The Use of Local Knowledge: Application to the Management of the Sole Fishery in the Gambia

Gambia-Senegal Sustainable Fisheries Program (Ba Nafaa)

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Cover Photo: Participatory meetings (Left and center photos); Sole sampling (Right photo)

Photo Credit: Coastal Resources Center

Acknowledgements

There is little doubt that involving stakeholders as partners in developing management plans will assist in the progress towards improved management of the fishery resources. Local knowledge based on generations of observations is a major contribution by artisanal fishermen to this process. We wish to thank the fishermen of the Gambia who participated in this project to gather information about the sole resources. Those fishermen drew maps, assisted in at-sea work plotting coordinates with GPS units, and spent countless hours relating their experiences and those of their ancestors to us. This information dramatically improved the data poor scenario and allowed very specific questions to be formulated and investigated.

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1. Introduction

Fishermen's life and livelihood depend on their ability to understand the environment and the behavior of the targeted resources. Much of this knowledge is passed down through generations of fishermen living in fishing communities and new information is added through real life experiences. Most of this knowledge is not in written form, nor is it found in any established format. However, it is usually of such breadth and depth that it is invaluable in understanding the past, present and future of fisheries resources.

Local Ecological Knowledge (LEK) refers to a body of knowledge held by a specific group of people about their local ecosystems. This includes traditional and indigenous knowledge. It is usually considered to be subjective, intuitive, engaged, holistic, spiritual, qualitative and anecdotal. Formal scientific research in ecological information (SEK) is usually considered to be objective and neutral, quantitative, and rigorous. There is a heavy reliance on SEK as the primary source of information in resource management. SEK in fisheries also has a long history. It has evolved from a focus on species identification and taxonomy, through ecology, behavior and biomass estimates to ecosystem approaches to fisheries management. However, SEK information is usually limited – in scope, in time, and in applicability to changing environmental conditions.

LEK is proving to be a valuable tool for resource management but is mostly untapped. Incorporating LEK into the decision making process and creating community based resource management systems can have many benefits. Eliciting and using LEK in the early stages of a management action can make the difference between perception of usefulness and subsequent compliance (Scholz, et al, 2003). But local knowledge is not always accurate but it can be used to develop testable hypotheses that can confirm the reliability of the data (Ruddle and Davis, 2011). The need is to integrate and harness knowledge from various sources so that the community can effectively manage their resources, and remain resilient in changing times. This hybrid knowledge should allow both scientists and local stakeholders to produce useful policies and more effective management practices. Such cooperation minimizes conflict between ecological and economic values and among different management interests.

Most developing countries do not have the resources to compile simple information relevant to managing their fisheries such as catch and effort. Even more limited is their ability to conduct scientific research about the resources or the environment. Therefore, the FAO Code of Responsible Fishing recommends that States should investigate and document traditional fisheries knowledge and technologies, in particular those applied to small scale fisheries, in order to assess their application to sustainable conservation, management and development and that conservation and management decisions for fisheries should be based on the best scientific knowledge available, also taking account traditional knowledge of the resources and their habitat, as well as relevant environmental, economic and social factors.

There are many examples in the literature where local knowledge and scientific knowledge have been integrated (Mackinson and Nottesstad, 1998). There are several methods for capturing local knowledge into a more scientific framework such as GIS and consensus methods (Close and Brent-Hall, 2006); however, to truly combine knowledge it is important to show where they may differ and where they are complementary. Neis et al. (1996) illustrated how LEK could be used to understand northern cod stock structure, changes in catchability, abundance and potential impacts on cod recruitment of proposed management actions to reopen a capelin fishery. Rochet et al.(2008) examined shifts in species composition of the English Channel ecosystem by comparing fishermen's perceptions to data collected with a bottom trawl survey and found good agreement. In fact, fishermen's observations were more powerful for detecting changes.

Fisheries play an important role in the national and local economies of many transformational and fragile states. Ninety-six percent of fishers worldwide are nearshore and most are in developing countries. In spite of this, the fisheries sector—as compared to other sectors of the world food economy—has been poorly regulated. It has also been inadequately funded and neglected by all levels of government. The reasons are numerous; Factors include traditional systems of open access, the difficulty of monitoring landings and effort, the co-existence of multiple species that are caught with the target species, changing environmental conditions, and a general lack of governance and effective enforcement. These fisheries are usually data poor and financial resources are not available to develop information collection systems that include even simple data such as catch and effort.

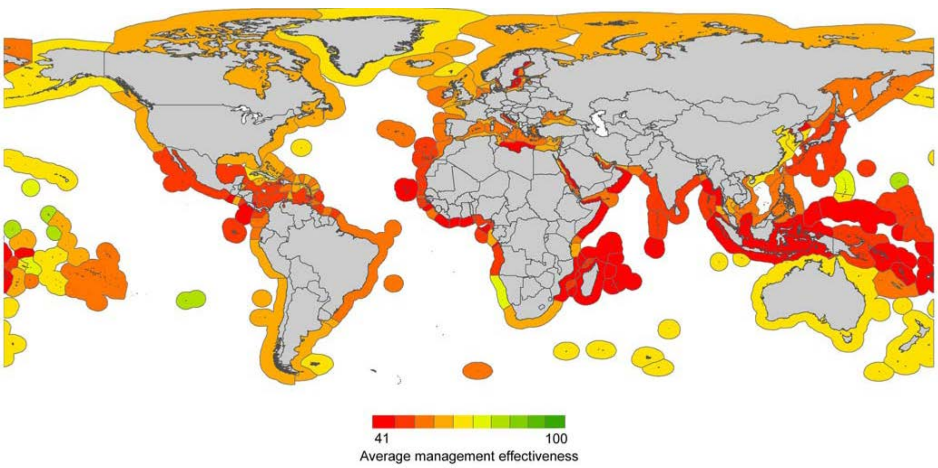


Figure 1. *The probability that fisheries in the EEZ are sustainable in 2004 based on transparent policymaking, implementation capacity, subsidies, fishing capacity, and presence of foreign fleets. (From Mora et al 2009).*

The Gambia, located in West Africa, has a coastline of about 80 km and 25 km of this lie in the Gambia River estuary. Its continental shelf is about 4000 km2 and contains some of the richest fishing grounds in the world. The Canary Current Large Marine Ecosystem (CCLME) produces large upwelling areas that receive additional nutrients from the Gambia River. Fish landings usually total around 47,000 MT per year, mostly produced by the artisanal fleets. The Gambia is pursuing a Marine Stewardship Council (MSC) label for their artisanal sole fishery. To date, no data poor fisheries have been able to pass the strict criteria because of a lack of information relative to the fishery and the resource. To enable them to progress towards meeting the sustainability criteria, the MSC prepared a list of action items to be completed and several groups within the Gambia agreed to work together to accomplish this: The Department of Fisheries, the Atlantic Seafood Company, Gambian Fisheries Development Association (GAMFIDA) and the BaNafaa Project (A USAID funded project under WWF). Much of this information exists only as local knowledge. Therefore, as part of the effort to develop a co-management system for Gambian fisheries, fishermen were asked to participate on compiling information relative to the resource and the fishery. This report summarizes the findings of this 1 year effort integrating LEK with current existing knowledge about the ecosystem.

2. Methods and Materials

Initially, several meeting were held with stakeholders on co-management, describing the state of knowledge on sole and aspects of fisheries management. This was followed by visits to fishing communities (February, 2010), a stakeholder meeting in March 2010 and subsequent at sea trips with designated fishermen to map out important areas. Sole mapping was conducted from March 20 to April 23, 2010, in the coastal waters off the South Bank of The Gambia. BaNafaa representatives accompanied local fishermen from the landing sites at Bakau, Brufut, Tanji, Batokunku, Sanyang, Gunjur, and Kartong at sea and gathered information related to the habitat of the sole fish. GPS coordinates were obtained for various locations at sea that were indicated to be sole spawning areas or hotspots by the fishermen. The fishermen identified the areas of interest at sea, described the habitat types, provided information about sole and some by-catch species. BaNafaa staff recorded the information and took GPS coordinates at the areas that were identified as spawning grounds, rocky or sandy habitat, turtle hotspots, locations of nets, and hotspots of other species. Depth measurements were taken with a string at the majority of the areas where GPS coordinates were recorded.

The GPS unit used to record way points was a hand held GPSMap 60CSx Compass with an accuracy of < 10 meters. DNR Garmin software was utilized to upload the GPS coordinates from the device and also to manipulate the data for use in ArcGIS. 9.4 A base map of The Gambia was created in ArcGIS 10.1, and the GPS coordinates and their attributes were transferred to the map.

3. Results

3.1 Physical Characteristics of the Environment

Wind and rainfall are major factors of environmental importance to the fisheries in the Gambia controlling degree upwelling and nutrient enhancement. Gambia lies within the sub-tropical belt at 13 degrees N latitude. The climate is characterized by two seasons: wet season (between June and October) and a dry season (November to April). During the wet season (The Nawet), the heat rising from the Sahara creates an area of low pressure that encourages southwest winds and monsoons as they meet with the northeast trade winds. This causes the rainy season where rainfall amounts can exceed 51 inches/year.

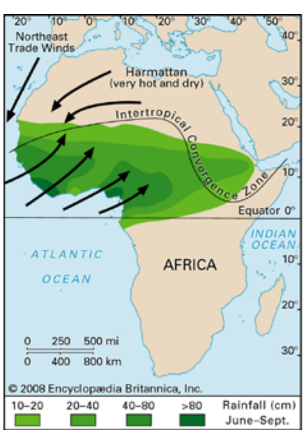
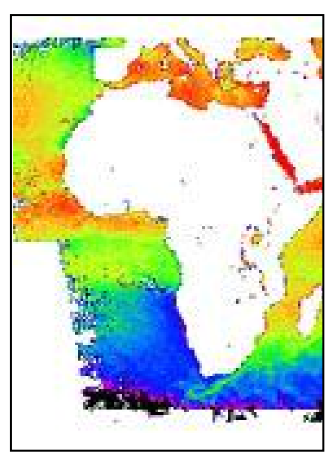


Figure 2a and 2b. *Wet season conditions. (a) Changing ITCZ and wind patterns with resulting change in sea surface temperatures (From Encyclopedia Britannica, Inc., 2008 and eduspace.esa.int).*



The Canary current displays variations in strength based on wind conditions. Several fronts develop seasonally synchronized with coastal upwelling. The upwelling zone expands in winter and shrinks in summer and fall. During the rainy season, the sea surface water temperature rises as upwelling becomes weaker.

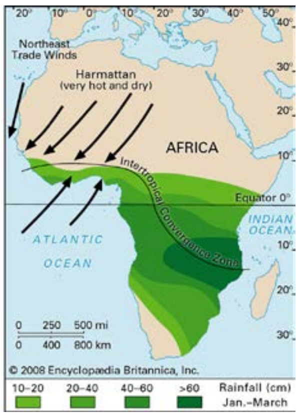
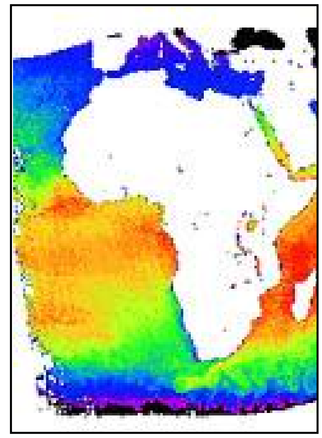


Figure 3a and 3b. *Dry season conditions. (a) ITCZ drops southward allowing for stronger NE trade winds causing more upwelling and cooler sea surface temperatures (From Encyclopedia Britannica, Inc., 2008 and eduspace.esa.int).*



During the dry season, the winds are primarily northeast bringing dust from the Sahara and the Sahel (Called the Harmattan). Sea surface water temperatures drop as upwelling increases and dust effectively block sunlight from reaching the ocean’s surface.

Fishermen observe that sole respond to the amount of rainfall/changes in temperature. Fishermen report that the sole habitat is offshore in about 60 m of water. They stay there from November to January. With the January upwelling, they begin to migrate. During the rainy season, fish migrate towards the coastal areas because of the increased water temperatures. Sole are most plentiful in coastal areas between June and September. Normally, sole bury in the sand but in warmer water, they spend more time on the surface of the sediment. After the rain, they migrate to the warmer water of the ocean and deeper sea. From August on, the warmer water temperatures cause fish to rot in the nets before they are harvested. The fish begin to move back to deeper waters. Migration routes were identified possibly pointing to a population of sole that move south from Senegal to spawn in the Gambia River mouth as well as a northerly movement of fish found offshore. Fish from Senegal (in the north) travel to the Gambia River from March to May to spawn possibly using the area between Buoy 2 and 3 for passage.

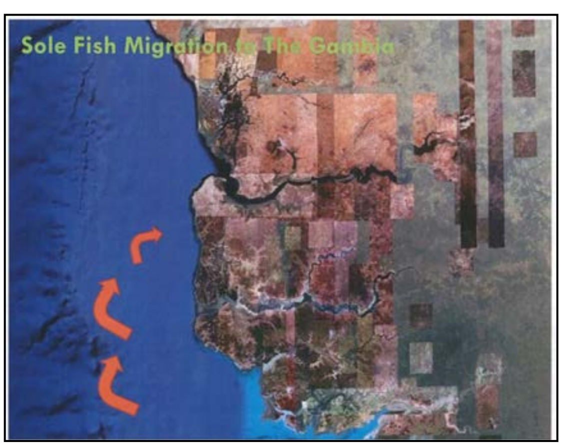


Figure 4. *Fishermen’s knowledge. Fish also travel south from Senegal to the Gambia River estuary to spawn. This level of detail is not available in the scientific literature.*

Monthly landings collected by the DoFish correlate well with the migration pattern explained by the fishermen. If landings represent availability, the peak months occur in the spring and summer periods. However, it is recognized that fishing effort is greatly reduced during the winter when fishermen are not in the Gambia and during the warmest months when fish spoilage is highest.

In January, the sole are found in deep offshore waters. With January upwelling, water is colder and they begin to migrate to shallower water. They start to appear in February following a south to north migration. In July they arrive at spawning grounds. They remain in spawning grounds through August, Sept and October, and return to their deep sea habitat in November and December.

Figure 5. *Map of FisheriesKnowledge.*

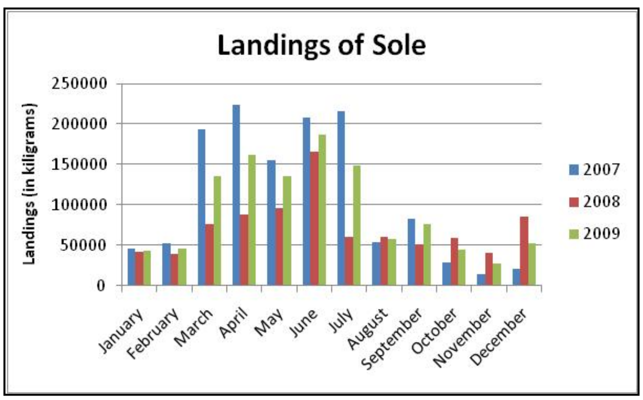
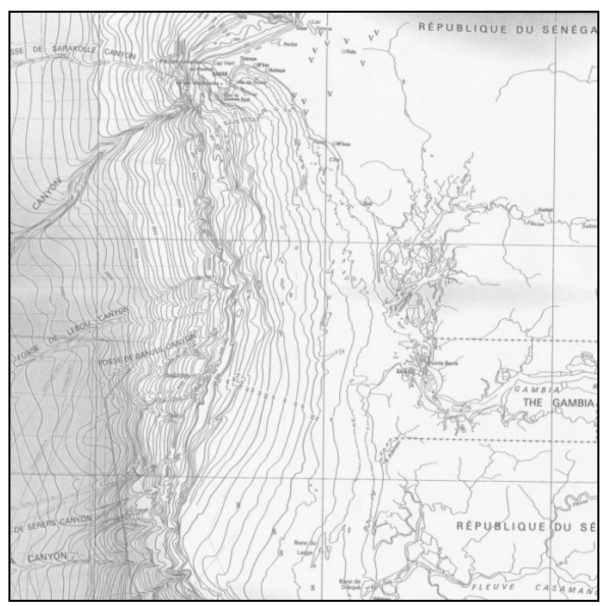


Figure 6 (Left). *Sole landings collected by the Gambian Department of Fisheries shows trends in catch that track the fishermen's indication of fish availability.*

Figure 7 (Below). *Chart of bathymetry showing wide shallow continental shelf off of the Gambian coast.*



3.2 Bottom Type and its Importance

The Gambia is a flat country with little elevation (max is 50 m above sea level) situated on a vast plateau of sedimentary sandstone. The coastline consists of sandy beaches interrupted by low cliffs and associated rock falls. The continental shelf widens as you move south from Dakar, and is mostly composed of sand and large outcrops of rock. The shelf break has been pushed offshore as a result of the deltaic outbuilding. Salt tectonics appears to be a major feature creating salt domes near the river deltas.

The fishermen identified sediment as a major factor in sole distribution and spawning. Spawning grounds are described as shallow sand areas interspersed in rocks areas – called a pass. During the at sea mapping, fishermen identified major fishing areas, rocky and sandy areas. There is good agreement between the published chart and those features which the fishermen located.   However, in the picture below, additional detail on a large muddy area in the river mouth (result of fluvial deposits) was provided by the fishermen.

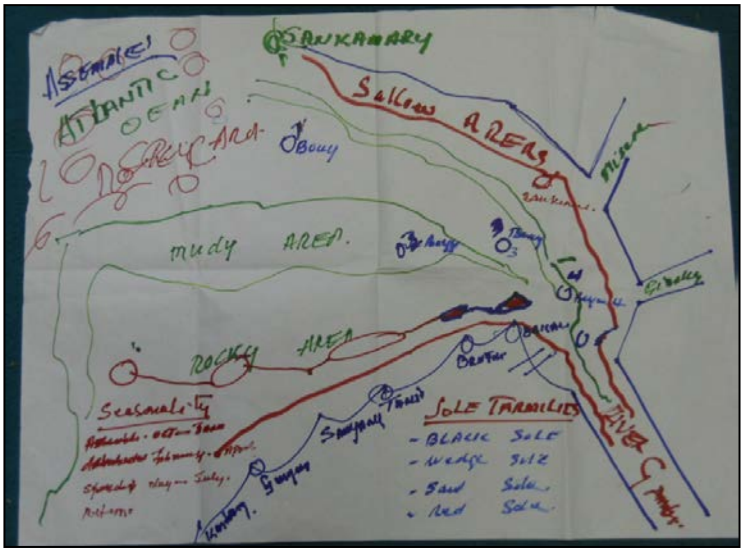
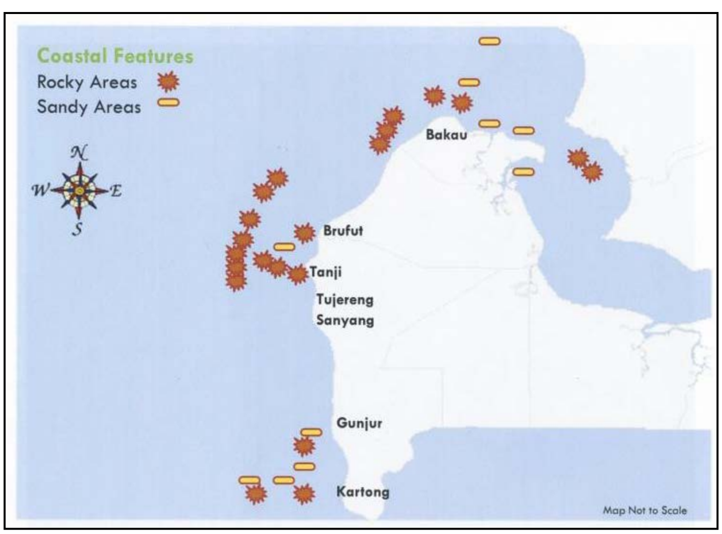
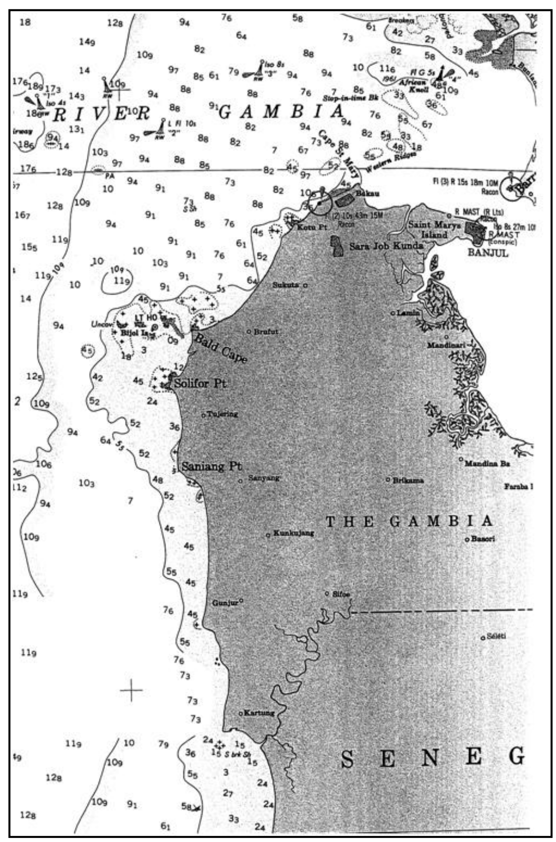


Figure 8. (Left) *Map drawn by fishermen highlighting in detail the sandy, muddy and rocky bottom features of major fishing areas. Note reference to species and seasons that they established as important information.*

Figures 9a and 9b. *Good agreement between published chart on right and fishermen generated knowledge as illustrated on GIS template.*





3.3 Site Specific Knowledge

MOUTH OF GAMBIA RIVER

Nets are set between buoy 2 and 3 in Brufut, Buoy 1 off Sanyang, 4th buoy off Barra. Between Barra Point and Buoy 5, there is little fishing activity. During high tide fishermen are concentrated around that area following the sole into the River.

BAKAU

Figure 10. *GIS Map of Bakau*

In Bakau, the rocky areas were identified as feeding areas and possible interaction with turtle might occur. The major spawning area was shown to be sandy. Special significance is associated with the buoys (1-5) along the coast.

Areas of interest that were identified at sea by the Bakau fishermen and related information are as follows: Bkpomba is a sole spawning area that has a sandy bottom and an approximate 3-meter depth; Bkturtle is a rocky turtle hotspot area, where a turtle was spotted during field reconnaissance; Bkberreba is a rocky area that is an aggregating and feeding area; and additional rocky areas ranging from 2 to 12-meters deep were identified.

BRUFUT

The major rocky areas were plotted in the Brufut area. Fishing nets are mostly set between buoys 2 and 3. Usually must travel 2 hours from Brufut (using 15 hp engine)

Areas of interest that were identified at sea by the Brufut fishermen and related information are as follows: Herri Magamu is a lobster and ladyfish fishing area that is rocky and approximately 11-meters deep; Pass Lampabi is a sandy area with a 5-meter depth; ten additional rocky areas with depths from 4 to 13-meters were also observed. One of these rocky areas, Herr Lampabi, is very close to Bijol Island, a turtle hotspot and marine protected area by the

Figure 11. *GIS Map of Brufut*

Department of Parks and Wildlife Management (DPWM) that was also identified during Tanji site reconnaissance.During an onboard discussion, the fishermen also briefed the Ba-Nafaa Staff about “Sameh”, a rocky area, and the boundary where fishermen believe that the black and red sole fish meet. Below Sameh the red sole are believed to predominate and above SAMEH, the fishermen catch primarily black sole.

TANJI

Major rocky areas were identified in the Tanji area ranging from 4.5 meters to 10.5 meters. Garas Rock is a major fishing feature in the area. The sole fishing area is identified as sandy bottom and the spawning area is a large sandy patch heading towards deeper waters. Pelican Island is located off Tanji.

Figure 12. *GIS Map of Tanji*

BATOKUNKU

Figure 13. *GIS Map of Batokunku*

Areas of interest that were identified at sea by the Batokunku fishermen and related information are as follows: Five rocky areas ranging from 3 to 4.5-meters in depth were identified

GUNJUR

Figure 14. *GIS Map of Gunjur*

Areas of interest that were identified at sea by the Gunjur fishermen and related information are as follows: Payusu is a lobster hotspot and rocky area with an approximate 7-meter depth;; a gill net fishing area; Ebrimajone is a rocky sole hotspot area near Kartong Point; Alagifaye is a rocky sole hotspot area with an approximate 10-meter depth; Gibril is a sandy sole hotspot area; Sandy was identified as a red sole spawning area.

During an onboard discussion, the fishermen explained that the eggs are deposited between sand banks and the juveniles are found in the pass between the sandy and rocky areas. Sand on seaward side of rocky areas best for spawning such as Prayer and Kafaya Rock. The fishermen talk about “black rocks”.

SANYANG

Areas of interest that were identified at sea by the Sanyang fishermen and related information are as follows: Pass Modousisse is a sole fishing area that has an approximate 7-meter depth and a sandy bottom; Pap Secka is a black sole fishing area that has an approximate 10-meter depth and a rocky bottom; Musa Njie is a rocky area between Gunjur and Sanyang that has an approximate 13-meter depth; and nine additional rocky areas with depths from 6 to 13 meters were also identified.

During an onboard discussion, the fishermen stated that Buoy Bateau le Jola is a very good fishing ground, and that fishers from various landing sites are attracted to the area. They indicated that many different fish species are present in this area.

Figure 15. *GIS Map of Sanyang*

Buoy Bateau le Jola is a buoy marking the position where Bateau le Jola (a Senegalese ferry) sunk several years ago. The sunken ferry serves as a settlement for fish species.

KARTONG

Areas of interest that were identified at sea by the Kartong fishermen and related information are as follows: Berre Kunto (a rocky area of an approximate 4-meter depth) is a lobster fishing area and turtle hotspot; Pass Herrbumac is a sole fishing area where nets were observed that is a sandy area with 4.5-meter depth; Ndakaru (an approximate 12.5-meter depth) is described as the largest rock in the area, where many fishing nets were observed, and snail and toufa are said to be abundant; and four additional rocky areas were identified that range in depth from 6 to 12-meters.

An onboard discussion revealed that the fishermen believe that the mouth of the Alaheim River in Kartong is an important fish haven and should be protected, and fishing of this area be prohibited. The fishermen also stated that they have observed the sole fish to appear in Gambian waters before the fishermen in Brufut.

Figure 16. *GIS Map of Kartong*

3.4 Distribution and Movement

Red sole are usually found mainly in the shallower waters than black sole (Figure 17). It usually takes at least an hour of steam time to reach black sole fishing areas. In Sanyang, the Sameh Rock is the dividing line between red and black sole areas. Red and Black are found in the lower reaches of the River Gambia. They are usually bigger in weight and size than the coastal species. They are not considered to be as "tasty". Black sole are usually fished in the months of February and continues until April. Red sole is fished 12 months of the year.

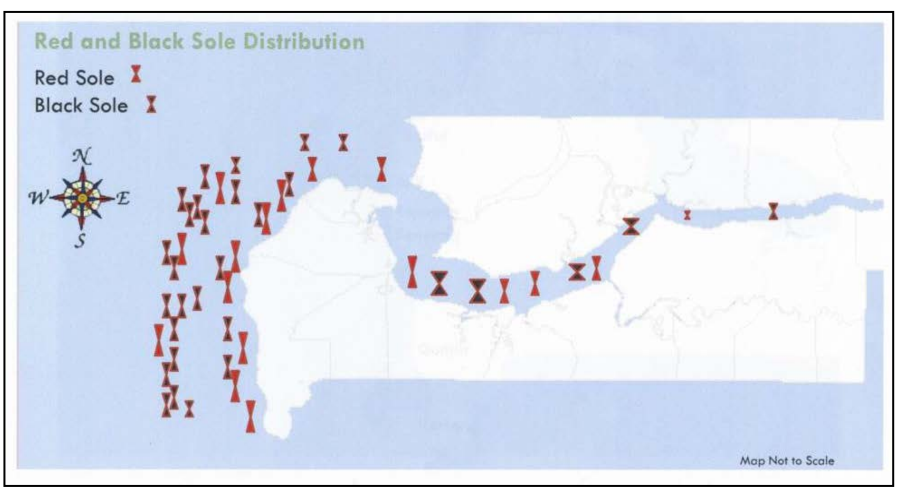
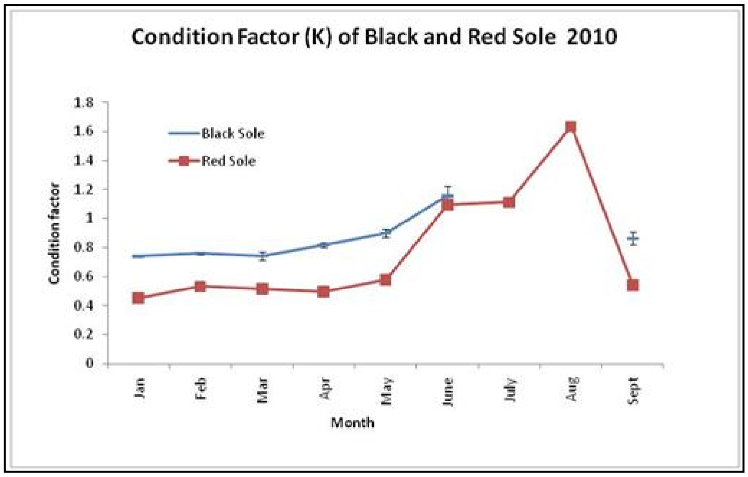


Figure 17. *Local knowledge of red and black sole abundance and distribution.*



Red Sole		Black Sole
Month	Avg K	Avg K
January	0.45	0.74
February	0.53	0.76
March	0.51	0.74
April	0.50	0.82
May	0.58	0.90
June	1.09	1.16
July	1.11	
August	1.63	
September	0.54	0.86

Figure 18 and Table 1. *Data collected from Atlantic Seafood on monthly sole landings. Fulton's condition index and it is calculated as K= 100W/L3, where W is the weight of the fish in grams and L is the length of the fish in centimeters*

The sole fish are found in the brackish water of the Gambia River. Tendeba is the most upriver location of capture reported by fishermen although some juvenile fish (Cynoglossus senegalensis, Citharichthys stampflii and Synaptura cadenti) were reported as far upriver as Wale Creek by Vidy, et al. (2004) and Albaret, et al. (2004).

3.5 Other Sole Characteristics

As the sole move to shallow waters starting in January, the females carry eggs that are not well developed. In June/July, the eggs are fully mature and are released in sandy areas (Except in Kartong, they said spawning is from March to April) . Contrary to the commonly described spawning behavior of flatfish which produces planktonic eggs that float freely in the water column, it is believed that the eggs of red sole are laid in the bottom sediment when the fish burrow. Larval stages may vary from a few days to a couple of months influenced by water temperature. Fishermen report eggs to be encased in a thin film which hatch after 3 days. After hatching these eggs become juvenile fish that become strong enough to be on their own after two weeks.

Data collected on the relationship between the length and weight of red and black sole confirm a change in condition index during the summer months (Figure 18 and Table 1). Abowei (2009) found that for red sole in Nigeria, K values vary over the season because of spawning activities with the lowest K value found during the spawning season. This would indicate that spawning occurs before June or after August.

Growth of the tongue soles is described as rapid (Chauvet, 1972) compared to other fish. The majority of the fish growth is predicted to occur during the first year. Fishermen state that young of the year recruit to their gear 6 months after spawning. The juveniles stay within the rocky and sandy areas for approximately 6 months. When mature, which may occur within the first year, they move to deeper waters. New information relative to growth is being developed using otolith samples to confirm these observations.

Palpal sole moves with black sole and trippo moves with red sole.

3.6 Bycatch

There are two sources of information on bycatch composition of the gillnet fishery (Tables 2 and 3). Fishermen recounted bycatch in their specific fishery and a bycatch survey was conducted in 2010 to formally record bycatch and percentages.

Table 2. Results of fishermen's knowledge

	Kartong	Sanyang	Gunjur	Batokunku	No place listed
Longneck croaker	x	x	x	x	
Cassava croaker	x	x	x	x	
Law croaker	x	x	x	x	
Catfish (Arius spp)	x	x	x	x	
Sompat grunt	x	x	x	x	
ladyfish	x				x
Bobo croaker	x	x	x	x	
Mackerel		x		x	
Butterfish		x		x	
Crabs		x		x	
Lobster		x		x	
Sea snail (Cymbium)		x		x	
Tiger shrimp					x
Barracuda					x

Table 3. Results of bycatch survey (July 2010-Jan 2011). Actual percentage of species caught in gillnets (with Cymbium removed). Cymbium typically constitutes up to 20-30% of catch (in weight).

Common Name	Name	Kartong	Sanyang	Brufut	Gunjur
Catfish	*Arius latiscutatus*	39.4	27.7	14.8	30.9
Sompat grunt	*Pomadasys jubelini*	8.0	4.8	8.9	15.1
Longneck croaker	*Pseudotolithus typus*	4.9	5.7	8.1	15.6
mackerel	*Scomberomorus tritor*	4.9	(0.03)	(0.55)	(0.2)
Red sole	*Cynoglossus senegalensis*	4.9	12.6	8.6	8.3
Cassava croaker	*Pseudotolithus senegalensis*	(3.1)	13.5	8.7	3.1
Law croaker	*Pseudotolithus brachynathus*	(1.7)	3.4	9.9	(0.09)
Bobo croaker	*Pseudotolithus elongatus*	(1.2)	0	5.9	(1.2)
Rubberlipped grunt	*Plectoryhnues mediterraneous*	(1.2)	(0.06)	5.4	(0.7)
Black sole	*Synaptura cadenati*	(1.7)	(2.8)	4.8	6.0
	Total weight of all catch (kg)	1703	2173	6034	2530

Agreement between these two perceptions was quite high (Table 4).

Table 4.

Reported by fishermen and seen in survey	31
Reported by fishermen, not seen in survey	1
Not reported by fishermen, seen in survey	9

What Has Changed over Time?

- More fishermen and less fish
- Use of outboard motors has driven fish into deeper waters – noise and vibration
- No directed fishery since price is so low.
- Older fishermen do not know the areas younger fishermen are working now. Further from shore.

4. Conclusion

Local knowledge is proving to be a primary source of information in data deficient situations, especially in developing countries where financial resources are scarce and institutional capacity is weak or inconsistent. For generations, scientists have discarded this information as "anecdotal" and weak compared to rigorous scientific hypothesis testing. However, non-scientists knowledge is rich in detail and often times more robust than a one-time sampling effort. Neis et al (1996) emphasizes that fishermen want to optimize catch while minimizing effort. Therefore, they tend to closely observe those environmental factors that contribute to fishing success: seasonal movements, habitat preferences, feeding behavior and abundance dynamics, as well as those physical attributes that affect distribution such as wind direction, current, water temperature, bottom characteristics and knowledge about the gear and fishing strategy.

Mackinson and Nottestad (1998) highlighted that communication and respect were key to combining the hard scientific data with the practical applied knowledge gained through experience.

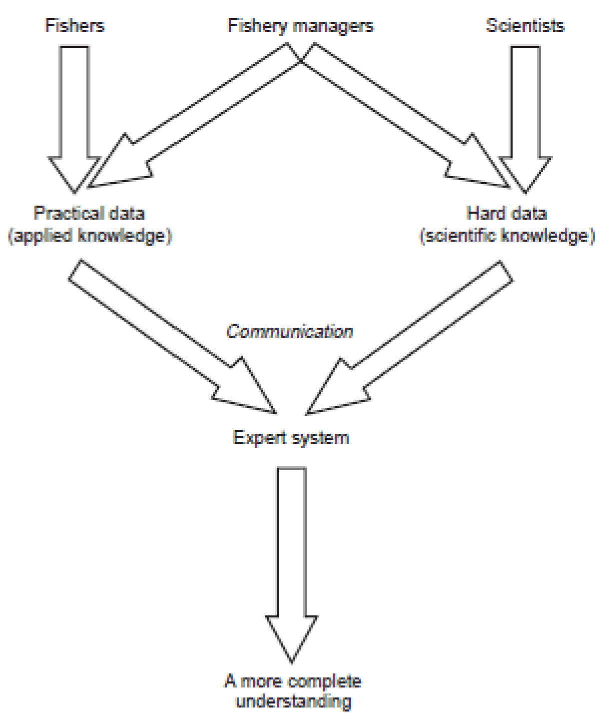


Figure 19. *Combining sources of data (From Mackinson and Nottestad, 1998)*

This combination should help to reduce uncertainty and build a more complete understanding of a complex environment.
Results to date on Gambian sole illustrate how closely local knowledge tracks the scientific knowledge especially in regards to the environment and factors affecting sole distribution and abundance. New knowledge is offered on the factors affecting distribution and abundance including migration paths, growth and reproduction that can be used to help manage the fishery. Fishermen are considering area/time closures to help protect spawning stock as a precautionary conservation measure.

Much of this information can be developed further, especially regarding the changes that have occurred over time. If measurable criteria can be established, it may be possible to use fishermen's observations as sustainability indicators to follow trends in abundance and possible overfishing states.

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Appendix A

Questions asked at stakeholder workshop:

1. What information is missing from the current presentations?
2. What gear type and methods are used?
3. When, where and how is sole caught?
4. What is the effect of rain, current, tides, or other factor on sole?
5. How is the fish caught in the gear? What else is caught?
6. What has changed over time?