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Spawning aggregations of fish in Cabo Delgado, Northern Mozambique: An interview-based survey of artisanal fishers

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Abstract
Seasonal aggregations at specific sites are common among some fish species. Experienced fishermen know where and when these aggregations happen, often targeting these spawning sites to increase their catch. This strategy can further contribute to endangering the survival of these species, especially for those already threatened by other forms of pressure. This study contributes knowledge to the spawning aggregation of fish in the north of Mozambique following survey work conducted around Cabo Delgado Province in six coastal villages in 2016, 2017 and 2018. The objectives of the study were 1) to identify the species and sites of spawning aggregation and 2) to determine the timing of spawning aggregations. Data collection consisted of interviews targeting the most experienced fishermen to obtain information on these subjects. The results indicate that out of 124 fishermen interviewed, 59% had knowledge of spawning aggregations. The information collected from fisher interviews revealed that there are at least six spawning locations and at least eight species aggregate to spawn (*Leptoscarus vaigensis*, *Lethrinus harak*, *Lethrinus nebulosus*, *Lethrinus obsoletus*, *Lethrinus olivaceus*, *Plectorhinchus gaterinus*, *Plectorhinchus schotaf*, *Siganus sutor*). Only *Siganus sutor* was reported to spawn in at least one of the fishing areas used by every village. The timing of spawning aggregations most reported by fishermen was during the Kusi (South) monsoon period.

Keywords: Coral fish, Spawning aggregations, Mozambique, Western Indian Ocean, Fisheries management

Introduction
Spawning aggregations occur in many reef species, grouping together large numbers of individuals at specific times and locations at approximately the same time of the year, lunar phase, and sometimes the same tide (Russell, 2001; Samoilys *et al*., 2006; Sadovy de Mitcheson and Colin, 2012; Russell *et al*., 2014).

The aggregation season for a given species in each location tends to be consistent, making these events predictable (Tamelander *et al*., 2008; Nanami *et al*., 2017). Fishermen usually use this knowledge to capture as many fish as possible during this key reproductive period, which can lead to a drastic reduction in the population density and unsustainable levels of fishing effort (Russell *et al*., 2014). Knowledge of fish spawning aggregations, their location and timing are fundamental for population management, whether for the creation of marine protected areas (MPAs) or other non-permanent fishing management measures, such as closures (Samoilys and Church, 2004; Samoilys *et al*., 2006).

Mozambique is not in the list of the 52 countries where spawning aggregations of fish occurs (Russell *et al*., 2014), despite the existence of spawning aggregation records for *Caranx ignobilis* in Vamizi Island in northern Mozambique (Silva *et al*., 2014) and Ponta do Ouro Partial Marine Reserve (PPMR) in southern Mozambique (Daly *et al*., 2018; 2019). The present study aims to assess local knowledge of fish aggregations in northern Mozambique to contribute to future fishery management. Furthermore, the findings on fish aggregations in this study will contribute to the database on the Science and Conservation of Fish Aggregations (SCRFA).

http://dx.doi.org/10.4314/wiojms.v19i1.3

Methods

Field work was carried out in October 2016, June and September 2017 and July 2018 in six coastal villages of Cabo Delgado province (10°29´S, 35°58´E – 14°01´S, 40°35´E). Four rounds of interviews were conducted in the Palma District (Quirinde, Quiwia, Lalane and Nsangue), one in Mocimboa da Praia District (Malinde) and one in Mecufi District (Mecufi) (Fig. 1). The selection of fishermen and interviews were conducted for an average of two days for each village.

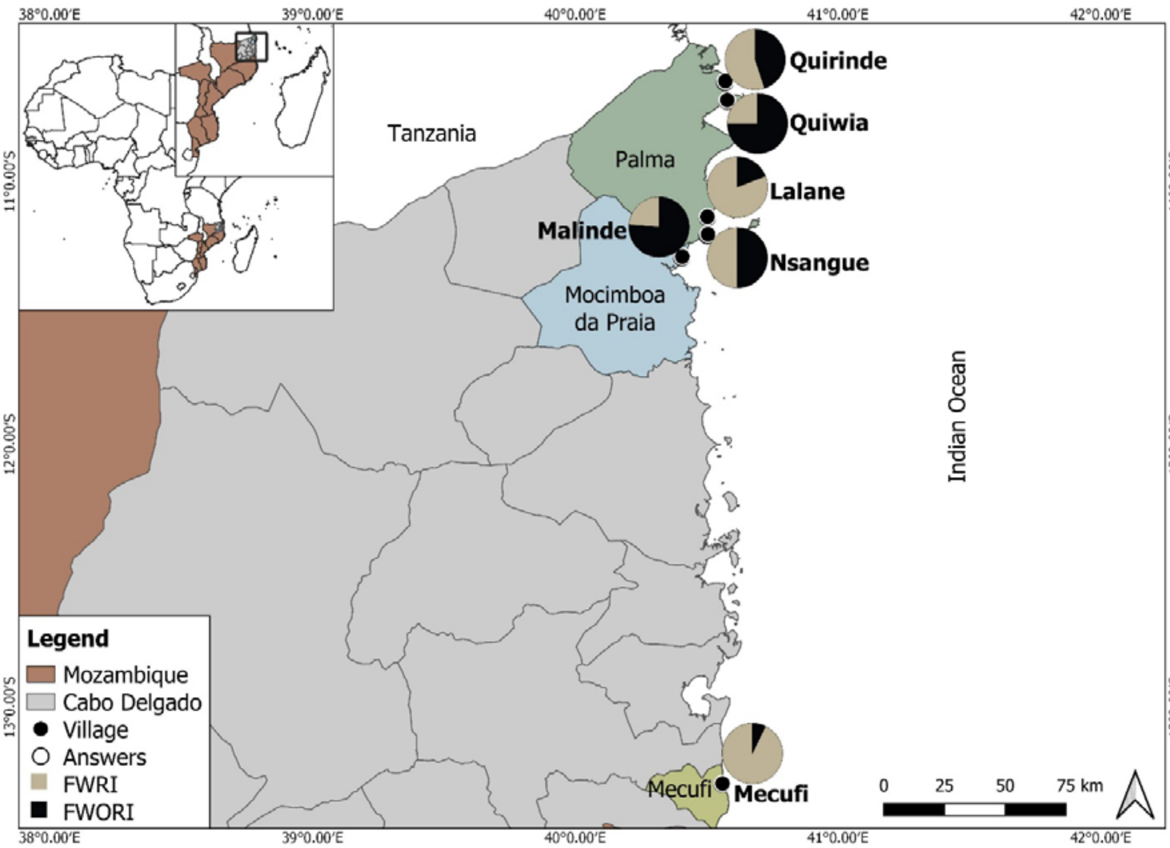

Figure 1. Coastal region of Cabo Delgado showing the percentage of responses of fishermen about the spawning aggregation phenomenon in each study village. The grey color shows the percentage of fishermen with reliable information who could provide reasonable evidence that the fishes were in spawning aggregations (FWRI=Fishers with Reliable Information). The black color shows the percentage of fishermen without reliable information who could not provide reasonable evidence that the fishes were in spawning aggregations (FWORI= Fishers without Reliable Information).

Data collection was carried out through semi-structured interviews (see supplementary material), based on the work of Robinson *et al*. (2004) and Samoilys *et al*. (2006). The interviews were conducted individually with fishermen and lasted approximately 15 to 25 minutes each. All interviews were conducted with the help of a local guide and included members of the local Community Fisheries Council (CCPs), technicians of Associação do Meio Ambiente (AMA - a local environmental NGO) and influential fishermen, to maximize data quality and diversity.

To assist with identification of the species and description of spawning aggregations, a field guide was prepared, featuring the species most likely to aggregate and spawn in the region, based on studies carried in the Western Indian Ocean (Samoilys *et al*., 2006; Sadovy de Mitcheson and Colin, 2012; www.scrfa.org), and on the field guide of Coral Reef Fishes (Lieske and Myers, 2002).

After identification of the species and their sites of spawning, the fishermen chose one or two species for more detailed discussion, including on information on location, lunar phase, tide, size, habitat, trends in catch, fishing effort and the period of spawning aggregation.

Suggested spawning sites were recorded using local names and were located using participatory maps of marine resources already developed by the communities in other projects (Fig. 2).

Data Analysis

The validation and interpretation of the data was based on how information from the fishermen on spawning aggregations corresponded with the criteria of verification described by Robinson *et al.* (2004) and Samoilys *et al.* (2006): 1) verification of the positive response on the knowledge of spawning aggregation; 2) knowledge of the species mentioned by more than one fishermen; 3) knowledge of the sites of spawning aggregation or more than one species mentioned by more than one fishermen; 4) verification of the

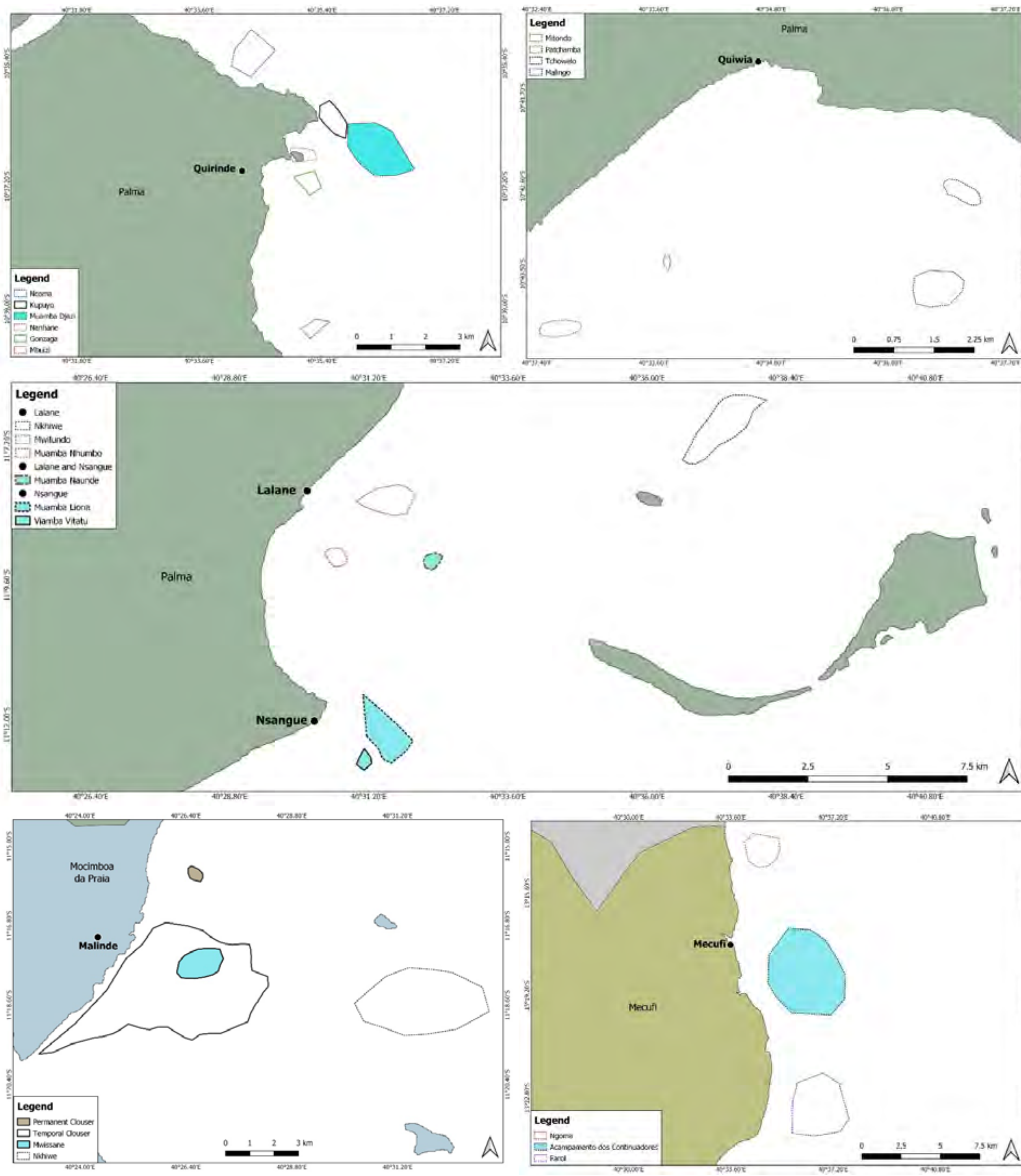

Figure 2. Spawning aggregation sites in all studied villages. The sites highlighted were the most reported.

probable species that aggregate to spawn according to Sadovy de Mitcheson and Colin (2012), Erisman *et al.* (2018) and the SCRFA database.

Only the responses in which the evidence for spawning aggregations was reasonable were used (Samoilys *et al.*, 2006). The questionnaires were discarded if the fishermen claimed that a species aggregated to spawn, but that throughout the interview they referred to the fish as "playing or feeding". Whenever a fisherman misidentified a species or aggregated different species, the entire questionnaire was discarded. Sometimes, even though the fishermen showed knowledge of fish species and sites of spawning aggregation, the information was not enough to infer the occurrence of reproductive aggregation because it was not referenced by more than one fisherman. This information was then also discarded.

The data was reduced to a subset which was then analyzed in steps 2), 3) and 4) to determine the data with the highest probability of providing species information and reliable spawning sites, which further reduced the dataset.

The species selected were those that the fishermen gave more detailed information on in relation to the month, lunar phase, tide and period of spawning aggregation. The information was also crossed-referenced with the list of Reef Fish Spawning Aggregations compiled by Sadovy de Mitcheson and Colin (2012) and the list of Fish Spawning Aggregations (FSAs) (Erisman *et al.*, 2018).

Subsequently maps of spawning aggregation sites were produced in the QGIS v.3.8 software using the available coordinates obtained from a participatory map of marine resources already developed (Colin *et al.*, 2003).

Table 1. Species reported to spawn in aggregation by more than one fisherman in all villages. Species marked in bold were reported in five villages. The numbers indicate how many times the species were reported by more than one fisherman per site. **Siganus sutor* was reported in every village.

Family	Species	Muamba Djazi	Muamba Naunde	Muamba Liona	Muamba Vitatu	Mwissane	A. Continuadores
Serranidae	*Epinephelus tukula*			2			2
Lutjanidae	*Lutjanus fulviflamma*	3	3	3		2	3
	L. ehrenbergi						
	L. quinquelineatus						
	L. kasmira					3	
Lethrinidae	***Lethrinus harak***	2		4	2	2	2
	L. obsoletus		2	3		2	2
	L. nebulosus	2					
	L. olivaceus	2			2		2
	Gymnocranius grandoculis	5				4	5
Siganidae	***Siganus sutor****	6	4	7	2	4	18
Haemulidae	*Plectorhinchus flavomaculatus*			2		4	3
	P. schotaf		3	7		5	
	P. gaterinus	2	3	7	3	4	
Scaridae	*Leptoscarus vaigensis*			7		3	11
Caesionidae	*Caesio coerulaureus*	3					4
	C. lunaris	4					5

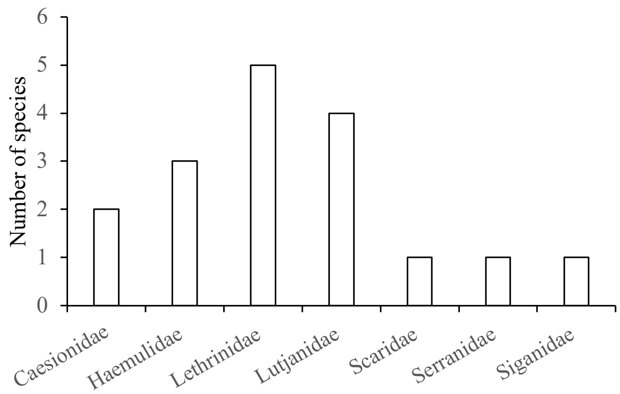

Figure 3. Number of species per family that aggregate to spawn.

Results

In total 124 interviews were conducted and 73 passed the validation criteria. Fifty one corresponding 41% interviews were discarded because the fishermen did not show knowledge of the phenomenon of spawning aggregation, 14 because the information was not co-validated by a second fisherman, and 37 because when asked the reasons why fish aggregate, they answered: "I don't know"; "They are always in this place"; "Playing"; "Feeding" (Fig. 1).

Overall, 17 species (Table 1) were reported to aggregate for reproduction, distributed in 7 families with a prominence within the group of emperors (Lethrinidae) followed by snappers (Lutjanidae) (Fig. 3). Eight species were common occurring in six sites (*Leptoscarus vaigensis*, *Lethrinus harak*, *Lethrinus nebulosus*, *Lethrinus obsoletus*, *Lethrinus olivaceus*, *Plectorhinchus gaterinus*, *Plectorhinchus schotaf*, *Siganus sutor*) (Table 1, species in bold). *Siganus sutor* was the only species reported in all studied villages.

In general, fishermen reported that most species spawned during the Kusi (South) monsoon period (dry season, April–July/August). However, some species were reported to spawn in Ulani (North) monsoon (rainy season, December–March) and inter monsoon period (Table 2).

Discussion

About one-third of the species reported by fishermen in this study are known to aggregate for spawning elsewhere in the world according to the list of Reef Fish Spawning Aggregations (RFSA) by Sadovy de Mitcheson and Colin (2012), and Fish Spawning

Table 2. Number of fishermen observations of spawning aggregations by month or period for the key species groups in all villages.
* no details were provided by fishermen for *Lethrinus nebulosus*.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Caesio coerulaureus	1	1	1			2	2	3				1
C. lunaris							5	4		2		
Epinephelus tukula								2	1			
Gymnocranius grandoculis				2			3	3	2	1		
Leptoscarus vaigensis	1	2		1			9	4		4		
Lethrinus harak	1						2	1	1	1		
L. obsoletus		1					1	3				
L. olivaceus							1	1				
Lutjanus ehrenbergi							1	1				
L. fulviflamma			1		1	2	1	2	1	2	1	
L. kasmira	1					1	1	2	1	1		
Plectorhinchus flavomaculatus		1					1	1				2
P. gaterinus		2				1		1		3		
P. schotaf				2					1	1		
Siganus sutor	3			1		2	1	7	2	4		1

Aggregations (FSAs) by Erisman *et al.* (2018). The proportion found in this study is relatively consistent with a study carried out in Seychelles (Robinson *et al.*, 2004).

The families of the species that were reported to form spawning aggregations in Cabo Delgado are already known, as recorded in the RFSA and FSAs lists and others studies (Russell, 2001; Samoilys *et al.*, 2006; Flynn *et al.*, 2006; Sadovy *et al.*, 2008; Sadovy de Mitcheson and Colin, 2012; Kobara *et al.*, 2013; Farmer *et al.*, 2017; Nanami *et al.*, 2017; Fisher *et al.*, 2018; Erisman *et al.*, 2018). These include the Serranidae, Lethrinidae, Lutjanidae, Siganidae, Scaridae and Caesionidae. However, Haemulidae was reported for the first time in this study. The occurrence of spawning aggregation of the Caesionidae family in the villages of Quirinde, Nsangue, Malinde and Mecufi was only previously recorded by Samoilys *et al.* (2006) in Kenya and Tanzania. However, the confirmation of these spawning aggregations in the literature does not eliminate the need for evidence from direct observation and assessing the gonad index (Domeier and Colin, 1997).

The spawning aggregation of snappers (Lutjanidae) was observed by the fishermen between June and October. This pattern differs from a study in Kenya and Tanzania, in which the spawning aggregation season of the snapper species was identified as occurring during the month of October with a smaller peak occurring in January and February (Nzioka, 1979), and from patterns recorded in the Seychelles, where the season peak is March and April (Robinson *et al.*, 2004).

Groupers are some of the more common species known to aggregate (Domeier and Colin, 1997; Samoilys *et al.*, 2006), however, only one species, *Epinephelus tukula,* was recorded in this study. Three fishermen reported the aggregation and the spawning season of this species in August/September. However, large spawning aggregations of *Epinephelus lanceolatus,* the giant grouper, are known from Vamizi Island (north of Cabo Delgado) during December/January (Isabel da Silva, pers. obs.)

Finally, the fish most reported by fisherman to aggregate for spawning was *Siganus sutor*. This species makes up a high proportion of catches in artisanal fisheries in the region, where a variety of gears such beach-seine, gillnets, basket traps, handlines and spearguns are used (Fischer *et al.*, 1990; MGDP, 2016; Bilika *et al.*, 2019). Most fishermen (76%) reported spawning aggregation of *Siganus sutor* between June and October, 19% between December/January, while only one fisherman reported it for April. This result differs from a study conducted in southern Kenya, where most fishermen reported occurrences of spawning aggregation between November and February, with some reports from March to October, and no records during August (Maina *et al.*, 2013).

The most reported spawning season in this study (June to October) is not corroborated by similar work in Kenya and Tanzania (Samoilys *et al.*, 2006) where most species spawned during October–April, during the Northeast monsoon. A possible explanation for this contrasting result could be attributed to the climatic differences between these regions, which could affect spawning (Johannes, 1978; Heyman *et al.*, 2005; Choat, 2012; Kobara *et al.*, 2013; Rosli *et al.*, 2014).

One of the limitations established during interviews was that some fishermen suspected that the study would result in restrictions on the sites of their fishing activities. This was seen in the northern villages of Cabo Delgado, namely in Quirinde, Quiwia, Lalane and in Malinde. However, fishermen from the established permanent marine reserve area (Nsangue) and from Mecufi were extremely cooperative with the study. These challenges were also reported in the study conducted in Kenya and Tanzania (Samoilys *et al.*, 2006).

Further verification of these results is important to confirm the spawning aggregation described, through direct observation on fish abundance and by observing the gonad index for assessing maturation condition. If a species is known to aggregate to spawn it will be more susceptible to overfishing (Samoilys, 1997; Vincent and Sadovy, 1998; Johannes *et al.*, 1999; Samoilys *et al.*, 2006). It is important to include fish aggregation data in the management of fisheries, by proclaiming temporal closures or reserve areas that fit the local patterns of spawning and consequently increase the sustainability of the fisheries for these species.

Acknowledgments

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References

Bilika F, Farooq H, Simão C, Soares A, Morgado F (2019) Composição específica da comunidade de peixes da Baía de Pemba (Norte Moçambique). Seminário Internacional. Alterações Climáticas, Biodiversidade e Sociedade: Desafios no contexto Africano. CAPTAR 8 (1): 144-155

Choat J (2012) Spawning aggregations in reef fishes; Ecological and evolutionary processes. In: **Sadovy de Mitcheson** Y, **Colin** PL (eds) Reef fish spawning aggregations: Biology, research and management. pp 85-116 [doi:10.1007/978-94-007-1980-4_4]

Colin PL, Sadovy de Mitcheson Y, Domeier ML (2003) Manual for the study and conservation of reef fish spawning aggregations. Society for the Conservation of Reef Fish Aggregations, Special Publication No. 1. pp 1-98+iii

Daly R, Daly CAK, Bennett RH, Cowley PD, Pereira MAM, Filmalter JD (2018) Quantifying the largest aggregation of giant trevally *Caranx ignobilis* (Carangidae) on record: implications for management. African Journal of Marine Science 40: 315–321 [doi:10.2989/1814232X.2018.1496950]

Daly R, Filmalter JD, Daly CAK, Bennett RH, Pereira MAM, Mann BQ, Dunlop SW, Cowley PD (2019) Acoustic telemetry reveals multi-seasonal spatio-temporal dynamics of a giant trevally *Caranx ignobilis* aggregation. Marine Ecology Progress Series 621: 185–197 [doi.org/10.3354/meps12975]

Domeier ML, Colin PL (1997) Tropical reef fish spawning aggregations: defined and reviewed. Bulletin of Marine Science 60: 698-726

Erisman B, Heyman WD, Fulton S, Rowell R (2018) Fish spawning aggregations: a focal point of fisheries management and marine conservation in Mexico. Gulf of California Marine Program La Jolla, CA. 24 pp

Farmer NA, Heyman WD, Karnauskas M, Kobara S, Smart TI, Ballenger JC, Reichert MJM, Wyanski DM, Tishler MS, Lindeman KC, Lowerre-Barbieri SK, Switzer TS, Solomon JJ, McCain K, Marhefka M, Sedberry GR (2017) Timing and locations of reef fish spawning off the southeastern United States. PLoS ONE 12 (3): e0172968 [doi:10.1371/journal.pone.0172968]

Fischer W, Silva C, De Freitas A, Poutiers JM, Schneider W, Borges TC, Féral JP, Massinga A (1990) Guia de campo das espécies comerciais marinhas e de Águas Salobras de Moçambique. Fichas FAO de Identificação de Espécies para Actividades de Pesca, Roma

Fisher EE, Choat JH, McCormick MI, Cappo M (2018) Relative influence of environmental factors on the timing and occurrence of multi-species coral reef fish aggregations. PLoS ONE 13 (12): e0209234 [doi.org/10.1371/journal.pone.0209234]

Flynn A, Sarramegna S, Kulbicki M (2006) Coral reef fish spawning periodicity and habitat in New Caledonia: a multi-faceted approach in a data-deficient environment. Proceedings of the 10th International Coral Reef Symposium. pp 1295-1305

Heyman WD, Kjerfve B, Graham RT, Rhodes KL, Garbutt L (2005) Spawning aggregations of *Lutjanus cyanopterus* (Cuvier) on the Belize Barrier Reef over a 6-year period. Journal of Fish Biology 67: 83–101 [doi:10.1111/j.1095-8649.2005.00714.x]

Johannes RE (1978) Traditional marine conservation methods in Oceania and their demise. Annual Review of Ecology and Systematics 9: 349-364

Johannes RE, Squire L, Graham T, Sadovy Y, Renguul H (1999) Spawning aggregations of groupers (Serranidae) in Palau. The Nature Conservancy Marine Research Series Publication No.1. 144 pp

Kobara S, Heyman WD, Pittman SJ, Nemeth RS (2013) Biogeography of transient reef-fish spawning aggregations in the Caribbean: a synthesis for future research and management. Oceanography and Marine Biology Annual Review 51: 281-326

Lieske E, Myers R (2002) Collins pocket guide: Coral reef fishes: Caribbean, Indian Ocean and Pacific Ocean including the Red Sea. Harper-Collins, London. 400 pp

Maina GW, Samoilys M, Alidina H, Osuka K (2013) Targeted fishing of the shoemaker spinefoot rabbitfish, *Siganus sutor*, on potential spawning aggregations in southern Kenya. In: Robinson J, Samoilys MA (eds) (2013) Reef fish spawning aggregations in the Western Indian Ocean: Research for Management. WIOMSA/SIDA/SFA/CORDIO. WIOMSA Book Series 13

MGDP (2016) Plano de reassentamento: Esboço final para aprovação do governo. Annex B: Plano de restabelecimento dos meios de subsistência pesqueiros. Governo do Distrito de Palma

Nanami A, Sato T, Kawabata T, Okuyama J (2017) Spawning aggregation of white-streaked grouper *Epinephelus ongus*: spatial distribution and annual variation in the fish density within a spawning ground [doi:10.7717/peerj.3000]

Nzioka RM (1979) Observations on the spawning seasons of East African reef fishes. Journal of Fish Biology 14: 329-342

Robinson J, Isidore M, Marguerite MA, Öhman MC, Payet RJ (2004) Spatial and temporal distribution of reef fish spawning aggregations in the Seychelles – An interview-based survey of artisanal fishers. Western Indian Ocean Journal of Marine Science 3 (1): 63-69

Rosli MR, Ibrahim AL, Masron T (2014) Prediction of reef fish spawning aggregations using remote sensing: A review. IOP Conference Series: Earth and Environmental Science 18 [doi:10.1088/1755-1315/18/1/012115]

Russell M (2001) Spawning aggregations of reef fishes on the Great Barrier Reef: Implications for management. Great Barrier Reef Marine Park Authority, Australia. 42 pp

Russell MW, Sadovy de Mitcheson Y, Erisman BE, Hamilton RJ, Luckhurst, B, Nemeth RS (2014) Status report – World's fish aggregations 2014. Science and Conservation of Fish Aggregations, California, USA. International Coral Reef Initiative

Sadovy de Mitcheson Y, Cornish A, Domeier M, Colin PL, Russell M, Lindema KC (2008) A global baseline for spawning aggregations of reef fishes. Conservation Biology 22 (5): 1233–1244 [doi: 10.1111/j.1523-1739.2008.01020.x]

Sadovy de Mitcheson Y, Colin PL (eds) (2012) Reef fish spawning aggregations: Biology, research and management. Fish & Fisheries Series Vol. 35. 621 pp

Samoilys MA (1997) Periodicity of spawning aggregations of coral trout, *Plectropomus leopardus* (Pisces: Serranidae) on the northern Great Barrier Reef. Marine Ecology Progress Series 160: 149-159

Samoilys MA, Church JE (eds) (2004) Conservation of coastal and marine biodiversity in the Western Indian Ocean: Progress in the Development of a Partnership Programme for Implementing the Jakarta Mandate. IUCN Eastern African Regional Program Nairobi, Kenya. 40 pp

Samoilys MA, Church J, Kaunda-Arara B, Kamukuru A, Jiddawi N (2006) Preliminary findings on spawning aggregations of reef fishes in East Africa. In: Proceedings of the 10th International Coral Reefs Symposium, Okinawa, 2004 June. pp 1335-1346

Silva IM, Hempson T, Hussey NE (2014) Giant trevally spawning aggregation highlights importance of community fisheries management no-take zone. Marine Biodiversity 45: 139-140

Tamelander J, Sattar S, Satapoomin U, Campbell S, Patterson Edward JK, Hoon V, Chandi M, Arthur R, Adam S, Samoilys M (2008) Reef fish spawning aggregations in South Asia and the Andaman Sea: Preliminary findings from local knowledge. In: Obura DO, Tamelander J, Linden O (eds) (2008) Ten years after bleaching - facing the consequences of climate change in the Indian Ocean. CORDIO Status Report 2008. Coastal Oceans Research and Development in the Indian Ocean/Sida-SAREC, Mombasa. pp 277-281

Vincent ACJ, Sadovy YJ (1998) Reproductive ecology in the conservation and management of fishes. In: Caro TM (ed) Behavioural ecology and conservation biology, Oxford University Press, New York. pp 209-245

Supplementary material

Reef Fish Spawning Aggregations Questionnaire

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 you seen/did you see this occur? 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.

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:
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 quarter, 3rd quarter): 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	
8	Fill out below any other points that you consider important regarding the fish spawning aggregation	