Manual for the Study and Conservation of Reef Fish Spawning Aggregations

by

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While effort has been made to verify and check the information included in this manual, no guarantees are made as to the accuracy or utility of any information included herein. It is essential that all activities undertaken on or in the water be properly planned and carried out. The methods described in this manual have been based on the experiences of the authors and others, however all users are advised to remember the conditions they encounter may not be the same and should take appropriate measures to modify the contents of this manual based on their local conditions. The authors are grateful to Ken Lindeman and Melita Samoilys for their comments on sections of the manuscript, and to Environmental Defense for funding the first print run of the manual.

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II. A. General

Two criteria are essential for the identification of a "spawning aggregation". They are, first, an increase in the density of fish present and second, the verification of spawning. “Transient” aggregations often involve long-distance migrations and a short reproductive season, while “resident” aggregations may form frequently, often over an extended period and occur close to, or even within, the areas of residence of participating fish (Domeier and Colin, 1997). The importance of applying specific criteria is to prevent misidentification of the nature of an "aggregation" of fish and to ensure an objective means of identifying and communicating this phenomenon. Given the limited amount of resources available for conservation and management of spawning aggregations, they need to be correctly identified to ensure that sufficient care and attention are allocated in the best possible way for aggregations to gain sufficient protection for long-term persistence. Note that there are occasions other than for spawning, such as feeding, for which non-schooling reef fishes are known to aggregate.

II. B. Increase in Density of Fish

Domeier and Colin (1997) defined a spawning aggregation as "a group of conspecific fish gathered for the purpose of spawning, with fish densities and numbers significantly higher than those found in the area of the aggregation during non-reproductive periods". This general definition, however, does not fit all situations and for some species, such as those that normally occur in dense schools, other criteria might apply (see Domeier and Colin, 1997 for more detail). The level of increase in density of spawning fish that constitutes an aggregation is, however, arbitrary. As a guideline, we suggest that a 3-fold increase in the density of spawning fish is the minimal threshold level that constitutes a spawning aggregation (Domeier and Colin, 1997). Although this value is likely too low, this inclusive first step allows us to collect information that can be reassessed at a later date when more is known about particular aggregations. There may be some examples where over-exploitation has reduced an aggregation to very low levels that would not fit a more exclusive definition. Fortunately most spawning aggregations have considerably higher levels of density increase, making it easy to verify with certainty that they are actually aggregations by our definition.

Since the criteria of what is an "aggregation" are based on an increase in density, it is usually necessary to have some idea of the typical non-aggregation density of any species of interest. In many cases, we do not have quantitative density information from before, during and after an aggregation. Researchers must usually rely on general qualitative knowledge about what is a "normal", non-aggregated, density and then be able to recognize when a significant increase in numbers has occurred. When there are suddenly 500 groupers in an area that would normally have 2 or 3, there is little doubt that a 3-fold increase in density has occurred. However, where fishes have been reduced in number, due mostly to fishing pressure, it may not be so easy to confirm the density increase. Methods are described subsequently for estimating the numbers of fish present and the area of an aggregation; in marginal cases, it may be necessary to make the same sorts of determinations during non-aggregation periods.

The social systems of reef fishes cover a broad spectrum of behavior, some of which involves temporary concentrations of fish. Haremic species may have a few individuals, normally scattered, that come together daily for successive spawnings of females with a single male. While these are irrefutably spawning groups, they do not meet the 3-fold increase criteria, hence are not considered spawning aggregations. Readers interested in the entire spectrum of reef fish spawning and/or aggregation types are referred to Thresher (1984), Sadovy (1996) Domeier and Colin (1997) and Petersen and Warner (2002) among others for more information.

II. C. Criteria to Verify Spawning within an Aggregation

The importance of documenting spawning within an aggregation of reef fishes can not be stressed enough. Reef fishes display many aggregating behaviors unrelated to spawning, allowing ample opportunity to mistakenly describe a spawning aggregation if spawning is not documented. Some reef fishes school daily in a manner that would seem to potentially be spawning aggregations. In the western Atlantic snappers and grunts typically shelter as schools on reefs during the day, milling about close to the bottom. In the western Pacific various snappers, such as *Lutjanus fulvus*, also form schools of hundreds of individuals that at times stream as a group across the reef, seemingly with a "mission" (spawning?). Actually they are really just "hanging out" during the day. Observers should always be wary of aggregations that contain more than one species since these are unlikely to be spawning aggregations (unless a planktivore is feeding on the eggs produced by spawning fish). In most cases true spawning aggregations are limited to one species. However, as in all of biology, there are exceptions to this general rule; some grouper aggregation sites can have members of multiple grouper species present. Sometimes more than one species will use a given area, and there may also be a low number of a third or fourth species present at an aggregation site.

Since it is important to confirm that the aggregation observed has formed for the purpose of spawning we have specifically identified two types of '**signs of spawning**' that include both **direct** and **indirect** indications of spawning. Direct signs provide unequivocal evidence for spawning, indirect signs are other indications of spawning that need to be accompanied by supportive information. This distinction is being applied in the SCRFA Global Database of Spawning Aggregations (www.scrfa.org) which aims to document all known aggregations.

At present SCRFA recognizes three **direct** signs to verify that a group of fish is spawning. They are 1) undisputed spawning observations, 2) females with hydrated eggs and 3) presence of post-ovulatory follicles in the ovaries of aggregating females. Each of these is discussed in detail subsequently in this manual.

If none of the direct signs of spawning has been observed, **indirect** signs can be used but should be carefully documented. Indirect signs can include behaviors or color patterns if these are demonstrably known to be associated only with spawning. GSI data, swollen abdomen and other proven indications of spawning could also be used.

Observations that do not meet the strict criteria of **direct** signs, may or may not be spawning. Such uncertain information should be suitably qualified, so that the reader has no doubt about whether the level of documentation is sufficient to confirm a spawning observation. This has not always been the case. There is considerable literature where workers have identified or reported "spawning aggregations" for many species with insufficient data to confirm that what they have seen is actually related to spawning. Some reports have included haremic spawning groups, non-spawning aggregations and misinterpretation of observed behavior as reproductive and "spawning aggregations". Often these are second hand reporting of observations of dubious

veracity. The difficulty is that once in print, even in gray literature, such information tends to be considered fact, and the problem with false records is that these can lead to wasted resources and a poorer understanding of spawning aggregation related patterns in general.

II. D. The Responsibility to Verify Information before Publication or Distribution

It is incumbent upon observers to verify what they believe to be spawning aggregations before reporting their findings in the literature. This includes both the scientific and gray literature, such as newsletters and circulated reports. SCRFA can assist in this regard with any questions. Unverified reports of possible spawning aggregations are still valuable, but workers should avoid at all costs the impression that a spawning aggregation has been confirmed as such when the two criteria (spawning and aggregation) have not been met. Unverified information can be reported, but the limits of the data or observations must always be part of the reporting (e.g., Lindeman and Claro, 2003). Otherwise, others who might not be aware of the limits of the information will assume that the report is scientific "fact".

Section III. Discovering Spawning Aggregations:

There is still a very active "discovery component" to work on spawning aggregations. Quite a few species, presently not known to form spawning aggregations, may eventually be found to have them, while many aggregations remain undiscovered. Discovering the unknown is never easy, especially when you are seeking a group of fish in 30 m of water somewhere along a hundred km of shelf edge that exists only for a short period each year. Consequently, scientists and managers need to use every resource available to increase the probability of success in finding spawning aggregations. Finding a previously unknown aggregation site is exciting and may provide valuable information but carries with it the responsibility to be careful about revealing its location prematurely to avoid its possible abuse.

III. A. Talking to Fishermen

To locate a spawning aggregation unknown to researchers, fishermen will often be the best initial resource (e.g. Johannes, 1981) (see Section VI). The knowledge level of fishermen varies greatly, but a truly knowledgeable, helpful individual is invaluable. Some fishermen with considerable knowledge of the fishes may not wish to share that information with anyone. For commercial fishing such information is often a business secret. Among subsistence fishers there is less commercial incentive, but disclosure of information may actually encourage commercial operators to move into what had previously been a subsistence fishery. Ideally the researcher can find knowledgeable fishermen with an active interest in getting their biological information recorded, either to pass on to future generations of subsistence fisheries, or to help establish workable regulations to maintain fishery yields. Always keep in mind what will happen when you make new information available to others. There may be cases where information needs to be kept confidential, such as in the case of specific locations of aggregations. You should always make certain your informants understand what you intend to do with their information.

It is important to make contact with fishermen prior to starting significant field work. This can be done in many ways, through fisheries co-ops, fish processing houses, village councils, and others. It never hurts to have some knowledge about the fish you are concerned with, but be careful about seeming to be a "know it all" when you make initial contacts. You are asking for help, and if you already know it all, why should someone help you?