacific), or because of high predation rates on fishing lines during aggregation periods.

6. What is the best way to monitor exploited fishes that aggregate to spawn? Because of the possibility of **hyperdepletion**, whereby catch rates of fish that continue to aggregate remain high even as the overall populations declines, data on catches should be collected both during the aggregation as well as the non-aggregation season.

7. Are broodstock difficult to obtain for mariculture research? Spawning aggregations could be valuable occasional sources of spawners in good condition.

In summary, the successful management of reef fish species that aggregate to spawn is achievable using a range of tools in the managers' legislative toolbox. Each species, region and socio-economic circumstance is different, so often there is no one tool that will be most effective. Many issues need to be considered in deciding on appropriate management approaches in each case. The bottom line, of course, is that aggregating fish often need protection if there is a high vulnerability to overfishing at their spawning aggregations.

And lest we forget, the management of spawning aggregations or spawning habitats is precautionary and variously called-for by a Statement of Concern agreed at ITMEMS2 (Second Inter-Tropical Marine Ecosystem Management Symposium), and a Recommendation by delegates to IUCN's Fourth World Conservation Congress (see: www:http://www.scrfa.org/server/spawning/concern.htm). Time/area closures for protection of spawning areas and periods are called for under the Convention on Biological Diversity, and protection of spawning habitat is included in Article 6.8 of the United Nations Food and Agriculture Organization's Code of Conduct for Responsible Fisheries.

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