Fishery-dependent Monitoring and Assessment of Reef Fishes that Aggregate to Spawn

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ABSTRACT

Reef fish species that aggregate to spawn pose particular data collection and management challenges in fisheries that are rarely monitored or managed. It is increasingly recognized that spawning aggregations should be viewed as 'capital in the bank', to be protected and allowed to generate the 'interest' that supports the associated fishery, rather than as fishing opportunities. However, this is often little understood by fishery managers or fishers who may have little knowledge of the vulnerability of aggregations; so fishing continues. An important tool for understanding and demonstrating current condition and fishing history of aggregating species is fishery-dependent information, especially landings, catch per unit of effort data and knowledge derived from fisher interviews. For aggregating species, landings and effort data should be collected both during and outside of the aggregation season because of the problem of hyperstability associated with aggregating behaviour. Fisher interviews, if properly conducted, cross-checked and validated, can provide powerful insights into fishery histories, and are excellent opportunities for information exchange that have yet to be widely applied in the Caribbean and tropical Atlantic. However, confidentiality of information on aggregation site locations obtained from fishery interviews should be respected.

KEY WORDS: Aggregation-fisheries, management, traditional knowledge

Monitoreo de Agregaciones de Desove que no Depende de la Pesqueria

Los peces de arrecife que se agregan para reproducirse son dificiles de monitorear y manejar. Se reconoce que las agregaciones de desove se debe protejar para que se genera huevos para generaciones futuras. No obstante, los que manejan la pesqueria, y los pescadores ellos mismos, a menudo no tiene conocimiento de la vulnerabilidad de las especias que se agregan. Para mejor comprender y demostrar la condicion actual y pasada, se necesita la recopilacion de datos pesqueros o informacion de los pescadores, incluyendo los desembarcos, captura por unidad de esfuezo y las entrevistas. En cuanto a las especias que se agregan para reproducirse, se debe recopilar informacion durante todo el ano, incluso durante la estacion de 'no-desove', debido al problema de 'hyperstability' asociado con cambios el comportamiento de los peces cuando se reproducen. Las entrevistas de los pescadores provean perspicacias importantes, si se hacen cuidadosamente, y son oportunidades excelentes para educacion y intercambio de ideas. Se podrian aplicar en muchas mas ocasiones el uso de las entrevista en el Caribe y Atlantico tropico. No obstante, se debe respetar la confidencialidad de la information recopilada en entrevistas.

PALABRAS CLAVES: Manejo, conservación, censo visual subacuático, entrevistas, hiperestabilidad

INTRODUCTION

Many commercially important reef fishes aggregate to spawn, yet most fisheries of aggregating species are poorly documented and their management weak to non-existent. For some species, spawning aggregations are the only times mating occurs and may be heavily exploited because the fish are temporarily plentiful, easy to find and readily caught. Despite severe declines in exploited aggregations of several species, and sometimes in the fishery of these species as a whole, these congregations continue to be widely perceived by fishing communities or fishery officers as important fishing opportunities, rather than as vulnerable life history phases that need safeguarding. Reasons for this are that aggregation declines or commercial use are fairly recent in many areas and hence not yet perceived as an issue, that aggregations are typically omitted from marine protected area designations or when discussing management options, and in some places, there persists the view that the sea will always provide. It is, therefore, important to be able to demonstrate that change can and does happen as a result of fishing, and in particular that change can happen quickly in species that aggregate to spawn, especially if their aggregations are targeted and almost always if targeted commercially.

Documenting and demonstrating trends in fisheries are not just important for fishery managers or of academic interest to biologists, but are essential for fostering support for protection and management within the broader community. Without at least some indications of fishery status and trends over time, even motivated politicians

encounter huge challenges in supporting their fishery managers in the face of national economic and other social pressures, armed only with the 'precautionary principle'. Communities might be reluctant to embrace the self-discipline of management if there is no general agreement that changes in their fisheries have occurred, or without some common appreciation of possible causes or outcomes under the *status quo*. Biologists and NGOs will be hard-pressed in many areas to convince communities of problems in the fishery based solely on their own rapid assessments, planning agendas and equations.

Fishery data from multi-species reef-associated fisheries are notoriously challenging to collect, but information can be valuable without necessarily being time-consuming or prohibitively costly to gather. There is much to be found in fishery-dependent information from catch rate (catch per unit of effort) and landings data, and from interviews in fishing communities, if properly collected and carefully interpreted (Colin *et al*. 2003). In this paper, I discuss the practices, pitfalls and imperatives associated with collecting, interpreting and applying fishery-dependent data in support of better understanding and managing fisheries of reef fishes that aggregate to spawn.

FISHERY-DEPENDENT DATA COLLECTION

The Realities of Collecting Catch and Effort Data

Coral reef-associated, multi-species, fisheries pose a formidable monitoring challenge. If documented at all, and most are not, there might be collection of landings data on a regular or semi-regular basis, information may come from local fish market sales or surveys at landing sites, and occasionally from logbooks or from sub-samples of fishermen (creel surveys); sometimes price information is included. Data may be collected by species, but is often non-specific and gathered by species group or family. Datasets may be structured and consistent over the long term, or, more commonly, collected irregularly according to short-term funding and personnel availabilities. The information may or may not be collated and published in reports in an accessible and consistent format. In sum, collection of reef fishery data is not given high priority by most fishery departments, and is under-represented in FAO (Food and Agriculture Organisation of the United Nations) statistics which tend to focus on the higher value fisheries (Sadovy 2005).

Even when collected, reported landings of certain species may be seriously under-represented because many fish do not enter the local economy and because only a small fraction of landing areas can be regularly accessed. For example, catches may be taken directly home for consumption, used as bait, undergo post-capture mortality through ghost-fishing, or be exported illegally; many groupers and wrasses in the live reef fish trade in Southeast Asia and the western Pacific are exported illegally by boat without going through regular channels. The hundreds of thousands of landing sites for millions of fishers, applying a wide range of fishing gears and activities in reef-associated fisheries, represent a formidable data-gathering challenge; the 7,000+ coastal fishing villages in Indonesia alone would require an estimated 1700 person years for rapid fishery assessments (Johannes 1998).

Yet, long-term species-specific data sets provide invaluable insights into fishery trends, or management effectiveness, and are powerful tools for identifying or demonstrating possible problems in the fishery (e.g. Dalzell 1996, Jennings and Lock 1996, Munro 1996, Sadovy *et al*. 2003). Without the need to be comprehensive, and by applying a practical understanding of local fishing practices, even small-scale data collection efforts can be extremely useful. There are a few fundamental considerations, however. Data should be species-specific, since declines in one species may result in compensatory changes in other, related, species obscuring species-specific trends. Data can often be better interpreted by knowing something of local fishing effort and under-reporting. In assessing the data, marked declines in particularly vulnerable species may signal problems in the fishery as a whole so species selection is important. Species-specific size information can also be valuable for tracking any changes over time. To check for possible overexploitation or to make general recommendations for off-take, annual catch volumes can be compared with a measure of natural annual productivity for the exploited reef area, as proposed when setting quotas for the live reef food-fish trade. In sum, given our general understanding of reef fish fisheries today, there is much that creative small and focused data collection exercises can indicate about the status of a given fishery or contribute for roughly calculating sustainable harvests.

Such data collection is particularly important for species that aggregate to spawn because these are often species that are naturally vulnerable to overfishing, especially so if targeted on their aggregations. For such species it is best to assess data collected both during and outside of the aggregation season, and certainly from the latter. This might seem counter-intuitive but is important because data coming solely from spawning aggregations, or from other similarly predictable gatherings, may exhibit 'hyperstability' whereby the relationship between catch (or CPUE) and abundance is not proportional. The lack of proportionality occurs because fish continue to gather to spawn in large numbers even as the population (i.e. overall abundance) declines (Figure 1) (Hilborn and Walters 1992, Walters 2003). This can send the false message that all is well with the aggregation-fishery until it becomes severely reduced and collapses. One example of possible hyperstability were continued high catches of Nassau grouper, *Epinephelus striatus*, in Cuba until sudden collapse of aggregation catches and the Nassau grouper fishery in the mid-1970s (Sadovy and Domeier 2005); rapid declines

later occurred elsewhere (Sala *et al.* 2001). An illustrative, albeit non-reef fish, example was the apparent high catch-per-unit-effort (CPUE) associated with general aggregating or schooling behaviour in the northern cod (*Gadus morhua*) fishery which helped maintain catches even as the fishery declined. This aggregating behaviour was a major factor in overestimating cod stock sizes, leading to inflated quotas and unsustainable fishing mortality in the 1980s and early 1990s (Rose and Kulka 1999). In both cases, examination of averaged catch data, over time or space, respectively, rather than just from aggregated animals, showed clearly that stocks were declining.

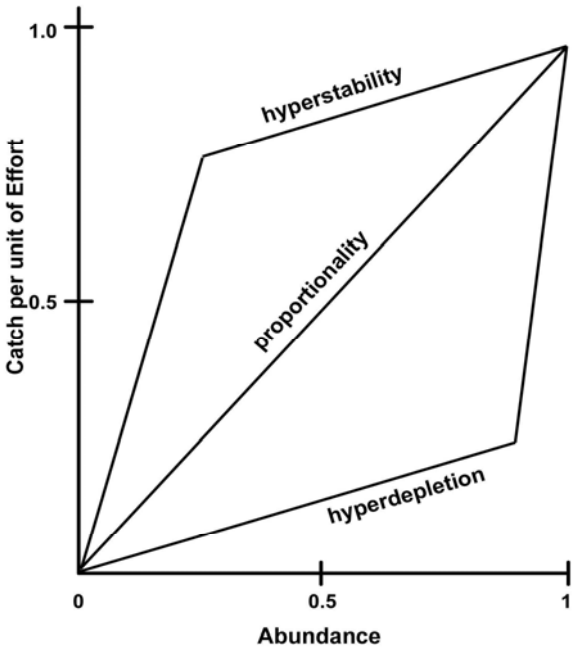

Figure 1. Changes in catch per unit of effort (or could be landings) with true abundance under different conditions of fish or fisher behaviour. Hyperstability occurs when behavioural changes mean that fish remain easy to catch even as their absolute abundance declines. (From Sadovy and Domeier 2005 based on Hilborn and Walters 1992).

What Fishers Know and Need to Know

For many reef-associated fisheries where coastal communities have long depended on healthy local stocks for food and earnings, the richness of local knowledge and experience can provide a valuable perspective on the fishery. Increasingly, biologists are following the lead of workers like Bob Johannes to understand fishing history and status from fisher interviews; the very specific and distinctive case of spawning aggregations lends itself particularly well to the interview approach (e.g. Johannes *et al.* 2000). However, cross-validation of collected data is necessary and great care needed in collecting and interpreting data if these are to be useful; poorly applied, the approach is at best a waste of time and effort, at worst it can be misleading. Importantly, every effort should be made to respect local knowledge and maintain confidentiality of spawning sites, at least until these can be protected or managed.

About five years ago, while it was clear that the spawning aggregations of several species in the Caribbean and tropical western Atlantic were in trouble and were finally attracting attention, little had yet been documented on exploited aggregations from anywhere in the Indo-Pacific region. Scattered publications and reports were suggestive of problems, and research was progressing on several aggregating species, most notably in Palau and Australia (Johannes 1997, Samoilys 1997, Johannes *et al.* 1999). However, there was no broad regional perspective to hint at the possible extent of the problem.

The Society for the Conservation of Reef Fish Aggregations (SCRFA) was formed in 2000 to systematically compile and standardize information on reef fish spawning aggregations. The overall aim was to build a stronger case for the management of aggregating species, but a specific focus developed to document information on aggregations from the Indo-Pacific, mainly through the medium of fisher interviews. Interviews were conducted with patriarch fishers in a range of countries in close collaboration with local fishery departments and/or NGOs. Not only was information collected, but the interview trips were also excellent opportunities for raising awareness about aggregations, especially among fishery personnel and local NGOs, many of which had never heard of aggregations or who had rarely entered fishing villages to talk with fishers about their catches.

Experience in Fiji, where spawning aggregations were undocumented prior to the SCRFA study, illustrates the value of this approach, as well as the need for validation. Several trips were made to Fiji and, in collaboration with the fishery research division of the government fisheries department, almost 100 individual interviews were conducted in coastal communities around the country. Interviews were standardized and generally conducted with older fishermen. Interviewer familiarity with local fish species and fishing practices is essential for gaining the respect and interest of interviewees, and to ensure that responses are consistent and reasonable. Importantly, interview occasions can be used to transfer information on exploited species back to communities in a way that is immediately perceived to be relevant and understandable.

Interviews clearly and consistently identified several aggregating species, declines in the majority of known aggregations, and increasing efforts to search for new ones. For several species that were particularly predictable at the times and places of aggregations, their virtual disappearance from annual landings was often reported. In the first year of interviews, 2003, 22 spawning aggregations were

identified, most showing clear declines in catch rates (usually assessed as kg per boat per best day fishing during the aggregation season for a particular species) (Figure 2). Results were cross-validated by comparing responses from neighbouring villages fishing in the same areas, inspecting local catches for species identifications and using photos and maps to confirm species and locations. Local markets and traders were also visited.

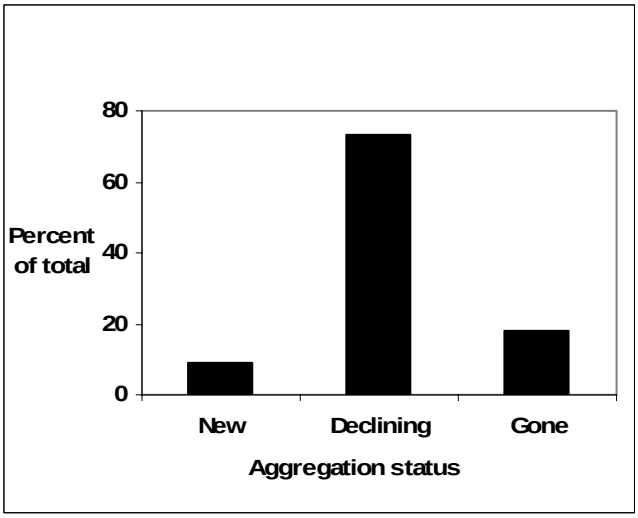

Figure 2. Current status of 22 grouper spawning aggregations in Fiji (2003) according to fisher interviews. Most indicated reduced landings at aggregations compared to the past (Declining), some sites no longer yielded fish (Gone) and several had recently been discovered (New). Source: Society for the Conservation of Reef fish Aggregations database: www.scrfa.org.

A validation exercise was conducted by divers in 2005 at several sites and times reported in earlier interviews (Sadovy, Cornish, Domeier, Colin and Lindeman *et al*. Unpublished). Aggregating species reported, and subsequently validated, were mainly *Epinephelus polyphekadion, E. fuscogutattus* and *Plectropomus areolatus*, which often aggregated at the same sites. Key messages were that several particularly accessible aggregating species had virtually disappeared from local catches, particularly *E. cyanopodus* and the sweetlips, probably *Plectorhynchus chaetodontoides*, and that different fishing gears can differ markedly in aggregation catches reported.

The experiences gained from the Fiji interviews were similar to several hundred other interviews conducted in 10 other countries in SE Asia and the western Pacific (Cornish 2005). In most cases, the results were presented and discussed in local communities, NGO offices and government departments and later used to develop or encourage community management action and inform local NGO work (e.g. Solomon Islands, Philippines, Palau), or foster draft legislation (e.g. Fiji). For reports from several countries and details on interview format, see www.scrfa.org. The interview approach is valuable for identifying aggregating species and for understanding aggregation-fisheries, revealing both surprisingly detailed knowledge (e.g. Hamilton 2005), and some interesting misconceptions (e.g. Aswani and Hamilton 2004). If properly conducted, this approach to understanding current status and recent history of exploited aggregations is compelling and invaluable: its full potential has yet to be explored in the Caribbean and tropical western Atlantic.

SUMMARY

Collection of fishery-dependent data for species that aggregate to spawn is essential for understanding the history and trends in their fisheries, making a strong case for management, gauging the outcomes of protection, and for transferring information to communities to better enable them to understand their own resources. Fishery-dependent data can be gathered as part of regular monitoring initiatives, periodic or special focus projects, or from fisher interviews. Each approach has its weaknesses, which can be largely offset by project design, preparation, validation and careful interpretation. What we cannot expect to achieve are the kinds of stock assessments possible for industrial fisheries; therefore we must be creative, apply common sense, refer to precedents, and be precautionary whenever possible (Johannes 1998).

Because many reef fishes that aggregate to spawn are also naturally vulnerable to overfishing because of other life history characteristics, such as longevity and slow sexual maturation, data are needed not only from aggregations but also from fisheries of aggregating species throughout the year. Being more susceptible than many other fishes in the reef fish assemblage, such species have value as 'canaries', their declines an early signal of possible problems in the fishery as a whole. As just one example, where healthy aggregations persist, the reef-associated fishery is often in reasonable shape. Apparent losses of or declines in aggregations were consistently associated, in our western Pacific and SE Asian SCRFA studies, with compromised fisheries and heavy fishing pressure in the study areas.

Given the many problems associated with collecting fishery-dependent information, a few key guidelines are proposed in respect of aggregating species. Landings data could focus on particular fishes (at the species not family level) and should be collected periodically throughout the year during spawning as well as non-spawning seasons. Notes should be maintained on some measure of effort, such as number of boats or fishers in the area, and on changes in fishing effort over time, such as introduction of outboards or bigger boats, to help in data interpretation.

For interview-based information collection, interviewers need to be knowledgeable about the fishery and species in the area where interviews are conducted, and some validation or cross-referencing must be applied to the data. It is valuable to use interviews as opportunities for

information transfer within communities or with local government departments and NGOs. The interview approach could certainly be more widely applied in the Caribbean and tropical western Atlantic than it is at present. Data on the current status and history of spawning aggregations are lacking in many areas, and this absence of fishery information continues to impede management action at local and national levels. Interesting this appears to be the case even if information on the same species is readily available from a neighbouring country.

The urgency to act and the need to do so without all the 'bells and whistles' we usually associate with fishery assessments could not be clearer than in the case of aggregating reef fish species. Most species that aggregate, among them many of the larger and longer lived reef fishes, have not evolved to withstand the heavy fishing pressures of modern times, especially at their vulnerable aggregations. Calls throughout the 1990s were made for protecting aggregations as a matter of course, in other words, as a precautionary measure; the information, scientific and anecdotal, collected since this call has only confirmed the concerns expressed, and highlighted the imperative for action (Sadovy 1993, Johannes 1998). The need has become clear not only to protect aggregations, but also to manage the fisheries of species that aggregate to spawn at all phases of their reproductive cycle.

Concentrated reproductive gatherings of fishes should probably be protected as a default management, or precautionary, approach. Although, in theory, there could be sustainable off-takes or pulse-fishing from aggregations, the realities of management, and of human nature, are that there is insufficient effective control in most places and under most circumstances for this to be workable. Weighing up the high probability of overfishing aggregations against their importance for maintaining populations of aggregating species, the risk is probably too great to allow their exploitation. Aggregations should be off-limits for fishing as a general principle; considered to be sources of seeds for the future, to be nurtured rather than plundered.

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