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Preliminary findings on spawning aggregations of reef fishes in East Africa

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Abstract

There is no published information on the occurrence of spawning aggregations of reef fishes in East Africa. Since this phenomenon occurs in many species of reef fish in the Caribbean and Pacific, and has just been reported from Seychelles, it is highly likely that this reproductive strategy is widespread in the Indian Ocean, in species known to aggregate to spawn. As a first step in gathering data on reef fish spawning aggregations in East Africa we conducted interview-based surveys with fishers. Key informants and older fishermen were targeted and information was collected on known species, aggregation sites and timing. Species from a total of six families: Serranidae, Lethrinidae, Lutjanidae, Siganidae, Haemulidae and Scaridae, were recorded, across four regions in East Africa with 18 species reported to form spawning aggregations. Corroboration amongst fishers across regions was low with only three species cited from > 1 region: *Lutjanus ehrenbergi*, *L. bohar*, and *Siganus sutor*. Only *Siganus sutor* was corroborated by fishers from both Kenya and Tanzania. Of the 18 species reported, two species, *Plectropomus punctatus* and *Siganus sutor* are endemic to the Western Indian Ocean. This research represents the first report of spawning aggregations in *P. punctatus*. The study has introduced the concept of reef fish spawning aggregations to a range of marine resource management practitioners, researchers and fishers in East Africa. Awareness of the importance of protecting spawning aggregations in the context of fisheries management and building resilience into the design of marine protected areas has now been initiated in East Africa.

Keywords: Fish spawning aggregations, fishers' knowledge, Kenya, Tanzania, Western Indian Ocean

Introduction

Many species of reef fish aggregate to spawn in large numbers at specific times and places (Johannes 1978, Johannes 1981, Colin et al 1987, Shapiro 1987, Samoilys 1997, Domeier and Colin 1997). This spatial and temporal predictability has made aggregating species extremely vulnerable to over-fishing (Vincent and Sadovy 1998). Notable examples include the Nassau grouper, *Epinephelus striatus* in the Caribbean (Sadovy 1994, Sala et al. 2001) and *Plectropomus areolatus* (Johannes et al 1999) and *P. plectropomus* in the Pacific (Samoilys et al in prep.). Groupers are particularly well known aggregating species (Domeier and Colin 1997), and this behaviour, combined with their other life history traits (long lived, late maturity, sex changing) and high food value make them particularly vulnerable to over-exploitation (Sadovy 1996, Vincent and Sadovy 1998, Sadovy 2001, Dulvy et al 2003).

Knowledge of reef fish spawning aggregations, their timing and location, is critical to designing marine protected areas (MPAs) and other legally protected resource conservation areas (Samoilys and Church 2004). Information on key sites where reef fish aggregate to spawn needs to be built in to MPA design, particularly through “no-take” zones. Zones that are fully protected from fishing should be located so that they encompass spawning aggregation sites. This approach has been developed into the concept of building resilience into MPA design and is currently receiving much attention within the conservation community (Domeier et al 2002, TNC 2004). Knowledge of spawning aggregations is also critical to the management of key fishery species. Building spawning aggregation protection into fishery management plans has been done in Australia where seasonal closures have been introduced for the Great Barrier Reef coral reef fish fishery (Turnbull and Samoilys 1997, Samoilys and Squire 2002, http: //www.dpi.qld.gov.au/ fishweb/11379.html), and in the Solomon Islands for the live reef fishery (Samoilys and Donnelly 2001).

Despite global interest and recognition of the importance of spawning aggregations of reef fishes, there is still a dearth of information on the phenomenon, particularly in the Indo-Pacific. Information on spawning aggregations has been in the scientific literature since the 1960's but most of the work has been carried out in the Caribbean, though more recently in the Pacific (Johannes et al 1999, Rhodes and Sadovy 2002). There has been no reported research in the Western Indian Ocean (WIO), with the exception of recent work by the Seychelles Fishing Authority (Robinson et al 2004).

In the present study, we investigated the existence of reef fish spawning aggregations along the Eastern African coast using local ecological knowledge of fishers. Using fishers' knowledge to design and guide research and have input to the management of a common fishery is highly effective (Meeuwig et al 2003, Haggan et al 2003), and is recommended as a first step for obtaining information on fish spawning aggregations (Colin et al 2003, Table 1). Preliminary research was initiated in May/June 2004 in Kenya and mainland Tanzania, which is reported here. The study is currently being extended into Zanzibar and Mozambique but data are not yet available (Samoilys and Church 2004). The objectives of the study were to: a) determine species forming spawning aggregations and the specific sites of aggregation formation; b) determine the level of awareness of spawning aggregations among fishers; c) sensitise fishers and marine resource personnel in East Africa on reef fish spawning aggregations and their implications to conservation and sustainable fisheries.

Methods

A workshop was organized by The World Conservation Union (IUCN) in March 2004 in Mombasa, Kenya for focal scientists and potential field team members from Kenya, Tanzania, Mozambique and Seychelles. The objectives of the workshop were to a) inform and train a research team in order to conduct questionnaire based surveys on reef fish spawning aggregations in Eastern Africa; b) design a field questionnaire to collect information on spawning aggregations from fishers, with likely species, sites and spawning periods identified; c) plan the field sampling and study areas. Training tools used were the Society for the Conservation of Reef Fish Aggregations (SCRFA) manual (Colin et al 2003) and The Nature Conservancy (TNC) CDRom on Reef Resilience (TNC 2004). The questionnaire developed is shown in Appendix 1. Field sampling was designed around available field researchers and their knowledge of fisher communities. Sampling areas extended from the Kenya/Somali border at the Kiunga Marine National Reserve (KMNR) (1º42.25S 41º31.78E) to Mnazi Bay-Ruvuma Estuary Marine Park (MBREMP) on the Tanzanian/Mozambique border (10º18S 40º23E), covering six main regions (Figure 1, Table 2). Survey regions in Kenya included villages along the north (Kiunga-Lamu) and south (Malindi – Gazi) coast. In Kenya, twelve and five fishing villages were chosen in the north and south coast sites, respectively, based on their accessibility, level of fishing activity and likelihood of fisher cooperation. Eight districts were selected in mainland Tanzania including Pangani, Muheza (Tanga region), Bagamoyo, Mafia (Coast region), Kinondoni, Temeke (Dar es Salaam region) and Mtwara.

Pictorial material was prepared for each field team to accompany the questionnaire. This material was designed to assist in species identification and to describe spawning aggregations. Laminated photographs of species likely to aggregate to spawn in the region (based on studies elsewhere) included: *Siganus sutor, Epinephelus fuscoguttatus, Epinephelus polyphekadion, Plectropomus punctatus, Lethrinus obsoletus, Plectorhinchus flavomaculatus, Lutjanus bohar* and *Cheilinus undulatus*. Pictures of snapper spawning aggregations in the Caribbean, a gravid female (*Epinephelus guttatus*) and ripe fish ovaries were used to illustrate characteristics of the phenomenon to fishers.

Field researchers selected fishers to be interviewed with the help of a local guide in each village. Due to the sensitivity of the subject among fishers and the need to interview informative fishers, deliberate attempt was made to interview either the most ‘patriarchial fisher’ or the most willing fisher. Respondent selection was therefore non-random and covered most gear types. For this reason, the number interviewed was not consistent and varied between 3-6 fishers per village. Interviews were carried out on a near-daily basis for a 3-5 week period. Suggested spawning sites were recorded using local names, often derived from prominent seascape features. Maps and charts were of little use to the local fishers and were hence not emphasized in the study.

Evidence for spawning aggregations ranged from observations in situ of fish behaviour to observations of gonad condition. Notably, fishers that swim with masks: lobster and spearfishers, as well as fishers that lay nets in the water, were more likely to know about spawning aggregations than boat or shore based fishers. Despite an initial bias towards targeting older fishers for the interviews, field reports indicated that younger spearfishers were more likely to know about the phenomenon.

Data Analysis

A cautious approach to data interpretation was followed which involved a process of elimination through three key sequential steps: i) Verification of positive responses to knowledge of spawning aggregations; ii) Knowledge of species mentioned by > 1 respondent; iii) Knowledge of spawning aggregation site mentioned by > 1 respondent or for > 1 species. Thus, first, only responses in which the evidence for spawning aggregations was reasonable, were used. For example, if the respondent claimed a particular species aggregated to spawn, but backed this up with a reply saying that ‘they were playing’ or could not provide any response, this respondent’s answer was disregarded. Unfortunately, this represented a large percentage of the data. Having thus reduced the data to a subset, the data were interrogated for steps ii) and iii) to establish the likelihood of the data being reasonable for species information and for spawning site information. This further reduced the dataset. Any unclear species identifications or grouping of species were also discarded.

Results

Over 200 fishers in Kenya and Tanzania were interviewed, of which 112 (56%) said they knew about spawning aggregations (Table 2). However the evidence for spawning provided by 59 of these 112 fishers was not convincing thereby reducing the number of fishers' records that were analysed further. The findings for each country are presented below.

Data on seasonality of spawning aggregations indicated the majority of species spawned during the North-East monsoon. However, some South-east monsoon, and inter-monsoon records were also given. Lunar periodicity information was not forthcoming. Periodicity data were not analysed further.

Tanzania Mainland

Tanga region

Of the 23 respondents in Tanga, 18 said they knew about fish spawning aggregations (Table 2), listing 28 species. However, reasonable evidence for spawning ("bellies are full of eggs and sperm") and clear species identification reduced this list to information on 16 species from 12 fishers (Table 3). When these data were interrogated for evidence from >1 fisher, or for > 1 aggregation site or >1 species per aggregation site, the list was reduced to only two species: *Lutjanus sebae* (2 fishers) and *Siganus sutor* (3 fishers) and none of these five fishers reported the same aggregation sites for these species. A total of 21 spawning aggregation sites were reported for the 16 species but only seven sites were reported by more than one fisher. The maximum number of different records (i.e. species or respondents) per spawning aggregation site was four.

Dar-es-Salaam region

A total of 17 fishers were interviewed of which only four said they knew about fish aggregating to spawn (Table 2), for seven species. Reasonable evidence was only given from three fishers for three species: *Siganus argenteus, Lutjanus ehrenbergi, and Epinephelus fuscoguttatus*. Only one species, *L. ehrenbergi*, was listed by more than one fisher. Six spawning aggregation sites were listed in this region, but none were mentioned by >1 fisher. However, two fishers each listed one spawning aggregation site for two different species: *S. argenteus* and *L. ehrenbergi*.

Mafia Island Marine Park and Mnazi Bay Ruvuma Estuary Marine Park

In Mafia 12 of the 13 respondents said they knew about fish aggregating to spawn and provided a list of 15 species. However, none of the 12 respondents provided sufficient reasons for suspecting a spawning aggregation (table 2). Reasons for why fish were aggregating ranged from: ‘Not known’, ‘they are always there’, playing around’ and ‘feeding’. For this reason, this information was discarded.

In Mnazi Bay 10 fishers said they knew about spawning aggregations, but when asked how they knew only one fisher was able to describe spawning aggregations, listing *S. sutor* and *L. harak*. The other nine fishers all cited feeding and playing as the reason for aggregating. Data from this region was therefore discarded.

Kenya

In Kenya, a variety of behavioural characteristics as well as anatomical and physiological changes were provided as reasons for why and how fish aggregate to spawn. Characteristics from the South coast that were considered reasonable evidence that the fish were aggregating to spawn included: “courting”; “rising up”; presence of "misty cloud”, "strings and mucus", “misty deposits”; “thought at first it was dust from frightened fish but discovered later they were eggs”. In contrast, fishers from the North region talked about ripe gonads with eggs.

South coast region - Kilifi, Mombasa, Diani

In the South coast region of Kenya 32 fishers responded positively and knew about fish aggregating to spawn (Table 2), citing 43 species. Reasonable evidence that the fish were aggregating to spawn was only provided by nine fishers for 16 species (Table 4) though there was some doubt that fishers could distinguish between the two siganids. Interestingly, much of the evidence was observations of fish behaviour, particularly courting and “rising up” in the water column, as well as the presence of gametes in the water (described as looking like “mist” or “mercury deposits”). Of the 16 species, only three species, *Plectropomus punctatus*, *Lutjanus bohar* and *L. fulviflamma* were identified by more than one fisher (Table 4), with at least two aggregation sites identified for each of these species. Notably, one aggregation site was identified for all three species, and *P. punctatus* was said to spawn at this site by two different fishers.

North coast region – Kiunga/Lamu

Of the 46 fishers interviewed in this area, 36 claimed to know about fish aggregating to spawn (Table 2), citing 22 species. Reasonable evidence of spawning aggregations was provided by 28 of the fishers for 19 species, of which 12 species were reported by > 1 fisher and with >1 aggregation site (Table 5). In contrast to the other regions, a large number of fishers reported the same species, and a large number of aggregation sites were cited (Table 5), with multiple species using the same sites.

Regional assessment

A total of six families, Serranidae, Lethrinidae, Lutjanidae, Siganidae, Haemulidae and Scaridae, were recorded across four regions in East Africa with 18 species reported to form spawning aggregations (Table 6). It should be noted that some of the Lutjanids are difficult to distinguish and although species identification was stressed by interviewers it is possible that similar looking species such as *L. monostigma* and *L. ehrenbergi* may not have been well differentiated by fishers. Corroboration amongst fishers across regions (Kiunga, Kenya south coast, Tanga and Dar-es-Salaam) was low with only three species cited from > 1 region: *Lutjanus ehrenbergi*, *L. bohar,* and *Siganus sutor*. Only *Siganus sutor* was corroborated by fishers from both Kenya and Tanzania: Of the 18 species, two species (*Plectropomus punctatus*, *Siganus sutor)* are only found in the Western Indian Ocean.

Discussion

Obtaining reliable information on the occurrence of spawning aggregations through interviews with fishers is difficult (Johannes 1981), particularly when the interviewers are new to the concept of reef fish spawning aggregations. In our study, all field interviewers were unaware of the phenomenon of spawning aggregations prior to the training workshop conducted at the beginning of the study. They were therefore asking questions on a subject that they were not very familiar with. An unambiguous questionnaire is vital in such circumstances; the samples provided by Colin et al (2003) and Robinson et al (2004) provided us with a useful starting point. Such interview-based surveys need to be very carefully constructed, and the interviewer needs to be well informed. This particular experience illustrates the importance of good planning, focused training of interviewers, clear guidelines for questioning, and well prepared and carefully constructed questionnaires and information sharing tools. The questionnaire developed here was constructed to address these needs in the WIO, and represents a useful tool for future studies.

The most difficult and critical question was "how do you know the fish were spawning?". In order to properly interpret the various responses to this question the interviewer needed a sound knowledge of spawning aggregations. Reef fishes form aggregations for feeding, schooling, and migrating that can be confused for spawning by unskilled observers. Training of interviewers in the present study was probably not adequate, but nevertheless there was a high degree of concurrence among fishers on the formation of spawning aggregations in some species, especially in northern Kenya. An additional difficulty encountered during the interviews was that many fishers were suspicious that the work would result in restrictions. This was particularly noticeable in National Marine Park/Reserve areas (Mafia, Kiunga, Mnazi Bay). In contrast, fishers from community based management areas (Tanga, Dar es Salaam) were not suspicious and were very cooperative.

Conducting interviews with resource users requires specific guidelines to ensure the use of information is explained in a clear, honest and simple manner. Moreover, to retain good relationships between the researchers, managers and local communities, it is important that the findings and conclusions are shared with the interviewees. It is anticipated that a simple version of the findings will be circulated in due course among the interviewees and other stakeholders.

The species cited as likely to be aggregating to spawn on the East African coast were all, with the exception of the Haemulidae, from families whose species are well known to form spawning aggregations in the Pacific and/or Caribbean, namely the Serranidae, Lutjanidae, Siganidae, Lethrinidae, Scaridae (Domeier and Colin 1997). To our knowledge the present study represents the first report of haemulid spawning aggregations since Moe (1966) reported aggregations of *Haemulon plumieri* in Florida. Both reports represent unconfirmed sightings. Interestingly, species of snapper (lutjanids) were among the most cited species in our study. In contrast, with the exception of recent work in Seychelles (Robinson et al 2004), spawning aggregations of snapper have not been reported in the Indo-Pacific previously, though they are well known to form spawning aggregations in Florida and the Caribbean (Domeier and Colin 1997, Domeier et al 2002).

The results of the present study are further corroborated by recent work in Seychelles: *Lutjanus sebae*, *L. bohar* and *Siganus sutor* have all been reported to form spawning aggregations in Seychelles (Robinson et al 2004). Of further note, two species reported in the present study are limited to the Indian Ocean (Lieske and Myers 2001): *Plectropomus punctatus* and *Siganus sutor*, and our reports on *P. punctatus* are the first for this species in the WIO.

Further verification of the results is important due to the difficulties of correct species identification in interview-based surveys. In the present study it is quite likely that fishers confused *Epinephelus polyphekadion* and *E. fuscoguttatus.* Similarly, the siganids are difficult to distinguish and *Siganus sutor* and *S. argenteus* are likely to have been confused. This highlights the need for verification of fishers' information through direct observations in the field.

Despite focused questions on *Cheilinus undulatus*, because of our interest in this highly threatened species (Sadovy et al 2003), no information was forthcoming. This suggests a number of possible explanations: the species does not aggregate to spawn in the coastal waters of East Africa, fishers are unaware that it aggregates to spawn, it is not a target species for fishers in East Africa, or populations are so depleted that aggregations no longer occur. Fishers' lack of knowledge about the spawning habits of *Cheilinus undulatus* is the more plausible explanation because we know that humphead wrasse are not traditionally targeted in the Eastern African region (pers. obs., Sadovy et al 2003). Further, it is likely that the species does spawn in aggregations in East Africa in locations accessible to the fishers we interviewed, based on its spawning behaviour in the Pacific (Colin 2004). This result highlights the need for further research on this vulnerable species in the Western Indian Ocean region, to ensure its spawning sites are protected before exploitation occurs.

Our preliminary results indicated most spawning aggregations in East Africa occur during the Northeast monsoon period (October – April). This information coincides with previous reproductive studies on reef fishes in East Africa (Nzioka 1979; Ntiba and Jaccarini 1990; Kaunda-Arara and Ntiba 1997; Kulmiye et al. 2002; Kamukuru and Mgaya in press).

Although the results are very preliminary they do suggest a difference in fishers' knowledge of spawning aggregations between Kenya and Tanzania, with more reliable information coming from Kenya. Differences in the information obtained is not likely to be due to differences in the ability of the field interviewers to obtain information since three interviewers were used in Kenya and four in Tanzania, all received the same training, and all were similarly unaware of the phenomenon of spawning aggregations prior to this study. Two reasons for the country differences are proposed. Kenya has had marine parks and reserves along its coast for a number of years, with the first Marine Park gazetted in 1968 (Obura et al, 2000, Francis et al 2002). In contrast Tanzania gazetted its first Marine Park (Mafia Island) in 1994. Further, dynamite fishing was widespread on the mainland coast of Tanzania for decades (Horrill et al 2001, Obura et al 2002), and has only been halted in the last 5-10 years. Therefore reef fish populations in

Kenya are likely to have received much higher protection than in neighbouring Tanzania. Secondly, fishing is and has been a more prevalent tradition among coastal Tanzanians compared with Kenyans (pers. obs.), and therefore fishing pressure is likely to have been and continues to be considerably greater in Tanzania than in Kenya. These observations may indicate that reef fish spawning aggregations have been disrupted through overfishing in Tanzania.

Other regional differences in the results are likely to reflect differences in fishing pressure and habitat damage. The most comprehensive data, in terms of number of species and multiple reports, was obtained from fishers in the Kiunga region, northern Kenya suggesting that fish spawning aggregations may be a common occurrence in this region. This may partly be due to the fact that there is a Marine Reserve in the area, but more likely it is due to its remoteness, inaccessibility and distance to markets (Church and Obura in prep). These factors have meant the fisheries and habitats have not been over-exploited to the extent of areas in southern Kenya and in Tanzania. Most of the lagoonal reefs on the south coast of Kenya are over-exploited (McClanahan and Obura 1995, Kaunda-Arara et al. 2003) as are reefs in Tanzania, particularly around Dar es Salaam, which have a long history of reef degradation (Jiddawi and Stanley 1999). It is possible that the deterioration of habitat and fish populations has reduced aggregation densities to low levels in Tanzania making them difficult to detect. In addition, species well know to form spawning aggregations are the groupers (Domeier and Colin 1997), which also constitute one of the more vulnerable reef fish families in relation to fisheries exploitation (Sadovy 1996), and they are particularly susceptible to overfishing of spawning aggregations (Sadovy 1994, Samoilys 1997, Vincent and Sadovy 1998, Johannes et al 1999). Since the early 1990s, the total catches of Serranidae in Kenya have declined the most among commercial fish species (Kaunda-Arara et al. 2003). The links between this decline and targeted fishing on spawning aggregations remains unknown in East Africa.

Although the present study cannot provide conclusive evidence of spawning aggregations in East Africa, it has been highly successful in creating awareness of the phenomenon in the region. The focal scientists involved represented leading research institutions in Kenya and Tanzania, and interviewers represented a variety of projects field staff from government Marine Parks and Reserves staff to marine resource personnel in community based field projects. As a first step and with little funding, the study was effective in spreading an understanding of the importance of spawning aggregations of reef fishes along 1600km of East Africa’s coastline. Additional collaboration with northern Mozambique is currently underway. An important aspect of the next phase will be to harness this interest and strengthen the capacity to research and manage reef fish spawning aggregations in the broader WIO.

These relatively rapid, low cost interviews were designed to guide us in developing a detailed research programme to investigate spawning aggregations, and in this they were effective. On the basis of this preliminary information from fishers we are returning to the South coast of Kenya to work with fishers who provided some of the most reliable information. We intend to verify spawning aggregation behaviour in situ and obtain gonads to conduct histological assessments of gonad maturity. We intend to work with government departments, both Kenya Wildlife Service in charge of Marine Parks and Reserves, and the Fisheries Department to encourage the concept of protecting spawning aggregations to help build resilience into marine parks and reserves (Domeier et al 2002, TNC 2004) and as a fisheries management tool (Turnbull and Samoilys 1997, Samoilys and Donnelly 2001, Samoilys and Squire 2002). Finally, the present study contributes knowledge of spawning aggregations in two species endemic to the Western Indian Ocean.

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Appendix 1

Reef Fish Spawning Aggregations Questionnaire
Eastern Africa Region, May 2004

General principles

1. Adopt casual/informal manner to gauge response and determine who will be willing to be interviewed
2. Where possible work closely with a guide/village assistant
3. Use the resources/material (laminated fish id sheets and photographs of spawning aggregations and running ripe gonads
4. Tease out existing local knowledge on spawning aggregations i.e. by seeing if they use change of fish colour, numbers, size of gonads – running ripe (eggs large, loose and expressed very easily)

****

Fieldworker:____________________ Date: ____________ Site:______________
ID Number:

SECTION 1

1. Fish spawning aggregations

1.1. Have you fished/seen/or heard of this phenomenon? Yes / No
1.2. How many sites have/did you see this? List names and/or locations.
1.3. What species/families were involved at each of the sites? If you can list the species per site write them in the space below for question 2.
1.4. Why do you think the species were aggregating: feeding, spawning, other, no idea? Give reasons for answer.
1.5. Why do you think they do it at the specific sites and nowhere else?

*If the answer to **Question 1.1** is YES, can you complete any of the following questions?*

****

2. Species - obtain details about the aggregating species mentioned earlier in Question 1, and tease out the species

2.1. What type(s) (species or common name) of reef fish were involved in the spawning aggregation(s)? If there is more than one example, please list them all.

SECTION 2

Questions in section 2 focus on one species at a time
Please fill out one table per species

	Questions	Answers
1.	**Species:** Clarify the species' identification using the fish id sheets	
2	***Location*** Map out on chart/map if possible Mark GPS point if possible Use local reference points Be as specific per species as possible	ID Number:
2.1	Where were these fish spawning aggregations seen/found? Please provide as much information as possible; draw a map if needed	
3	**Habitat and depth**	Habitat types include: coral reef, sand; seagrass, Reef profile types include: reef crest; drop-off; pass; outer slope
3.1	Can you give details about the type of marine habitat where the aggregation occurred?	
3.2	What was the depth of the aggregation?	Minimum: Maximum:
4	**Time and conditions**	Use Gregorian year/months The season Record continuity over months Use the Islamic calendar if it helps but convert later The period of day (am, pm, night, midday)
4.1	At what time of year (month, lunar phase, time of day) did you fish/see the aggregation?	Season (e.g. NE, SE winds & inter-monsoon): Month (list every month observed): Lunar phase (new, full, 1st qtr, 3rd qtr): Time of day (dawn, am, midday, pm, dusk, night):
4.2	What were the conditions of the sea at the aggregation site?:	Current (weak, moderate, strong): Tidal state (low, high, ebb, flow): Wind (NE/SE, strong, weak etc): Water temperature:
4.3	How long did the aggregation last? e.g. number of days	
5.	**Fishing pressure on the aggregation**	
5.1	How often have you been fishing or noticing this aggregation?	
5.2	Do you still fish this site throughout the year?	Yes/No
5.3	Are you still fishing this aggregation and if so for what reasons?	
5.4	How many boats fish the site currently?	

5.5	Have you noticed an increase of other fishers/boats targeting this aggregation? If so, by how much?	
6	**Catch size per fisher**	
6.1	If (When) the aggregation is (were) fished, is (were) the average catch larger than usual on this site compared to other fishing sites? If so by how much?	
6.2	What was the average size of the fish when the fish were aggregating compared to other sites?	
6.3	Have you noticed a change in the fish catch since you first fished it? If so how has it changed? (increase/decrease)	
	If so, when did you first notice a change in catch at the site?	
7.	**Personal views on the** aggregation	
7.1	Do you have any concerns about this aggregation?	
7.2	If so, do you have any suggestions to rectify or manage your concerns	

Please fill out below any other points that you consider important regarding the fish spawning aggregation.

Thank you for your assistance

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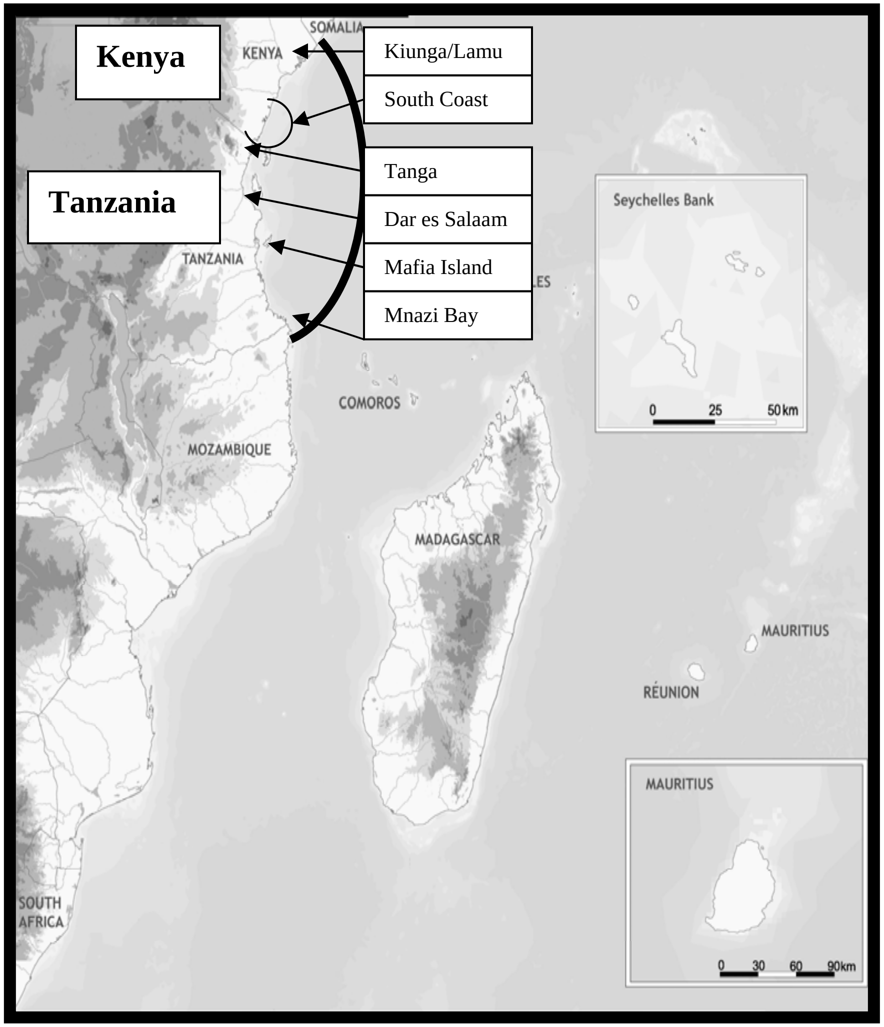

Figure 1. The East African region, indicating the study area.

Table 1. Fish spawning aggregation information needs against the research approaches.

Information needs	**Research approaches**
1. Site location	1. Fishers' knowledge (interviews), targeted surveys
2. Migration distance / pathways	2. Tagging, life history studies, fishers' knowledge
3. Temporal dimension	3. Fishers' knowledge, targeted surveys
4. Habitat / life history requirements	4. Fishery & other surveys

Table 2. Number of fishers interviewed in Kenya and Tanzania. The positive responses by fishers indicates the number of fishers who said they knew about spawning aggregations. The column of fishers with reliable information refers to fishers who could provide reasonable evidence that the fish were in spawning aggregations.

COUNTRY	REGION	NUMBER OF FISHERS	POSITIVE RESPONSES	FISHERS WITH RELIABLE INFO.
KENYA	Kiunga (north)	46	36	28
	South coast	88	32	9
	TOTAL	**134**	**68**	**37**
TANZANIA – Mainland	Tanga	23	18	12
	Dar-es-Salaam	17	4	3
	Mafia	13	12	0
	Mtwara	19	10	1
	TOTAL	**72**	**44**	**16**

Table 3. Reef fish species identified as forming spawning aggregations by fishers in Tanga region, Tanzania. * = species identified by more than one fisher.

Serranidae	Lutjanidae	Lethrinidae	Siganidae
Plectropomus areolatus *Epinephelus lanceolatus* *E. tukula* *E. polyphekadion*	*L. ehrenbergi* *L. kasmira* ***L. sebae*** * *L. bohar* *L. sanguineus* *L. rivulatus* *M. macularis*	*Gymnocranius grandoculis* *L. nebulosus* *L. olivaceus*	***S. sutor **** *S. argenteus*

Table 4. Reef fish species likely to form spawning aggregations in southern Kenya (Malindi – Gazi) derived from observations of spawning behaviour. * = species identified by more than one fisher.

Serranidae	Lutjanidae	Lethrinidae	Siganidae	Haemulidae
Epinephelus fuscoguttatus *E. multinotatus* *Plectropomus laevis* ***P. punctatus ****	*Aphareus furca* ***Lutjanus fulviflamma**** *L. kasmira* *L. quinquelineatus* *L. monostigma* ***L. bohar **** *Caesio coerulaureus* *C. lunaris*	*L. nebulosus*	*S. sutor* *S. spinus*	*Plectorhinchus gaterinus*

Table 5. Reef fish species likely to form spawning aggregations in northern Kenya (Kiunga Marine National Reserve) derived largely from observations of fish with ripe gonads. Note all species listed were observed by more than one fisher, and several aggregation sites per species were reported.

Species reported	Number of fishers reporting this species	Number of spawning aggregation sites per species
Serranidae		
Epinephelus polyphekadion	9	6
Cephalopholis miniata	2	2
Lutjanidae		
Lutjanus ehrenbergi	5	5
L.bohar	8	5
L. rivulatus	2	2
Lethrinidae		
Lethrinus harak	16	8
L. obsoletus	5	4
L. xanthochilus	5	5
Siganidae		
Siganus sutor	31	17
Haemulidae		
Plectorhinchus flavomaculatus	27	18
P. schotaf	18	13
Scaridae		
Leptoscarus vaigensis	5	4

Table 6. Reef reef fish species that were commonly reported as forming spawning aggregations by fishers in Kenya and Tanzania. Only ***Siganus sutor*** was reported from both countries. Species underlined are those that only occur in the Indian Ocean. * = reported from Seychelles (Robinson et al in press).

Serranidae	**Lethrinidae**	**Lutjanidae**	**Siganidae**	**Haemulidae**	**Scaridae**
Epinephelus polyphekadion *E. fuscoguttatus* <u>*Plectropomus punctatus*</u> *Cephalopholis miniata*	*Lethrinus harak* *L. obsoletus* *L. xanthochilus*	*Lutjanus sebae* * *L. ehrenbergi* *L. bohar* * *L. monostigma* *L. kasmira* *L. rivulatus*	<u>***Siganus sutor***</u> ***** *S. argenteus*	*Plectorhinchus flavomaculatus* *P. schotaf*	*Leptoscarus vaigensis*

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