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Fisher knowledge as expert system: A case from the longline fishery of Grenada, the Eastern Caribbean

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Abstract

We investigated a fisher knowledge generation process in the longline fishery for large pelagic fish in Gouyave, Grenada, using techniques of participant observation, interviews, and focus group discussion. We identified nine categories of knowledge that are important for finding and catching large pelagic fish: seasons, use of bait, gear technology, weather conditions, fishing practice, fish habits and behaviour, fish movement, 'folk oceanography' (seabirds, seawater colour, current), and fish stomach contents. Conceptualized as a decision-making rule structure, this information can be analyzed as an expert system, the rationale being to understand how human experts (fishers) use technological and ecological knowledge. We extract heuristic rules (expressed as IF–THEN clauses) based on fishers' description of how they make decision on how, where, and when to find and catch fish. Gouyave fishers are adaptive experts because they have the ability to learn from and deal with new situations. They rely on observation, experimentation, and experience through the feedback of fish catches and evaluation, learning adaptively to improve their understanding of the marine ecosystem and the resource.
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1. Introduction

Small-scale fishing throughout the world is based primarily on fisher knowledge, but it has only been recently that this knowledge has been studied and documented. Fishers have detailed qualitative knowledge of the fishery based on continuous interaction with the environment (Johannes, 1981; Ruddle, 1994). Fisher knowledge (also referred to as local or traditional ecological knowledge) can complement scientific knowledge (Johannes, 1998; Johannes et al., 2000), improve decision-making (Berkes and Folke, 1998; Baticados, 2004), and provide practical information that can be used in management (Bergmann et al., 2004; Silvano and Begossi, 2005). Such knowledge develops accumulatively and is transmitted culturally (Berkes, 1999). In the Caribbean, fisher knowledge does not often involve multigenerational cultural transmission; there are very few studies of fisher knowledge (exceptions include Warner, 1997; Gomes et al., 1998; Breton et al., 2006).

However, the Caribbean provides a suitable setting for the examination of the fisher knowledge generation process, especially in recently developed fisheries. When a new fishing technique is introduced, fisher knowledge is created rapidly as fishers develop the capacity to learn from their experience. They build their knowledge and skills in order to understand the technology and its interaction with the marine environment (Grant and Baldeo, 2006). New knowledge is being generated continuously, and feedback learning is occurring by trial-and-error.

We know that fisher knowledge exists and is well documented. What is not known is how a fisher knowledge system actually works. In this paper we propose that fishers have an applied knowledge system that can be described as an expert system, "a branch of artificial intelligence, providing theories and methods for automating intelligent behaviour. They are computer programs that use heuristic rules to store knowledge, which is used to infer solutions and help provide assistance in solving complex problems normally handled by human experts" (Mackinson, 2001, pp. 534). According to the expert system model, human experts use heuristic rules to store knowledge used in problem solving and help provide assistance in how problems are solved (Mackinson, 2001). The knowledge used

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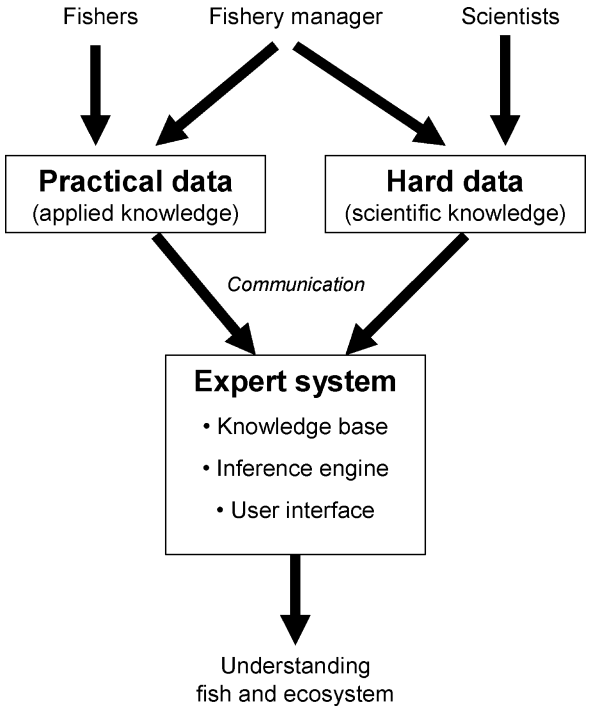


Fig. 1. Schematic representation of the model components (adapted from Mackinson, 2000).

for decision-making is not quantitative (as in scientific data) but qualitative and consists of fuzzy sets (Mackinson, 2000; Ozesmi and Ozesmi, 2004).

The expert system has three components, the knowledge base is the repository of rules, facts, general cases, exceptions and relations that can help human decision-makers solve problems. The inference engine is the mechanism for manipulating the encoded knowledge base for making inferences and drawing conclusions, using rules in the form 'IF *a certain situation occurs*, THEN *a known outcome is likely* and may contain several conditions linked by AND, OR, NOT. Finally, the user interface provides the link from the system to the user (Fig. 1) (Mackinson, 2001; Uricchio et al., 2004).

This paper is not concerned with the technical details of the expert system; rather it focuses on the collection and application of fisher knowledge in the construction of such a system. We find the expert system construct useful as it not only allows a description of the ecological and technological knowledge of fishers (the knowledge base), but goes two steps further. It helps understand fishers' decision-support system using IF–THEN rules to find and catch fish (the inference engine), and how fishers use social relationships to access the database of knowledge and decision-support system (the user interface).

The objective of this study is to explore fisher knowledge as an expert system. We investigate how fishers strive to achieve a better understanding of the marine ecosystem in which they operate, ensuring that their decisions are appropriate to catch fish and make a living. We begin with a description of the types of knowledge that are accessed and stored by fishers to find and catch fish. Second, we illustrate the decision-making process for fishing and present the schema of a knowledge production process to explore how fisher knowledge develops. Finally, we describe how knowledge is transmitted, i.e., how fishers are granted access to this knowledge.

2. Study area and methods

2.1. Study area

Gouyave, the study site, is a fishing community on the west coast of Grenada, which is situated between 11°00′ and 12°30′ north latitude (Fig. 2). Traditionally Gouyave fishers operating close to shore used beachseine, handline, and fish trap to catch inshore pelagic species, offshore pelagic species, and demersal, respectively. During the revolution, which began in 1979, Cuban master fishers formally introduced pelagic surface longline (or simply longline) fishing to Grenadian fishers. The introduced longline technology was made from 2 by 113 kg monofilament plastic, drilled and twisted mainline and dropline with 30–50 hooks of total length 0.5 km, which was stored and deployed from a box. Traditional vessels were wooden canoes 4–5 m in length powered by oars, sail, or a 30 HP engine. By 2003, fishers made significant changes to longline technology. Twisted monofilament was replaced by single 68–227 kg plastics, the box replaced by reels, and hooks increased to over 300. The total longline length increased to 11 km, and fishers travelled up to 160 km from shore. Gouyave had over 300 fishers and 92 boats, with 82% of fishers and 72% of boats involved in longline fishing. The longline fishing fleet comprised three vessel types. Type 1 was a day-trip wooden open pirogue less than 5.5 m in length with one 48 hp outboard engine. Type 2 was a day-trip fibreglass forward-cabin pirogue between 6 and 9 m in length with two 48 hp outboard engines. Type 3 was a 4–5 days-trip fibreglass vessel between 9 and 12 m with inboard engines (Grant, 2006).

The main pelagic species caught, in terms of catch by weight for the period January to December 2002, were yellowfin tuna (*Thunnus albacares*, 49% catch by weight), Atlantic sailfish (*Istiophorus albicans*, 28% catch by weight), common dolphinfish (*Coryphaena hippurus*, 10% catch by weight), white and blue marlin (*Tetrapturus albidus* and *Makaira nigricans* combined as fishers did not distinguish the two, 6% catch by weight), and swordfish (*Xiphias gladius*, 2% catch by weight). Other species (5%) included blackfin tuna (*Thunnus atlanticus*), wahoo (*Acanthocybium solandri*), bigeye tuna (*Thunnus obesus*), and skipjack tuna (*Katsuwonus pelamis*) (Fisheries Division landings statistics, unpublished data). This study focuses on recording fisher ecological knowledge for the five main species.

2.2. Methods

This study was conducted between December 2002 and March 2004 as part of a larger research project on managing small-scale fisheries in the Caribbean (Grant, 2006). Multiple research techniques were used for data collection and verification. Such techniques include a semi-structured interview, observation, participant observation, and a focus group discussion.

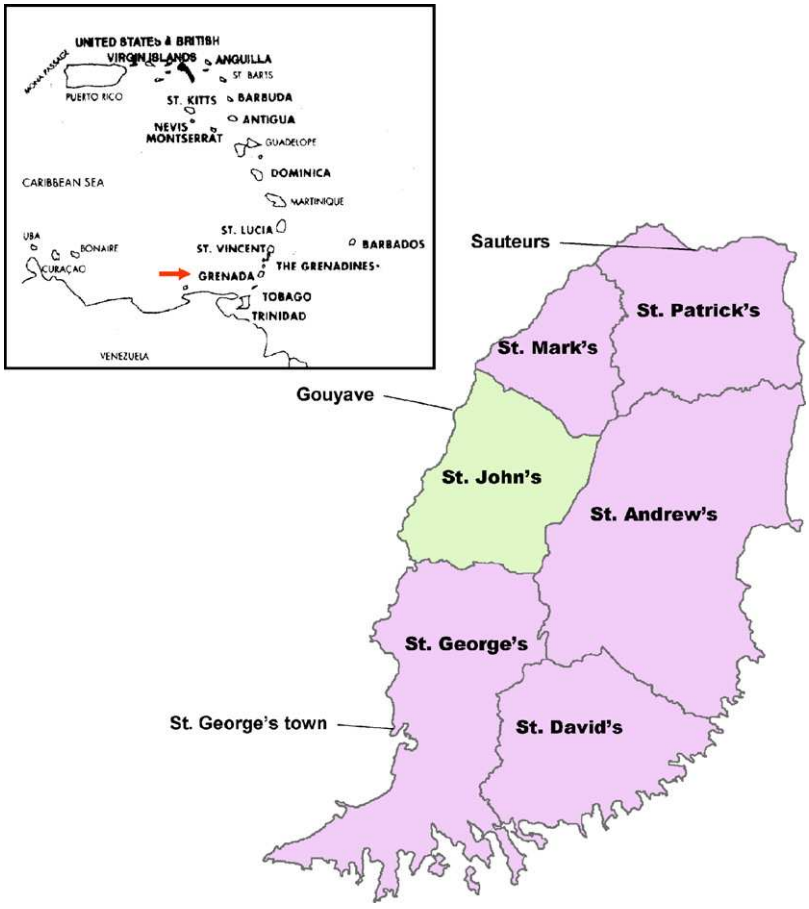


Fig. 2. The study area: Grenada and the Eastern Caribbean.

The study began by observing fishing activities in the community. The researcher lived in the community during the research period, and was able to observe fishing activities at the Gouyave fish market, and listened to fishers in social groups and bars discuss fishing. It was then that a pattern started to emerge: fishers not only had ecological and technological knowledge, but they had a pattern of decision-making and sharing system that made them experts. After the observation period, an informal focus discussion was initiated with four fishers to identify variables that were important to finding and catching fish. Information gathered from observations and focus discussion were used to design a semi-structured interview.

The semi-structured interview was divided in two parts. First, the fishers were asked if, why, and how seawater colour, current, presence of birds, bait, and weather conditions affect longline fishing; in particular, the relationship (if any) between these variable and yellowfin tuna, sailfish, marlin, common dolphinfish, and swordfish. Second, they were asked to give details on fish biology, including stomach content, observation of ripe eggs, peak harvesting, feeding behaviour, and migration pattern as it relates to the five pelagic species. Fishers were also encouraged to talk about other important factors not mentioned in the interview. Forty knowledgeable fishers (active and retired) were selected to participate in the interviews. Selection was based on fishers' recorded fish landings, knowledge, and recommendations by other fishers. The sample included fishers between the ages of 20 and 78 years, with an average 21 years of fishing experience (range 5–50 years), 82% of them with primary and 11% with secondary education. Of the sample, 70% were captains, 20% crew members, and 10% retired fishers. Active fishers did an average of 80 fishing trips per year.

Results from the semi-structured interview showed some knowledge variation amongst fishers. Therefore, participant observation was used to verify the information obtained from interviews. The researcher went on three fishing trips and participated as a crew member while at the same time questioned fishers on their activities to fill in missing gaps in the interviews. Where there was discrepancy between the interview and observations, the fishers were questioned for clarity. Likewise, fishers were spontaneously questioned on fishing activities while events occurred, for example, why did you not go fishing today? The researcher also worked continuously with three of the most successful fishers in the community to understand how they made daily decisions regarding longline fishing.

Bird identifications were based on colour pictures (Reffaele et al., 2003) and the researcher quizzed fishers while at sea. Fishers were asked to identify the birds and discuss their association with pelagic species. Common English fish names used in this paper follow Froese and Pauly (2006).

3. Results

This section describes the three components of the fisher knowledge expert system in Gouyave. The knowledge base (Section 3.1) represents the different types of knowledge fishers hold in order to find and catch pelagic fish. The inference engine (Section 3.2) represents how fishers use the knowledge base to make decisions, and the user interface (Section 3.3) describes knowledge transmission among fishers.

3.1. Fisher knowledge regarding longline fishing

3.1.1. Seasons

All fishers agreed that knowing the harvesting and reproductive seasons helped to determine when to put most of their efforts into fishing specific pelagic species and when to switch between different longline weight types. The peak harvesting seasons for yellowfin tuna were March to May and September to October; marlin, January to February and May to June; dolphinfish, March to August; sailfish, October to January; swordfish, September to January; and flyingfish, January to early June. Fishers reported that the reproductive season for yellowfin tuna was between March and July. Dolphins and sailfish had two periods, March to June and December. Not much was known of swordfish and marlin, because according to fishers they had never observed 'ripe eggs' (i.e., sign of reproductive activity) in marlin.

3.1.2. Use of bait

Fishers all agree that bait was important to longline fishing; without appropriate bait fishers could not fish. Fishers used four bait types: flyingfish (*Hirundichtys affinis*) caught with gillnet; jack (*Selar crumenophthalmus*) caught with beachseine net; ballyhoo halfbeak (*Hemiramphus brasiliensis*) caught with gillnet; and imported squid. Flyingfish and jack were the main bait used, and when these were scarce fishers resorted to ballyhoo and squid. Fishers (70%) acknowledged that flyingfish was the natural and preferred bait for large pelagic species. However, due to the seasonal nature and low abundance of flyingfish, fishers started using jack. The initial outcome was fishers used flyingfish between January and May, and jack between June and December. Fishers also experimented with jack to determine the preferred size and attractiveness of the bait to its prey. They discovered that yellowfin and marlin preferred live, medium and large sized jack, and sailfish took any bait size. Prey was attracted to jack because of their shiny body colour, movement, and the sound they made.

Longline fishing practices were influenced by bait type. We describe the two techniques:

Fishing with flyingfish. Fishers used the 'drift and set' technique, which gave them enough time to catch flyingfish while setting the longline. Fishers lured flyingfish with coconut branches (as shade) and macerated fish, then use a gillnet (mesh size 2.54 cm) approximately 30 m in length or a handline to catch them. Usually one gillnet haul, taking 30–45 min, would catch enough flyingfish to bait 150–200 hooks. Handline fishing usually involved all fishers on board. Fishers then set the longline using the 'drift and set' technique, which allowed the current (in a north to south direction) to drift the boat while fishers remove flyingfish from the gillnet or handline to bait and set the longline. This technique was physically hard work, as an average fishing trip lasted from 7 a.m. to 10 p.m.

Fishing with jack. Fishers used the 'steam and set' technique due to available jack, which was taken onboard. This technique required the storage of live jack, thus fishers added a bait-well at the stern of small open pirogues and the middle for cabin pirogues vessels. Fishers purchased live jack from beachseine fishers, stored them in 'sacs' at sea (about 90 m from shore) for up to a maximum of 1 week. This was the optimum time to store jack before they lost weight. At the start of a fishing trip, fishers removed the jack from the sac and place them in the bait-well. Fishers set longline using the 'steam and set' technique, i.e., using engine power to set the line perpendicular to the shore. As the bait was readily available onboard, fishers could bait hooks and set in the water in a continuous motion. With this technique, fishers were able to return to shore by 4 p.m.

3.1.3. The effects of longline weight

Choice of longline weight types was dependent on bait and fish species being targeted. There were five longline types constructed from different monofilament weight, the heaviest 227 kg and the lightest 36–45 kg (Table 1). Some vessels had up to two longline weights, e.g., an open pirogue could have a regular (136 kg) and a light (68–91 kg) longline. The weight type chosen for fishing was dependent on two factors: bait type, bait size, and fish weight. In regards to bait type and size, flyingfish require heavier, large jack require heavier, and small jack a lighter longline weight. In regards to fish weight, for sailfish with a maximum weight of 26 kg, fishers used a light-light longline (68–45 kg) as compared to yellowfin tuna with a maximum weight of 95 kg, and therefore required a heavier longline weight (more than 90 kg).

3.1.4. Weather conditions

According to 95% of fishers, weather conditions were important, as it affected fishers' ability to go fishing or not. Weather meant a combination of rainfall, cloud cover and type, and wind intensity. The dry season (March–June) was the best time for longline fishing as reported by 76% of fishers. Rainy conditions were dangerous for small open pirogues to go fishing as they could get swamped quite easily. It was also difficult to navigate boats in such conditions due to poor visibility (difficulties in observing land feature used for navigation). Fishers also observed cloud cover, type of clouds, and cloud movements. Dark cloud cover and type indicated rainy conditions; while cloud movement indicated wind direction and strength. Heavy winds were associated with rough seas. Fishers' ventured out during good to fair conditions (no rain or heavy wind), but during bad weather conditions they would stay ashore.

3.1.5. Fish feeding behaviour

Fish feeding behaviour is an indication of the best time of day to set the longline, the attractiveness, and size of potential bait. Fishers were able to describe the feeding behaviour of the large pelagic species. They agreed that yellowfin tuna are fast, fierce,

Table 1
Description of five longline types, named according to the weight of the monofilament plastic

Longline type and monofilament weight	Fishing month	Target species	Bait
Heavy longline 227 kg	June–October	Yellowfin tuna sailfish marlin swordfish	Live or dead flyingfish
Regular longline 136 kg	Year round	Yellowfin tuna sailfish marlin	Live jack—large and medium live flyingfish
Light longline 91–113 kg	Seasonal	Yellowfin tuna sailfish marlin	Live jack—large and medium
Light-light longline 68–91 kg	December–February	Sailfish	Live jack—small
'Common tur' longline 36–45 kg	Seasonal	Blackfin tuna sailfish	Live jack—small

and hungry-feeding, traveling in schools for miles to get their food. They feed early morning between 4 a.m. and 9 a.m. and late evening between 4 p.m. and 8 p.m., this was determined from the time period when fishers were more likely to catch fish on the longline. Once the tuna meets its prey they swim in a circle, making the circumference smaller to move the prey closer together. Once the circle is small enough, they bring the prey to the surface and feed.

Marlins and sailfish use their extended upper jaw to feed, which can be dangerous to fishers when fish are hauled into the boat. Sailfish, while swimming in a circular pattern around its prey will curve its body causing the caudal fin and upper jaw to almost touch to prevent the prey escaping. While they feed the dorsal fin ("umbrella") is extended to prevent the prey from escaping. Marlins use their upper jaw ("sword") to spear large prey, surface, shake the catch into their mouth. Thus, fishers tend to use medium and large bait size to catch marlin. Common dolpinfish are said to be smarter feeders as they take more time to investigate the prey, then feed; therefore, the attractiveness of the bait was important for catching this species.

3.1.6. Fish movement

Fishers (85%) knew nothing of the migration patterns of large pelagic species outside Grenadian waters and 15% knew little. The latter group agreed that large pelagic species traveled from northern countries, where it is cold, to warmer southern countries like the Caribbean. The rest of the story is unclear. However, fishers knew how to track the movement of fish in Grenadian waters by relying on boat catches to give clues as to where fish were traveling. Most fishers tried to keep fishing grounds secret by approaching the village from different directions. To gather information, fishers questioned other fishers who landed a good catch to determine where they fished. Many used GPS to track their fishing sites, others noted where on the line fish were caught and set the line accordingly on the next trip. All this gave fishers a spatial picture of where the fish were traveling and changes in fish movement patterns.

3.1.7. Folk oceanography

Knowledge of 'folk oceanography' gave fishers clues of where to find fish. Such knowledge included the presence/absence of sea birds, seawater colour, and current strength and direction.

3.1.7.1. Birds as indicators. According to one fisher (Roger Gill, pers. comm., February 18, 2003, Gouyave):

> If you want to be an effective fisherman, you have to analyze how the birds' fish, the movement of the birds, where they are heading, where they are feeding, what time they come and feed, and then you will always be catching fish. You could have the technology, but you still have to know the natural influences.

Fishers were in general agreement (98%) that the presence of birds was an indicator that fish was present. Fishers agreed that if there were no birds, then no fish were in the water, because the birds traveled with the fish. A large flock of birds flying close to the surface of the seawater was a strong indicator that fish were present. Fishers set their line near birds to increase their chance of catching fish. They were able to identify over 15 species of birds, and associate the presence of certain fish species with bird (Table 2). In addition, fishers also observed other birds but did not associate them with the presence on any particular fish species, for example red-footed booby (*Sula sula*), masked booby (*Sula dactylatra*), red-billed tropicbird (*Phaeton aethereus*), and Cory's shearwater (*Calonectris diomedea*).

3.1.7.2. Seawater colour. There was general agreement among fishers (93%) regarding occurrences of different coloured water, but not always good agreement on species composition in the different kinds of water (Table 3). From the interviews water colour can be an indicator of species composition, but they are still learning about this phenomenon. Fishers identify three seawater colours: blue, green, and dark green. Blue water colour occurred mainly between December and July. In this water fish chose what to eat because they can see the bait; therefore, it is important to use live bait that will attract fish in this water colour. More yellowfin tuna were caught in green water. There was also a darker shade of green water, sometimes called "grumsy water". The green and dark green shade of water occurred mainly due to the Orinoco water flow, usually during August to November. This nutrient-rich water from the Orinoco, a major river that empties out into the Caribbean, creates lenses of greenish water rich in plankton and small fish. The dark green water occurred mainly in August. In dark water, fish tended to feed unselectively because they are not able to see the bait or prey. Thus fishers can use live or dead bait with similar catches. There was not much agreement among fishers on the preferred water for dolphinfish.

3.1.7.3. Current strength and direction. Most fishers (95%) agreed that current strength and direction is important for the presence of fish. In strong current the fish drift away, and in

Table 2
Bird species associated with the presence of fish species identified by Gouyave fishers with reference to common English names according to Raffaele et al. (2003), and local names used fishers

English name	Bird species	Local Gouyave name	Fish association			
			Yellowfin tuna	Dolphinfish	Sailfish	Flyingfish
Brown booby	*Sula leucogaster*	Booby	X	X		
Audubon's shearwater	*Puffinus Iherminieri*	Jablote or duck bird	X			
Magnificent frigatebird	*Fregata magnificens*	Tancoon or seaso	X	X		
Laughing gull	*Larus atricilla*	Mauve or sea gull	X	X		
Storm-petrel	*Oceanodroma* sp.	Hazel				X
Roseate tern	*Sterna dougallii* (or tern)	Kawit				X
Brown noddy	*Anous stolidus*	Moien			X	
Black noddy	*Anous minutus*	Moien			X	
	Stercorarius sp.	Sea hawk				X

X indicates a positive association.

slow (or 'soft') current the fish stay in the area and feeds. Fishers described current direction as 'up' meaning north; 'down', south; 'in', east; and 'out', west. Overall, fishers preferred the 'up and out' current which was better for fishing as it brought fish, and stretches out the longline making it easier to fish. The south and southwest currents were usually stronger and carried fish away. Constant changes in current directions referred to by fishers as 'old weather tide' caused problems, as a longline could fold back and become tangled.

3.1.8. Stomach content

Fishers investigated the stomach content to determine the bait type and size eaten by the fish. Such study was done while the fish were being cleaned, aboard the fishing vessel or at the fish market. The stomach was cut open, water passed over the content, and larger objects were removed and identified. Fishers considered the amount of digested and undigested food, and the prey type and size in the fish's stomach very informative. If the stomach was empty, it meant there was no prey around, which could be associated to seawater colour or current movement. And if the stomach was full, it could mean the bait was effective at attracting the fish, and the time the fish was caught was the feeding time for the fish. Stomach content was also associated with fish diet and potential bait in the future. Fishers concluded that the diet of yellowfin tuna and marlin included large and small finfish, cephalopods, and crustaceans. The diets of dolphinfish, sailfish, and swordfish included small finfish and cephalopods (Table 4). This was how they deduced that squid was excellent bait for large pelagic species. The size of fish in the stomach of the fish was also important. This was how fishers determined the size of jack suitable to attract different fish species.

3.2. Using fisher knowledge to find and catch fish

We infer from detailed discussions with fishers, a fisher knowledge generation process or an inference engine. We identified nine categories of specific knowledge base, which fishers used to find and catch large pelagic species using longline (Fig. 3). The process to find and catch fish began with knowing the harvesting and reproductive seasons and bait type, abundance, and size availability. Based on the outcome of seasons and bait, they then chose the most appropriate longline weight type. If weather conditions (rainfall, rough seas, and cloud) were favourable, fishers would make the decision to go fishing. While at sea, the type of bait, fish habits and behaviour, and fish movement determined the fishing strategy. Where fishers actually placed the longline in the water depends on their knowledge of 'folk oceanography'.

Of the various categories of knowledge, some were within the control of fishers while others were outside (Fig. 3). Fishers were able to control (to some extent) bait, longline weight, and fishing practice. They did this by experimenting with different options. For example, they altered the weight of the line and bait type, as available. Those outside the control of fishers included seasons, weather conditions, fish habits and behaviour. Thus fishers could

Table 3
Seawater colour and main fish species associated with the water mass ($N = 40$)

Water colour	Local name	Characteristics identified	Fish association				
			Yellowfin tuna	Marlin	Dolphinfish	Sailfish	Flyingfish
Blue	Clear water	Occurs intermittently 8 months of the year (December–July)	X	X	X	X	X
Green	Green water	Occurs intermittently 4 months of the year (August–November)	X		X		X
Dark green	'Grumsy water'	Is less predictable and occurs for shorter periods than green water (mainly in August)	X		X		

Table 4
Diet of yellowfin tuna, marlin, dolphinfish, sailfish, and swordfish according to fishers in Gouyave ($N = 40$)

Food item	Species name	Fish association				
		Yellowfin tuna	Marlin	Dolphinfish	Sailfish	Swordfish
Blackfin tuna	*Thunnus atlanticus*	X	X			
Kingfish	*Scomberomorus cavalla*		X			
Skipjack tuna	*Katsuwonus pelamis*		X			
Yellowfin tuna	*Thunnus albacares*		X			
Dolphinfish	*Coryphaena hippurus*	X	X			
Wahoo	*Acanthocybium solandri*		X			
Flying gurnards	*Dactylopterus volitans*	X				
Atlantic thread herring	*Opithonema olignum*	X				
Ballyhoo	*Hemiramphus brasiliensis*	X	X	X	X	X
Jack	*Selqr crumenonophthalmus*	X	X	X	X	X
Anchovies	*Anchoa hepsetus*				X	
Couvalli jack	*Caranx hippos*	X		X	X	X
Filefish	Monacanthidae (Family)	X				
Four-winged flyingfish	*Hirundichtys affinis*	X		X	X	X
Guincaman	*Cypselums cyanopterus*	X		X		
Robin	Decapterus spp.	X	X	X	X	
Brazilian sardine	*Sardinella brasiliensis*	X				
Squid	*Loliginidae*	X	X	X	X	X
Crab (unspecified)		X				

experiment with the variables they could control, while learning from the variables they could not. For example, fishers would actively seek out birds, and/or avoid strong current because they knew that fish avoided strong currents.

To illustrate the expert system built on a multi-layer decision-tree, the heuristic rules format was applied (IF *a certain situation occurs*, THEN *a known outcome is likely*). Since the goal was to analyze how fishers made decisions around fishing which was influenced by the various factors in combination, attributes were typically used in the IF part of the rules, and descriptors in the THEN part (Box 1). The outcomes of these conditions provided feedback and opportunities to learn from the process.

Box 1. An illustration of a Gouyave longline fisher decision-making process

IF	Season is December
AND	Bait is available—medium and small jack
THEN	Prepare light-light longline of birds—abundant
AND	Seawater colour is blue
AND	Current direction N or NW
AND	Fish tracking—50 km west
THEN	Should catch sailfish
IF	Fish catch—sailfish, but a poor catch
AND	Other boats were more successful
THEN	Evaluate performance—eliminate bait, crew performance, longline, 'folk oceanography'
AND	Try again

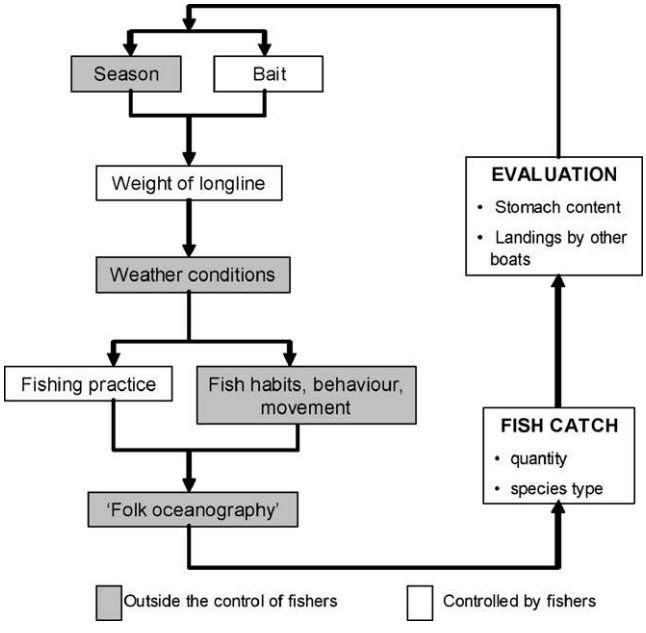


Fig. 3. Schematic of fisher knowledge production process based on a decision-making structure for surface longline fishing in Gouyave, Grenada. The diagram is simplified, as decision-making can be more complex than presented.

At the end of a fishing trip, fishers reflected on their observations (ecological clues) and the decision-making process that resulted in their fish catch. Evaluation involved comparing their fish catch with other boats, and analysing their performance against the categories of knowledge. If other boats were more successful at catching fish, the fisher often conducted a critical analysis of his performance. In this performance analysis, the fisher eliminated categories of knowledge that could affect fish catch. For example, to eliminate bait as a factor, the fisher investigated the stomach content of the fish caught. The fisher also sought assistance from others to analyze his observations and discuss what could be done to improve his catch, making the necessary adjustments on subsequent trips. This knowledge production process was repeated every time a fisher went on a fishing trip. Confirmation of what they know and new

experiences were shared within social groups and networked to become a pool of knowledge.

3.3. Knowledge transmission

Adding to and updating the knowledge base was a dynamic process involving learning and sharing this knowledge with others, the user interface. Fishers used three strategies to transmit knowledge: apprenticeship, mentorship, and information sharing. When fishers were asked how their initial training in longline fishing began 53% said they learned from older knowledgeable fishermen, 31% from observing other fishers, 19% from the Cuban master fishers, and 13% from their father or family members (question allowed for multiple responses). They worked aboard vessels with other fishers, similar to apprenticeship, although they were oftentimes paid a share as a regular crew member. Promising fishers were mentored by master fishers giving pointers.

The knowledge base was continuously updated by fishers meeting socially in small informal groups to discuss fishing experiences and strategies. These social groups were the forum where knowledge transmission occurred. Groups were small in size (5–10), with homogeneity of identity and interest, established rule structure, and organized with an informal leader. This led to trust building, shared values, and a sense of identity. To become a member of a group, an invitation was extended only after the individual was evaluated and deemed fit to join. Fishers could be members of multiple groups, moving from small social group setting to bar groups, gathering and passing information between them. Information sharing was not limited to Gouyave, as there were also interactions at sea and with fishers from other communities.

4. Discussion and conclusions

The expert system is a useful lens to understand how fishers operate with a knowledge base, an inference engine, and a user interface. Fishers contribute their experience and observations to a cumulative pool of knowledge, and use heuristic rules (IF *this* THEN *that*) to make decisions. They have to know what to do in any known or previously encountered situation. New scenarios are opportunities for trial-and-error learning, where the outcome is noted. A skilled fisher is one who can apply his knowledge to most situations with favourable outcomes. The social environment or the user interface gives fishers access to the knowledge system, as it provides updates to the knowledge base and makes changes to the rule structure. Fishers have to be part of the social structure to network and share this information.

Where a fishing technique has been introduced and knowledge is evolving rapidly, the user interface becomes a critical component. For example, after 5 years away from longline fishing, a fisher decided to return. He did not seek the advice of current fishers, but thought the experience and knowledge he had was enough to decide the type of equipment to purchase and how to fish. After several poor fish catches he decided to stop because of accumulated debt. In frustration he went to a successful fisher and asked what was wrong. He was told that his techniques were outdated and problems were identified with his use of bait, fishing practice, and line construction. The fisher was not part of the social networks and did not have access to knowledge and decision-making updates.

There was considerable variation among fishers regarding their fishing knowledge and ability to deal with new challenges. Not all fishers have the ability or the same access to knowledge, and some are still learning. They do not have equal powers of observation or learning. The knowledge production can be viewed as a learning process, where the application of knowledge to different scenarios produces an outcome that is evaluated and adjusted as necessary. This repeated practice, experience with the various variables, and evaluation of the outcome over time (Fig. 3) increases fishers' experience and knowledge, which leads to better retention and improved adaptability. This continuous learning and the ability to deal flexibly with new situations has made these fishers adaptive experts (Fazey et al., 2005). They are able to recognize patterns, organize many categories of knowledge, and retrieve information. Hence, they solve problems by using their understanding of the ecosystem, making predictions, and acting flexibly when faced with unexpected situations. The knowledge developed thus far in Gouyave is consistent with published biological data about the ecology and behaviour of yellowfin tuna, marlin, sailfish, dolphinfish, and swordfish (Froese and Pauly, 2006). The reading of seawater colour, as part of 'folk oceanography', is also consistent with fisher knowledge from other parts of the Caribbean (Gomes et al., 1998).

The context of these observations and learning is important. Extracting local knowledge from its social and environmental context does not often work (Agrawal, 2002). The knowledge of Gouyave fishers cannot be exported to another geographic area or fishery without being adapted to the new local context. Applying fisher knowledge from one case to another is risky, as the knowledge base and the inference engine might not be relevant, and there has to be a social environment that supports and updates the system.

The Gouyave longline case shows that it is adaptive learning, rather than the knowledge content itself, that is important. How fishers deal with environmental uncertainty is a kind of adaptive management (Walters and Holling, 1990). Much of the knowledge generated around longline fishing is based on observation, experience, and trial-and-error learning. However, adaptive management proper also requires deliberate experimentation, and Gouyave longline fishers do this with gear, fishing areas and use of bait. Environmental uncertainty provides new 'experiences' from which to learn, and these experiments are repeated and outcomes are stored in individual and social memory.

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