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Understanding and improving safety in artisanal fishing: A safety-II approach in raft fishing

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ABSTRACT

Artisanal fishing with rafts is responsible for most of the Brazilian Northeastern region fishing production. Fishing is done in open sea, with very small boats in the unpredictable and often hostile maritime environment. Safety is achieved through the fishermen's expertise to adjust their performance to cope with the demands and disturbances. Under this environment, safety should be improved by constraining the way people do things, based on traditional safety management principles or Safety I. This research describes a Safety II approach to improve raft fishing safety in a typical Brazilian beach community. Safety II main focus is on fishermen activities and strategies to construct safety during their fishing expeditions. The methods, following the action research iterative procedure, are workplace empirical studies to uncover knowledge, expertise, and artifacts that inform fishermen sensemaking and the Functional Resonance Analysis Method FRAM to model the fishing capture expeditions. Results indicated that the fishermen's safety related trade-offs during fishing expeditions depends on their sensemaking, and to improve safety there is a need of a broader, systemic and continuous approach, involving not only objective measures and devices to inform and to support sensemaking for safer decisions, but also ways improve survival conditions of fishermen.

1. Introduction

The artisanal fishing system studied in this paper – raft fishing in Brazilian Northeast coastline – has no formal safety system (no external safety-inspections, instructions, or any other formal safety instructions) as in the traditional industry sectors. This is an activity primarily based on personal knowledge (on fishing, raft navigation, and safety), consisting of a replicable, orally transmitted set of specialized skills, and culturally shared practices and beliefs that have stood the test of time (Diegues, 2002). Therefore, the levels and kinds of risks to health and safety depend on the environmental, social, economic, and cultural context. Interactions among these factors can contribute to increasing or diminishing risk perception (e.g. leading fishermen to abort fishing due to weather or sea conditions), which in such a loosely-controlled work space is very important for workers' safety. Under such characteristics, the Safety-II perspective appears to be the more adequate way to analyze and improve safety.

Morel et al. (2008) investigating decision-making of professional sea-fishing skippers concluded that traditional safety measures improve safety is done in "detriment of self-managed safety" (Morel et al., 2008, p-14). They also envisioned the need of new safety methods that cope with "the two types of safety, constrained on one hand, and self-managed on the other" (Morel et al. 2008, p-14). Nowadays, it is becoming clear that the Safety II (Hollnagel, 2014; Sujan et al., 2017) framework has the concepts and methods under such a holistic vision of safety could be created. Safety-II can be viewed as system and/or people abilities that keep the system functioning under varying conditions, in order to have the higher possible number of intended and acceptable outcomes (Hollnagel, 2014). From a Safety-II perspective, the purpose of the safety management in artisanal fishing systems, like the one described in this research, is to facilitate as much as possible the ways in which things can go right, in the sense that fishermen have safe fish capture expeditions.

Therefore Safety II issues on raft fishing are related to the navigation abilities with very small boats (the rafts) in the ever-changing maritime environment. Fishermen navigate along the coast (3–10 km) in expeditions of around 8 h with sail and/or small motor propulsion, and there is a risk to be adrift (when propulsion fails), to turn the raft, and occupational injuries due heavy load and physical demands of the activity. Safety in this situation involves complex processes, especially in decisions to abort or continue navigation due to weather, sea, or raft conditions. The major part of understanding whether safe conditions still exist relies upon the sensemaking (Klein et al., 2007; Klein et al., 2006), or common sense (Thorvaldsen, 2013) of fishermen. In this work

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environment, the Safety-II perspective providing conditions for fishermen to succeed under expected and unexpected conditions, according to their actual work conditions, appears to be the most adequate way to improve safety in artisanal fishing settings.

The main research question that drove this study was:

How a Safety-II perspective can improve the understanding of safety in artisanal fishing, enabling the development of useful, practical and applied safety measures?

Other research questions needed to answer the first one are:

- What is the current context, practices, and functions involved in the safety of fishing expeditions?
- What are the existing sensemaking behaviors that inform decision-making during fishing expeditions?
- How can workers' safety actually be improved considering the environment in which artisanal fishing is situated?

2. Background and literature review

2.1. Artisanal fishing with rafts at Ponta Negra beach

Brazil fishes at sea about 580 thousand tons per year (Castello, 2010). The fishing communities represent a population of approximately 800,000 artisanal fishermen, involving 2 million people who produce about 55% of the national fishery production (Callou, 2010). In 2007, 28.8% of the national fish production occurred in the Northeast coast (Fig. 1) and artisanal fishing was responsible for 96.3% of this production (Castello, 2010). An important part of artisanal fishermen uses the "jangada" (raft), a secular sail-vessel with dimensions ranging from 3 up to 8 m that is suitable for the type of sea, wind and sandy coast found in the area (Diegues, 2002).

This study was done in the Ponta Negra beach located in the Rio Grande do Norte (RN) State. Rio Grande do Norte, in its 410 km of coastline, has 25 coastal municipalities, 97 fishing communities and about 13,000 fishermen who carry out the activity for subsistence and commercial purposes. Of the RN registered fishing fleet, 28.5% (1071) are rafts, which in 2007 have caught 2175t of fish (IBAMA, 2007). Of the 381 vessels registered in the Colonia Z-04 Fisheries and Aquaculture of Natal, where Ponta Negra is located, 22.8% (87) are rafts.

Fig. 1. Map of Brazilian Northeast region.

Fig. 2. The raft used for fishing at Ponta Negra. .
Source: Jaeschke, 2010

The Ponta Negra fishing community was chosen for this study because it is one of the main raft fishing communities of Natal, capital of Rio Grande do Norte State, the city where is located the university and the research group who developed this research. This community lies and has its fishing based at the most famous tourist beach of the state, the Praia de Ponta Negra. Artisanal fishing still represents an important participation in the production and commercialization of the fish in Natal city, whose main consumers are the restaurants and hotels of the city. It is a traditional community, similar to many others existing in Brazilian Northeast coast, where raft fishing occurs. Ponta Negra was initially populated by artisanal fishers, very small farmers, and currently by artisanal fishermen, workers, street vendors, and public employees. Another important issue for the choice of Ponta Negra concerns the demands on the safety and health of fishermen that appeared after a screening on Natal poor communities (Saldanha et al., 2012). Fig. 2 shows the raft used for fishing at Ponta Negra measuring from 3.6 to 5.14 m in length and 1.4 to 1.7 m in width, weighing around 642 kg, accommodating 2 crewmembers: the captain or master and a helper or bowmen that carries out different functions.

Rafts were originally designed to be propelled by sail, but the use of a small fuel engine for propulsion began in 2005. Currently, rafts design was adapted to use engine propulsion (ways to attach the engine to the Captain seat and a shaft added to the propeller) and most of the fishermen prefer to use the engine. It reduces the dependence of wind conditions and navigation time, thus reducing working time and improving the quality of the fish caught. The use of the engine decreases physical workload (required for sail navigation) and reduces the shipwreck events. When the engine is used, the master (captain) drives the vessel almost by himself, reducing the need for help from the bowman. However, with the engine, the costs of the shipment were increased. Fuel consumption varies from 4 to 6 L per shipment.

The fishing expeditions occur from Tuesdays to Saturdays. The weather and sea conditions during the summer (December-March) are more favorable than during the winter season (June-September) – characterized by intensive period of rains – resulting in more productivity on summer season. A 2010 study on fishing production with 11 rafts in January and 12 rafts in June showed that in January the 11 rafts completed 81 expeditions capturing 2854.5 kg of catch, averaging 35.24 kg per expedition. In June, the 12 rafts completed 106 expeditions, capturing 1211 kg of catch, averaging 11.42 kg per expedition (Celestino et al., 2012).

Fig. 3 shows the steps of the fishing expeditions. The raftsmen depart to the sea either in the small hours (2:00 a.m.), returning in the morning (between 8:00 a.m. and 9:00 a.m.), or in the afternoon (2:00 p.m.), returning after dusk (between 8:00 and 9:00 p.m.). The duration of the expedition varies from 3.5 to 9 h, depending on propulsion type (motor or sail), meteorological conditions (wind speed and direction),

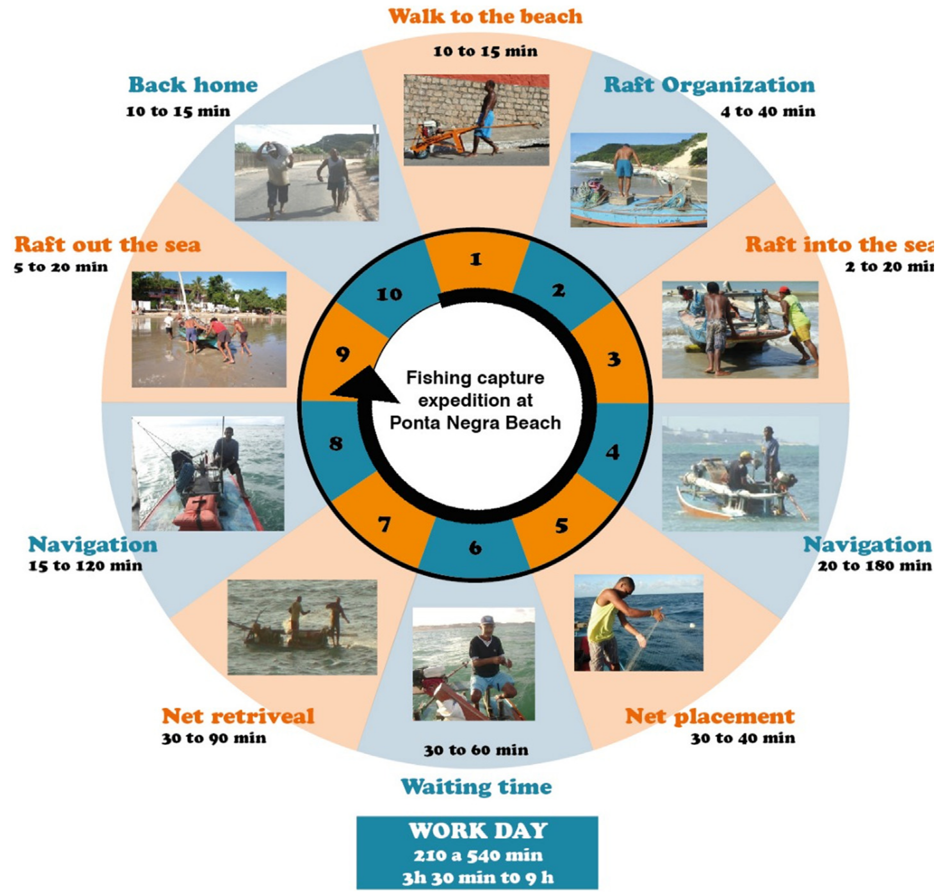

Fig. 3. The fishing expedition steps: after the decision to go fishing, they walk to the beach, organize raft, move the raft into the sea, and begin the navigation to the fisheries. After fishing they return home in similar steps. .
Source: Jaeschke and Saldanha, 2012

sea conditions (mainly tides), location of fishing grounds, number of nets placed into the sea (17–30 nets of 100 m can be placed, covering 1700–3000 m of the sea), catch effectiveness (quantity of fish caught by placed nets), and even the presence of algae stuck to the nets.

There is a strong physical component in the fishing activity due the heavy loads carried on, the ways to put the raft into/out the sea, the movements done during the launch and removal of nets, and the raft navigation itself (including the efforts to turn the raft over if needed). The raft fishing in Ponta Negra is made only by men. In the Brazilian fishers' communities, in general, the women either take care of the home-work and their families, fish shellfishes or oysters, work making handcrafts, work in agriculture, work for other families, or work in restaurants, bars and hotels.

The learning is done on the job. The apprentices follow the masters in the expeditions and begin to carry out the procedures, practices, and strategies, becoming initially bowman (helper) and then becoming a master or captain: *"It is a difficult activity to learn … but with enough fishing time, the person learns and he only learns by going there"* (Fisherman, Jaeschke and Saldanha, 2012). To be considered as a master or captain, a fisherman must master the navigation techniques that comprise: knowledge about the weather (rain, winds) and sea conditions (waves, tides, moons and winds), navigation and safety (management of the raft) involving the use of the rudder, placement of sails, engine, triangulation and location of fishing spots, and fishing techniques (laying, withdrawal and storage of fishing nets, identification and storage of fish), raft maintenance skills etc.): "*For everything you have to have a wisdom, it is not only to know how the wind goes, the places to go, the ways … you have to know everything at the same time to be a good master"* (Fisherman, Jaeschke and Saldanha, 2012).

There are no formal records on accidents/incidents on artisanal fishing with rafts at Ponta Negra Beach. The data briefly described here is gathered from Saldanha et al. (2017) compiled based on reports from the raftsmen. Most of raftsmen reported work-related accidents when the raft is at sea, and 2 fatalities were remembered. All of them reported that they have already had their raft turned in at least one capture expedition.

Being adrift was also reported as a major problem, mainly because the communication and response actions in this situation are very precarious. The Port Authority and the Fire Department start search only after 24 h of the first communication, which makes it more difficult to locate the vessel or people adrift. In many cases, fishers themselves have taken the initiative to look, on their own, for vessels or colleagues who have not returned, with success.

Fishermen recognize that they do not always follow Maritime Authority Standards for vessels used for inland navigation, a category in which the rafts are inserted. Under this category, vessels are only allowed to sail up to around 5 miles from the coast. However, rafts go beyond this limit in search of more distant fisheries, because fish are scarcer in the areas near the coast. Fishermen report that they do not wear the life jackets during expeditions. The vests are used only after the raft turns, while the raftsmen were adrift. They explain the non-use of jackets due to the difficulty of movements with the vest. For this reason, they keep the lifejackets on the raft tied by a rope or stored in the internal compartment of the vessel. This last option makes the access to vests even more difficult when the raft turns.

2.2. Safety-I and Safety-II in artisanal fishing

Available worldwide statistics indicated that fishing is a very dangerous activity (Casey et al., 2018). Fishers are susceptible to work accidents, injuries, and death (Luo and Shin, 2019). Death and injury among workers in the fishing industry all over the world occur at much higher rates than national averages: about 24,000 deaths occur every year in fishing, and an estimated 24 million non-fatal accidents every year (FAO, 2001; Jensen et al., 2006; Zytoon, 2012). Roberts (2010) indicated that Britain's most hazardous occupation is commercial fishing that had from 1996 to 2005 higher work accident rates than all other UK industries.

Some studies have been conducted to assess and improve safety on artisanal fishing. Piniella and Fernandez (2009) developed a preventive checklist to be applied before the fishing expeditions. Perez-Labajos (2008) recognized the dangerous aspect of fishing proposing a legal framework of reference for organizations policies and measures to improve safety in the fishing sector.

These articles are according to the Safety-I approach, in which safety management requires an organized effort to obtain safety requirements, to design a safety management structure and processes aiming at the definition of tasks, rules, and prescriptions to fit the predefined safety requirements (Li and Guldenmund, 2018). Almklov et al. (2014) argue that safety management systems, based on generic safety management principles under the compliance perspective (Safety I), do not take into account – and even marginalize – the situated safety knowledge developed by the workers during their activities.

Such characteristics of Safety-I indicate that this approach should not be used to improve safety in work environments where workers at the sharp end have established safety practices that pervade work activities themselves, which could be argued to comprise roughly all existing work environments. Particularly, Safety-I approach can be misleading where there is no formal safety management, no detailed description of the work process, and where the work activities occur under highly variable and dangerous conditions, such as the case of artisanal fishing with rafts.

The complexity and the ever-changing characteristics of maritime environment, the need of constant interactions, their potential to produce resilient performance, and their influence on the safety of workers indicate the need for a holistic, socio-technical approach based on system and resilience engineering to understand the health and safety issues of workers involved in fishing (Utne, 2006), according to the Safety-II perspective.

In accordance to these ideas, recent studies have pointed out new approaches more related to Resilience Engineering and the Safety-II perspectives. For instance, an investigation of how Norwegian coastal fishermen deal with occupational risks led by Thorvaldsen (2013) indicated that, in spite of the development and enforcing the use of safety regulations in the European Union, there is a lack of compliance to regulations. She concluded that professional fishermen deal with risk as a balancing act, carrying out continuous assessments and decisions related to sea and weather conditions, fish, profits and safety (Thorvaldsen, 2013).

Davis (2012) showed that among Maine (US) commercial fishing vessel captains there is a trend to undervalue occupational risk. Her study also disclosed that the ones more likely to downgrade fishing risk are those who are middle-aged, less educated, those who come from a fishing family, and those whose vessels were found to be non-compliant with formal safety regulations. The characteristics of most Brazilian raft fishermen match almost entirely the Davis' profile of fishermen that undervalued their occupational risk. And for those who undervalue risk, to follow formal safety regulations elaborated far from their everyday work does not make sense.

In their study in Nordic countries, Thorvaldsen et al. (2018, p-101) found that "fishers do appear to appreciate measures that are practical and obvious in their everyday work" and they recommend involving fishers in the development and implementation of safety measures. This is because safety measures are only effective if they are implemented, and that depends on how workers perceive such measures (Thorvaldsen et al., 2018).

While studying commercial fishermen in North Carolina (US) who work in non-industrialized settings and do not have access to industry formal safety regulations, McDonald and Kucera (2007) related that their safety is based on work practices and attitudes. The study also identified specific safety measures such as "appropriate gear and boat maintenance, weather decisions, and working cooperatively when ocean fishing" (McDonald and Kucera, 2007, p. 289).

Storkersen (2018), in her study on how the International Safety Management Code affects Norwegian coastal transport, concluded that "full potential for safety management with practical procedures" (Storkersen, 2018, p. 7) are not fully exploited due to audit requirements, and that "companies, and operational personnel would benefit from safety measures less concerned with auditability and more focused on safety itself" (Storkersen, 2018, p. 7).

3. Methods

The research described in this paper followed the Action Research iterative process (Argyris, 1994), from fact-finding to understanding the problems, action/solution planning, solution implementation, evaluation and reflection. After workplace studies based on observations, interviews, conversational actions (de Carvalho et al., 2016) to collect data on raftsmen work activities, the Functional Resonance Analysis Method – FRAM (Hollnagel, 2012) was used to analyze the safety of fishing expeditions. The Functional Resonance Analysis Method (FRAM) models socio-technical systems based on the analysis of the systems functions and their couplings. FRAM follows the concepts and precepts of Resilience Engineering (Hollnagel et al., 2006) and had been used in different domains ranging from healthcare (Jatobá et al., 2018), up to highly regulated safe-critical systems like energy & oil (Cabrera Aguilera, et al., 2016), aviation (de Carvalho, 2011), and maritime operations (Patriarca, 2017).

FRAM was selected when the research group realized that safety in artisanal fishing with rafts would not be improved only by understanding the hazards, risks and providing recommendations through new rules, procedures and safety prescriptions, and decided to follow a Safety-II perspective. In fishing expeditions, safety is constructed and balanced according to the experience, expertise, cultural values, and personal needs of workers in a changing environment, which renders safety prescriptions or procedures very difficult to elaborate and even more difficult to follow. Under this environment, the use of FRAM enabling the understanding and reflection on safety-related function variabilities, seems adequate to fulfill the aims of a Safety-II based analysis. Along the research this comprehension was proven to be needed to produce safety-related interventions that make sense under disclosed raft fishing work situations.

The main steps of FRAM as used in this study were (Hollnagel, 2012):

- Setting the goal – fishermen safety – for modeling and describing the situations to be analyzed;
- Identifying the main functions of fishing expeditions, and characterizing them, according to input, output, preconditions, resources, time, and control, using the FRAM Model Visualizer;
- Characterizing the variability of functions, with the participation of fishermen;
- Aggregate functions searching for safety-critical paths, based on potential/actual couplings among functions.

The data to create the functional resonance models came from Ponta Negra community, where fishing activity using rafts was undertaken by a group of 42 fishermen, from which 22 agreed to participate in this research. 38% were fishermen between 41 and 50 years old; 29% of the population is from 31 to 40, and 24% is from 51 to 60 years old. The youngest group (21 to 30 years old) represents 7% of the raftsmen.

The group involved in data collection and analysis are formed by professors of two Brazilian federal universities with long experience in ergonomics and safety, along with graduate students. Research was conducted in a two-way interaction process where: (a) researchers understanding how safety is created or jeopardized; and (b) extensive discussion with workers on alternative ideas to improve safety. Researchers were instructed to document as much as possible the interactions through field notes, hot reports, audio/video records, and photos.

The method can be divided into several phases with different objectives which are highly interconnected. Due to the situated or grounded approach of the research and its evolution over time, research activities were not carried out in subsequent linear steps. Rather, many of the research activities had overlapping focus, so that parts of each phase also influence findings in other phases in a bootstrap way (de Carvalho et al., 2016). The main research phases were:

Social construction. This phase enabled the involvement of the research team with the Ponta Negra beach community, as shown in Fig. 4.

- **Investigation of existing formal documentation**. Although there are no detailed work prescriptions for fishing with rafts due, there are some rules issued by Brazilian port authorities (NORMAN-02/DPC, 2005).
- **Data collection on work activities in fish capture expeditions**. Data collection procedures included direct observation of the preparation and launch phases of fishing expeditions, as well as conversational actions with fishermen on topics like navigation, fishing and safety. Additional sources of data included: think aloud verbalizations during simulations of fishing activities with the raft on land; films of the fishing expeditions made by the researchers near the coast; and films made by the fishermen themselves in their own raft far from the coast during fishing expeditions.
- **Data compilation, participatory confrontation, and analysis**. Data from observation, conversational actions, simulations and films were confronted alongside fishermen to investigate variability within expedition phases, as detailed in Section 3.
- **Modelling of fishing expeditions using the Functional Resonance Analysis Method (FRAM).** Based on the prior steps, system functions and their potential variability were represented in FRAM diagrams.
- **Validation with fishermen and recommendations**. Focal groups were established within the local fishing community discussing and validating the results, paving the way for the kick-off of a program of safety workshops and the development of projects aiming at improving safety and production goals through a systemic perspective.
- **Safety Workshops and Ongoing Projects.** A program of workshops to discuss safety issues was established along the development of specific projects to address the issues revealed by the analysis. The safety workshops were aimed at sharing and validating research results among all the members of the fishing community, as well as a participatory development of recommendations. The workshops were held at least in two moments for each safety measure (see Section 3.5). In the first moment data was reviewed and validated. In the second moment of the workshop, collective solutions were conceived, based on the following question: "What can we do to improve this/such aspect?" The timeline of workshops depends on the evolution of action planning and safety measures to be implemented.

3.1. Study limitations

The application of Action Research disclosed paths to improve the safety of raft fishermen through reflection on several safety-related measures proposed along the research (see Table 3 at the end of the Results section). However, there were difficulties and delays to implement some of the proposed safety-related measures using only the people directly involved in this research. This limitation was partially solved incorporating actors from other university departments for the design and construction of the new wheelbarrow to transport the rafts to the sea, the new prototype of rafts, and computer applications. To avoid unnecessary delays in action plans, making the iterative action research process too long, members of these groups should be incorporated into the research as early as possible. Another limitation was the practical impossibility to make direct observations of the fishing activities during fish capture expeditions. To overcome this limitation, fishermen were instructed to take photos and to film the expeditions. The interviews, simulations of activities, and collective validations were also used to cope with this limitation.

4. Results

The fish capture expedition was divided in two FRAM models. Fig. 5 presents the basic couplings among functions regarding the preparation and launch phases of the expedition, and Fig. 6 the functions during navigation. Both FRAM diagrams were organized around the function "Make sense of conditions for navigation and safety" highlighting the

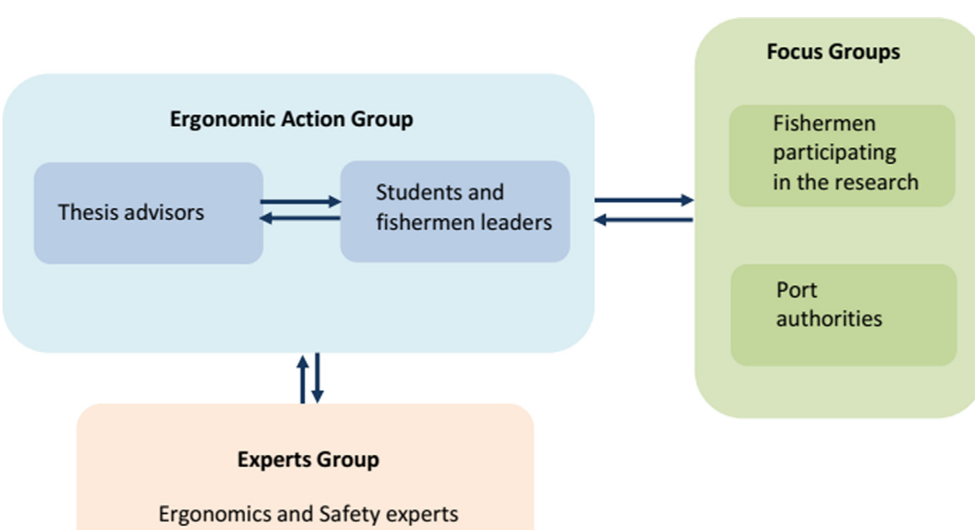

Fig. 4. Social construction diagram. The Ergonomic Action Group was composed of people involved from university and the community. Focus groups were formed by people who provided data and information and/or participated in the validations. The experts group was made up of people with extensive experience in ergonomics and safety research.

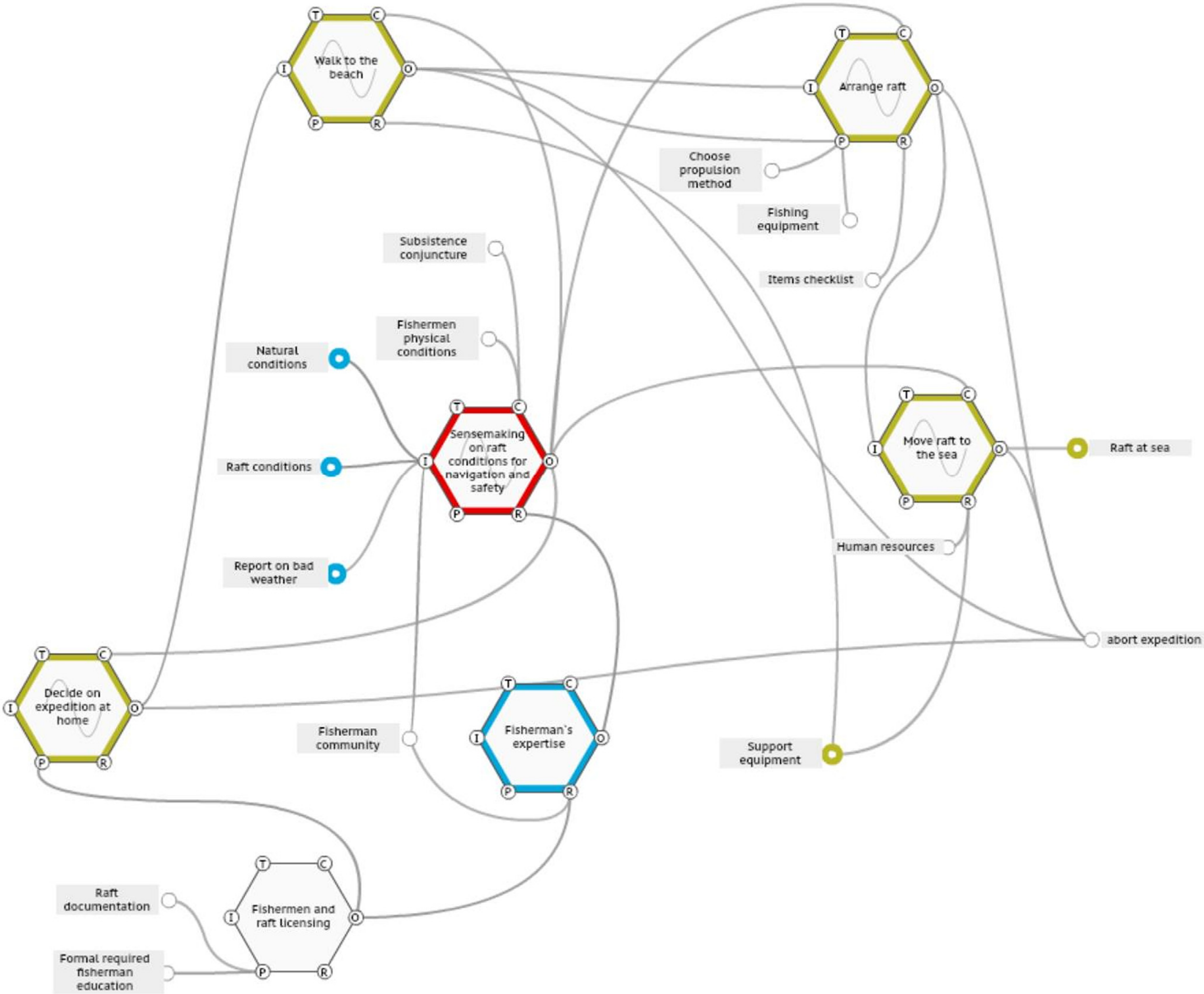

Fig. 5. FRAM diagram from the decision to go up to launch of the raft into the sea.

central role played by the fisherman's sensemaking in the safety of the expedition. This function represents a cognitive process that happens during a very short time period (typically taking seconds or minutes at most) and transforms holistic inputs into a mental mapping output of the current situation for navigation, based on fisherman expertise and personal conditions.

The inputs of sensemaking functions are the current contextual information available for the fishermen from where they extract appropriate cues that may disrupt their previous understanding, leading them to a phase of pattern recognition. Fishermen's expertise is the main resource they have to identify patterns, to activate action scripts, and to make mental simulations using their mental models. The output of sensemaking function "conditions for navigation and safety evaluated" controls the safety decisions to abort or finish the expedition (it is the control input for nearly all other modeled functions) and is itself controlled by fishermen's personal factors.

As shown in Fig. 5, the decision on launching an expedition begins at home, when fishermen observe the weather condition, especially whether there is an indication of heavy rain. At this moment, fishermen have already a basic idea on the raft safety condition, although they will visually check the raft integrity later when they arrive at the beach. Three potential outputs based on that sensemaking process are expected: fishermen may become still in doubt, whether they can go fishing, or they may abort the expedition. Usually, fishermen abort the expedition at this point due to adverse weather or inappropriate physical condition. Sometimes, subsistence conjuncture plays a fundamental role on the sensemaking function output, acting as a variable input that controls the sensemaking function, as evidenced in the following account of one fisherman: *"It depends on the needs of the person. I have already gone against the tide under a storm because there was nothing to eat. But it's not good at all."* Once fishermen decide to go fishing, the next step is to walk to the beach where they can have better indicators to analyze climate and tide conditions.

At the beach, fishermen refine their expedition plans. At this point, due to a holistic perception of the weather conditions, sea and tide conditions, provided by the affordances of the beach environment – weather indicators are analyzed based on tacit knowledge through the observation of the sky, the wind directions and intensity, the tide level, and the cloud formations – they decide on the convenience of go fishing and make the initial plan for the expedition (where to go).

Having planned the expedition, fishermen start preparing the raft for navigation. At the "prepare raft" function, fishermen evaluate the integrity of the hull, when he looks for holes, cracks, fissures, and flaws in the raft; then they make a mental checklist of all necessary items for a safe navigation. If still in doubt, they may gather more information about the sea, the tides and the best fishery that day from arriving fisherman from earlier expeditions. Bad weather, strong wind, adverse tide, and precarious raft conditions should be reasons to abort the

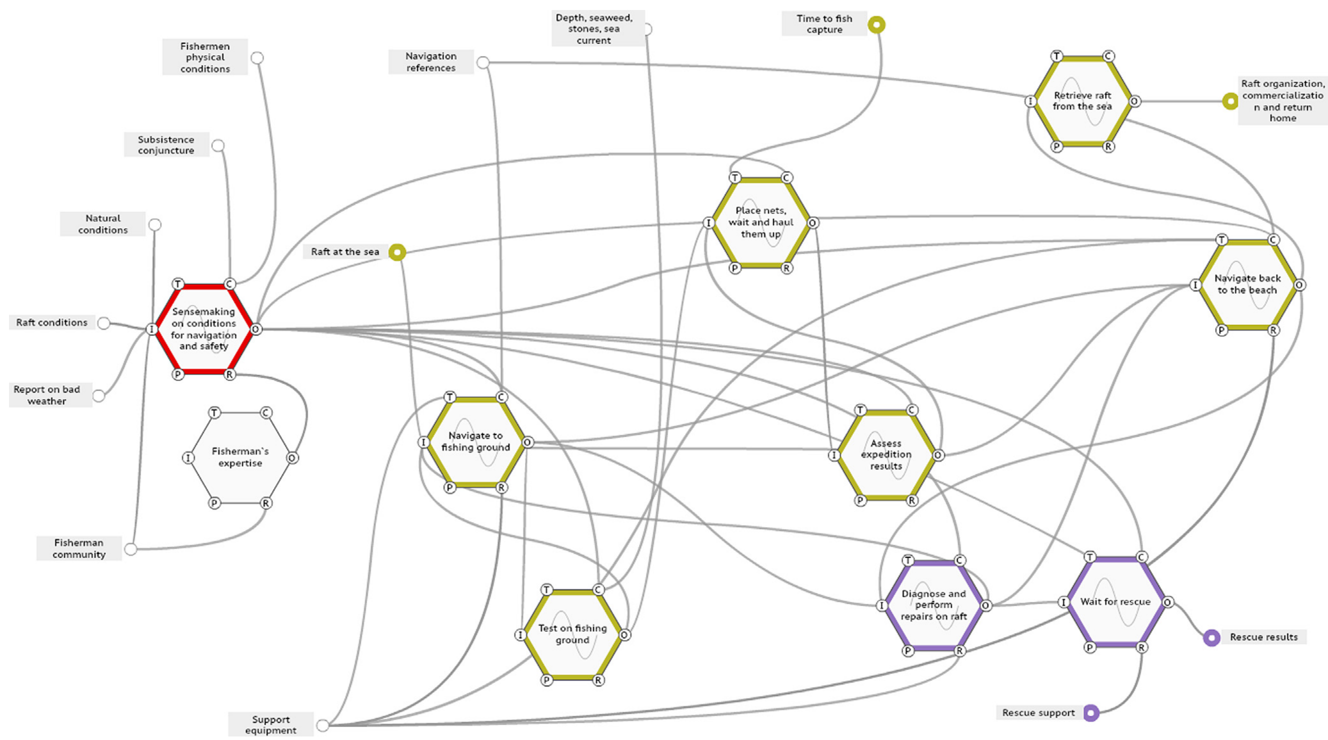

Fig. 6. FRAM diagram for navigation and fishing.

expedition at this stage; still, the necessity of go fishing due to subsistence needs may be the major fisherman driver. Despite the fishermen expertise and experience, a decision based on subsistence needs increase the variability of this function‘s output, leading to unsafe decisions. At this stage, fishermen define the type of propulsion to be used: sail or motor propulsion. When the raft is prepared and organized, fishermen move the raft to the sea.

Table 1 shows the potential variability for preparation and launch of the raft. It indicates that the “Make sense of Conditions for Navigation and Safety” function has high output variability in terms of or imprecise range. This variability is inherent to the macrocognitive processes related to sensemaking, leading to resilience and safety from one side and bad decisions from another.

Information about the sea, tide and fishing grounds conditions are the main source of resilience for fishermenś decision on quitting or going ahead with the expedition. However, the quality of this information is normally poor. They may get some information at afternoon’s expeditions, when fishermen returning from morning expeditions give some advice.

The fishermen do not consult meteorological bulletins on a daily basis, as they rely on their own expertise. They also usually rely on the “bad weather advice”, which sometimes is delivered by the port authority. This report is not always issued and comes in the form of a paper bulletin attached to the wall of a precarious support building at the beach by the representative of the Ponta Negra beach raftsmen community. However, this report may not reach the fishermen, either because nobody pasted the paper on the wall, or the shack used by the fishermen at the beach is in bad conditions.

Two control functions are constantly influencing the decision to go fishing or aborting an ongoing expedition. These are the fishermen’s physical conditions and the subsistence conjecture. Fishermen’s physical (and psychological) conditions are usually related to the subjective perception of each person about their wellbeing and health at the moment they decide to launch an expedition. Another personal function influencing sensemaking process is “Provide subsistence conjuncture”. The sensemaking process leads to the formulation of satisficing accounts that control safety decisions in different phases of the expedition.

The only external control on fishermen work comes from the Port Authority. It is based on a License to sail a boat that fishermen must have and the boat license itself, shown as a background function (in grey) in Fig. 5. However, the theoretical and practical knowledge taught in the professional fisherman’s course needed to get the license does not provide an effective contribution for them, mainly due to the gaps between what is taught and the actual fishermen previous knowledge and schooling. Most of the raftsmen declared to have a license; however, only 19 out of 40 took the course. Most of them obtained the document more than 30 years ago when the course did not exist. Low level of schooling is an impediment to the participation and approval of many professional fishermen in the course because many are illiterate or functionally illiterate.

The diagram for FRAM model related to navigation functions is shown in Fig. 6 and Table 2 describes the variability of the functions during navigation and fishing. The sensemaking function during navigation and fishing, despite having the same resource and control aspects of the previous sensemaking function, has a few more inputs. These are the perception of inner compartment water level, objects in the sea, and ships nearby, thus concerning the behavior of the raft in the sea and coming from the function “Provide raft conditions”.

When the expedition starts, the fishermen have already a robust idea of the chosen fishing ground they are targeting. During motor propulsion navigation experienced fishermen are always looking for drifting objects and jetsam in general (e.g. pieces of wood, trash and plastic bags) that could crack the hull or damage the propeller. If the propulsion mode chosen was the sail, then fishermen must take care to launch the sail only after the rudder is attached to the raft. If this maneuver is not performed they lose control of the raft.

Most fishermen do not know how to fix propulsion motors, and if it fails during the expedition, they should hoist the sail to navigate. However, it was found that the introduction of the propulsion motor as a preferred method to navigate caused some raftsmen to neglect the necessary sail care and proper maintenance, as it is kept stored for long periods, thus causing material deterioration. This scenario can jeopardize the very feasibility to use the sail, as illustrated by the following

Table 1
Potential variability for preparation and launch of the raft.

Function	Output	Variability regarding time		Variability regarding precision	
		Range	Description	Range	Description
Sensemaking on raft conditions for navigation and safety	Raft conditions for navigation and safety	On time	Mental processes that consume relatively very little time in the general process time-frame	Imprecise	The very nature of the sensemaking output varies greatly depending on the dynamic relative importance of each function input along a given expedition (e.g. the change of weather conditions or occurrence of injury), enhancing the function output. This brings resilience (continuous monitoring/recovering possibilities) and brittleness (biased sensemaking) of the whole process
Fisherman's expertise	Expertise on weather conditions, seasonal fishing, raft behavior, raft organization and repair	On time	Outputs are stable regarding time along the expedition time-frame	Precise	Outputs are stable regarding precision along the expedition time-frame
Fishermen and raft licensing	Fishermen and raft license obtained	On time	Outputs are stable regarding time along the expedition time-frame	Precise	Outputs are stable regarding precision along the expedition time-frame
Decide on expedition at home	Go fishing, abort expedition, still on doubt,	On time	Mental processes that consume relatively very little time in the general process time-frame	Imprecise	Biased or jeopardized sensemaking (which at this step is at an early stage and only takes into consideration a few information inputs) can lead to biased decision or a state of doubt
Walk to the beach	Arrival at beach, expedition planned, abort expedition	Not at all	Incremental sensemaking input during this phase may lead to safety concerns that result in aborting the expedition	Precise	The outcome of this function is binary with regard to precision
Prepare raft	Raft prepared and organized, abort expedition	Not at all	Raft preparation may be aborted if damaged plywood or stolen item is verified	Acceptable	Assessment of the damage to the hull and deck is purely visual, thus is hampered by precarious lightning conditions
Move raft to the sea	Raft at sea, abort expedition	Not at all	In case of injury of fishermen or raft damage during transporting the expedition may be aborted	Acceptable	In case the maneuver is not precise the raft may bump into the ground, the logs or into objects in the sea, thus hull plywood may be damaged and fisherman may even get injured

statement by a fisherman: *"If the engine breaks you have to use the sail. Then you open the cloth, and the cloth is already spoiled, then the entire cloth rips, and you stay there. You may try to paddle, but you cannot go back."*

The redundancy and consequent safety improvement that the 2 propulsion modes could provide are not actually incorporated by the system. Reports on incidents in which the fishermen are adrift in the sea are usually caused by damages in the propulsion. Therefore, it is important that raftsmen get advantage of the 2 redundant propulsion modes available, keeping the sails in a good state, and making the necessary repairs on their return to shore, even when sails are not normally used.

Another factor impacting safety during navigation is navigating during the dark hours. Expeditions usually start at 2 am (returning at the daylight) or at 3 pm (returning after dark). During night navigation, visibility is reduced, increasing the risk of accidents. Collisions, reduced perception about climate and tide changes, and reduced visibility of obstacles at the sea are constant threat fishermen must deal with.

Raftsmen use the triangulation as navigation method based on the position of the stars and on points of reference at the beach. Nowadays, urbanization caused an ever more vertical skyline at Ponta Negra beach, which became an obstacle for fishermen to use the triangulation method. To deal with this situation, eight rafts are using GPS technology to locate the fishing grounds and to navigate during expeditions. The GPS was introduced after safety workshops during this project.

When fishermen arrive at the fishing ground, the motor is turned off (or the sails are collected); then they perform a fishing test to verify if they are at a potentially abundant fishing ground. During the test, fishermen assess sea depth, the presence of water and seaweed, as well as the tide behavior. It reduces the risks of unsuccessful fishing, the physical workload on net retrieval (due to the entangling of seaweed), or the damage or total loss of the net (due to rocks). At this point, sensemaking is used to judge if the fishing ground is a good choice for placing the nets or if it is better to look for another fishing ground. It is important to note that every moment at sea is a potential decision-making the situation, in which fishermen could be confronted with threats or particular occurrences and must decide the best action to dampen the output variability of the system. It occurs when the seas are rough, there are strong winds, or the hull plywood is damaged. In such cases, fishermen must be especially aware to control the water level in the inner compartment (damping variability on the navigation function output). This is also important in the case the raft capsizes, once the righting maneuver is impacted by this variable (not enough water in the inner compartment will make the maneuver too strenuous, and too much water will cause the raft to sink). Raft untap skills is also very important to damp overall system variability. It is a highly risky maneuver that requires special skills that are passed on from masters to apprentices. However, because there is no formal learning process, these skills are put into practice only in real capsizing situations. During safety workshops, experienced fishermen were encouraged to explain how they right a flipped raft for the novices.

Once fishermen establish the fishery, they launch the nets, wait for the fish to be caught and retrieve them. Launching the net requires synchronism among the crew, equilibrium, and a great static effort made by fishermen. Besides that, during the nets launch, the lid that covers the inner compartment is removed to get the net and water may enter, especially in rough sea situations. If the raft turns with the inner compartment without the lid it can be filled with water and the raft cannot be untapped. In this case, the raft will remain turned, and the raftsmen will be holding the raft, because if they try to climb on the raft it tends to sink. It should be noted that, because they do not wear lifejackets during the expedition, they have a hard job to release them from the inner compartment in this situation.

The waiting time before retrieving the nets varies from 30 to 60 min and depends on fisherman estimates regarding quantity and quality of the fish caught. After retrieving the nets, fishermen assess the quantity

Table 2
Potential variability for navigation and fishing.

Function	Output	Variability regarding time		Variability regarding precision	
		Range	Description	Range	Description
Sensemaking on raft conditions for navigation and safety	Sensemaking for navigation and safety	On time	Mental processes that consume relatively very little time in the general process time-frame.	Imprecise	The very nature of the sensemaking output varies greatly depending on the dynamic relative importance of each function input along a given expedition (e.g. the change of weather conditions or occurrence of injury), enhancing the function output. This brings resilience (continuous monitoring/recovering possibilities) and brittleness (biased sensemaking) of the whole process.
Navigate to fishing ground	Arrival at fishing ground, Go back, Repairs needed	Too late, not at all	Time to reach fishing ground may vary greatly due to location of the chosen fishing ground, wind and tide conditions, especially if sail is used. If the motor is used time tends to be more accurate. In days with rough sea and rough winds there is increased risk of raft capsizing, increasing time variability. Sometimes expedition needs to aborted before reach the fishing ground	Imprecise	Capability to reach the fishing ground can be undermined by low visibility (in case of departure during the small hours or during downpour), and difficulties in navigating by triangulation (due to the ever more vertical skyline of the beach). Moreover, repairs on the raft, control of water level in the inner compartment may be needed during navigation or by arrival at the fishing ground
Test on fishing ground	Fishing ground approved or not	On time	This function is consume relatively very little time in the general process time-frame	Acceptable	Several factors influence this function‘s output, including fish caught, sea depth, presence of seaweed and rocks, and tide behavior
Place nets, wait and haul them up	Quantity of fish caught, Quality of fish caught (size, freshness, type)	Too early/ Too late	Outputs from upstream functions often indicate that waiting time to retrieve nets should be longer or shorter than initially estimated, to optimize quantity and quality of fish caught	Imprecise	In rough sea or during downpours water enters the inner compartment during this phase due to it being open, thus fishermen need to control its water level. Placing and hauling up nets is risky for workers once they need to stay at the edge of the raft and can fall into the sea. The waiting time may vary in a particular fishing ground, and the fish caught may be few of become damaged/ spoiled
Assess expedition results	Go back, Keep fishing, Go to another fishing ground	On timeOn time	This function is consume relatively very little time in the general process time-frame	Imprecise	Function output is influenced by quantity and quality (in terms of freshness and integrity) of fish caught, climatic conditions, physiological conditions of fishermen, and also subsistence conditions. Biased sensemaking due subsistence conditions can result in inadequate or even unsafe decisions
Navigate back to the beach	Go back to the beach, Raft cannot go back	Too late/Not at all	Time to reach the shore may vary due to fishing ground location, wind and tide conditions. Incidents leading to injury of fishermen or damage to the raft may also hamper the capability to return, both temporarily or permanently. Raft capsizing is indeed more prone to happen during this phase, due to fatigue and sleepiness	Imprecise	Fishermen often need to control the water level in the inner compartment due to seepage caused by hull damage. Capability to return to the shore is undermined by low visibility (in case of return during the night or during downpour), difficulties in navigating by triangulation (due to the ever more vertical skyline of the beach) as well as physiological consequences of the expedition workload. Variability can also occur due raft capsizing
Retrieve raft from the sea	Raft on the beach	On time	This function is consume relatively very little time in the general process time-frame	Acceptable	Raft retrieval maneuver may not be precisely executed due to fishermen tiredness, the beach terrain angulation and the greater weight of the raft after returning to shore. Therefore, during the maneuver the raft may bump into the ground, damaging the hull and even injuring fishermen
Diagnose and perform repairs on raft	Repairs are successful or not successful	On time/not at all	Repairs may not be possible due to lack of adequate repair tools or materials of lack of expertise (e.g. motor failure)	Imprecise	Identification of seepage spots is often difficult, and repairs may turn only partly successful of not successful enough to restore navigation capabilities
Wait for rescue	Rescue made or not made	Too late/Not at all	Fishermen may not be found at all or may be found too late to secure a successful rescue	Imprecise	Rescues that are carried out too late may halt the health and physical integrity of fishermen

and quality of fish captured and determine the moment within the waiting time most fish were caught (by analyzing fish freshness), which enable them to deduce if most significant shoals are still present in the fishing ground or have already left the area. This sensemaking process controls the assessment of the expedition results and establishes whether or not they should keep fishing – in the same location or in another place. A decision to navigate back to shore is made if enough fish were already caught, if the weather and sea conditions are becoming not favorable or if, despite a low amount of fish caught, the raftsmen think new attempts to fish in any fishing ground will not be successful enough. The hauling up of nets usually lasts between 30 and 90 min and is generally considered by fishermen to be the most exhausting phase of expeditions. This is mainly due to the effort from pulling the nets with the additional weight from the fish caught and the seaweed that often get entangled, as well as the position on the very edge of the vessel and the required posture. In addition, this stage is held after dawn or dusk when the fishermen are tired.

Afterwards, the fishermen navigate back to the beach. At this moment the raft is considerably heavier due to the plywood being soaked and the fish caught. All the risks related to navigation phases are increased during the return to shore due to the intense fatigue and sleepiness experienced by fishermen. Hence, this phase accounts for most reported accidents and incidents. After reaching the beach, the raft is withdrawn from the sea using the same technique as when it is transported to the water. With the raft secured in the sand, the fishermen retrieve fish caught and the expedition comes to an end.

Improving safety on artisanal fishing from the Safety-II perspective requires measures to facilitate ways in which things can go right. Such measures concern artifacts to inform sensemaking by showing current contextual information, new ways to share and accelerate safety-related knowledge, transformations in the fishing management and commercialization processes, and in ways to improve fishermen subsistence conditions to deal with the issues that create bias on sensemaking. Table 3 summarizes projects and actions that are underway in the Ponta Negra community as a result of this research project. All actions and projects follow the action research iterative and participatory approach, from the conception up to test and validation.

5. Discussion

The research question which motivated this research was how the Safety-II approach can improve the understanding of safety in fishing expeditions enabling the application of useful, practical, and applied safety measures. The first part of the question – understanding safety in artisanal fishing (current context, practices, and functions involved in the safety of fishing expeditions) – was answered by the detailed analysis of fishermen's activities that inform FRAM models, showing that in the fish capture expeditions things go normally well not because people follow prescribed rules or behave as someone thinks they have to do. Things go well because fishermen made continuous assessments and performance adjustments based on their own sensemaking. The Safety II perspective, describing the behavior of the expedition's functions, as modelled by FRAM, shows how performance variability – manifested into functions' dampening mechanisms – is important to build safety while allowing the fishing activity itself to happen. Understanding performance variability enables the inclusion of workers knowledge in safety measures, which Safety I management systems do not normally include (Almklov et al., 2014). Therefore, the development of useful, practical and applied safety measures must be done in consonance with the Safety II perspective (Hollnagel, 2014): safety measures considering the workers safety knowledge to ensure as much as possible that everything goes right, rather than prescriptions to avoid what can go wrong.

The importance to a deeper understanding of current context and practices in fishing domain to develop more effective safety measures has already pointed out in several recent works. After studying the impact of maritime safety regulations to Norwegian coastal transport, Storkersen (2018) disclosed a perception from crewmembers that "procedures do not take variability into account and hamper them in skill and knowledge-based decision making" (Storkersen, 2018, p. 87). She concludes that extensive proceduralization might then disrupt navigation activities (Storkersen, 2018), mainly because extensive proceduralization may constrain people activities (Morel et al., 2008). The study of Thorvaldsen et al. (2018) with commercial fishers from Nordic countries found that guidelines and information from the authorities on safety and accident prevention were not considered to be much influential on the prevention of occupational accidents in fishing, as such guidelines do not match the actual fishermen's safety behavior. In the same way as observed in this study on artisanal fishing, the Nordic commercial fishermen deal with safety using their sensemaking, carrying out continuous assessments and decisions related to sea and weather conditions, fish, profits and safety (Thorvaldsen et al., 2018). The importance of sensemaking in safety decisions also appeared in commercial fishing expeditions in Denmark. Knudsen and Gron (2010) found that economic factors had a strong influence in the fishers' perception of risk, stating that "fishermen's risk perception can be explained by the need to adopt coping strategies, compromises and resilience in an environment marked by uncertainty and unpredictability" (Knudsen and Gron, 2010, p. 87), which is almost the same conclusion that McDonald and Kucera (2007) reached when studied commercial

Table 3
Projects under development at Ponta Negra.

Actions	Description
Artifacts redesign	***New raft project:*** Modifications to the raft design, maintaining the characteristics and specificities existing in the Brazilian artisanal shipbuilding, adapting it to the socio-economic and cultural characteristics of the raft communities, aiming to improve the construction methods and the fishing operations, reduction of the operational costs of the vessel, improving safety and navigability and buoyancy, improving working conditions, reducing accidents and occupational diseases ***Wheelbarrow project:*** A wheelbarrow to transport the rafts to the see
New technologies to inform sensemaking	***Lighting:*** Development and use of handmade artificial lighting system for night navigation ***Navigation technology:*** Use of information and communication technologies (cellphone, GPS). 8 rafts have started to use GPS to find fishing grounds and to guide navigation. ***Search and rescue:*** Development of a collaborative monitoring system for search and rescue of drift rafts in the community
Training program	***Workshops on safe-related expertise:*** a continuous safety program of workshops to discuss safe-related issues regarding navigation (new technologies, cellphone on board, use of engine instead sail), raft conditions, evaluation and share advices on weather and sea conditions; community support in case of accidents (raft adrift in the ocean) ***Maintenance of the vessel:*** Training on the use and make available tools and spare parts to repair faults in the engine or raft components during the expedition (a new knowledge to be acquired) ***Postural Education:*** promotes the understanding of the relationship between the postures adopted in the work and its repercussions. ***Fish handling:*** deals with the storage and handling of fish on board, aiming to improve the quality of the product marketed
Management of fishing processes	***Aspects and recommendations aimed at improving management:*** a) of the fishing activity (organization of work and production); (b) of the fishing-related institutions; c) the interaction of these institutions with the fishing community

fishermen in North Caroline.

The research question on the existing sensemaking behaviors that inform decision-making was answered by FRAM models constructed around sensemaking functions. The sensemaking functions were conceived according to Klein et al. (2007) and Klein (2013) model on how individual sensemaking takes place in dynamic environments. The fishermen's sensemaking, that guide situation understanding and corresponding actions, are constructed using prior experience combined with tacit knowledge by appropriate cognitive structures called schemas (Klein et al., 2007), informed by current data on the situation, leading them to a phase of pattern recognition (Baber and McMaster, 2016). Fishermen continuously monitor weather and raft conditions and when confronted with a potentially adverse situation, they search for cues on weather, on information they previously gathered with another fisherman, and on the analysis of the raft behavior, so they can look for the best solution based on their expertise. These findings on fishermen's sensemaking are very similar to sensemaking behaviors found in other domains (Baber and McMaster, 2016; Klein et al., 2007; Weick, 1995). During their routine on fish capture expeditions, fishermen continuously monitor if something goes wrong, exchanging different modes of sensemaking (Kefalidou et al., 2018): individual, based on their own assessments and needs; collaborative, based on information coming from other fishermen; and artefact-based, weather bulletins, Lightning, GPS, and Cellphones. It was found that these different sensemaking modes emerge and are combined within the variability of routine (normal) expeditions, when fishermen make sense of an incident situation. For instance, the cellphone on board, enabling the collaboration in cases where the raft became adrift, combining two sensemaking modes, can be very useful to dampen the variability of the overall system in this dangerous situation. Therefore, fishermen should be aware of these strategies and be informed as much as possible by different artefacts, to be able to perform safely their job. The FRAM analysis has shown that the combination of quality of weather and sea information (an artifact-based sensemaking) with a biased individual sensemaking, due to poor subsistence conditions, is the main sources for high variability in the safety decisions on giving up a potentially dangerous expedition.

Most of fish capture expeditions in Ponta Negra go well because the expert fishermen are able to constantly adjust their performances to match the conditions of work constructing their everyday safety. Even considering the inherently dangerous working conditions related to the unpredictable maritime environment, rapid weather changes, unstable working platforms, manipulation of heavy equipment, and difficult communication, the records of fatal accidents are rare. According to the reports obtained from the fishermen of Ponta Negra beach, there were 2 fatalities in a period of 15 years of continuous fishing expeditions, with the last one occurring 13 years ago. Considering that in each expedition there are 2 fishermen and each of the 31 Ponta Negra rafts performs an average of 96 fishing expeditions per year, the ratio Fatal accidents/(Number of fishermen * Number of expeditions) amounts to 2/89,280 = or 224×10^{-5}. For the traditional Safety approach (Safety I), a safety figure of 10^{-5} means a very safe work system (Amalberti, 2006), thus not demanding immediate safety investments or attention to the development of safety improvements.

However, as revealed by the FRAM analysis, the safety on fishing expeditions, from a Safety II perspective, is affected by strong potential and actual output variability in the sensemaking functions (in both timing and precision), as well as potential nonlinear couplings (especially those involving uninformed, biased or compromised sensemaking) that can lead to situations where satisficing decisions turn to sacrifice decisions (Gomes et. al., 2015) due to the efficiency-thoroughness tradeoff – ETTO (Hollnagel, 2012) between the expedition safety and the need to produce (catch fishes for surviving). In FRAM terms, instantiations of poor individual sensemaking can expose fishermen to out-of-the-ordinary particular circumstances (functional disturbances) that the performance variability mechanisms featured by downstream functions are difficult or even not able to be dampened.

An instantiation in the sensemaking function occurs when scarce financial resources available to the fisherman's family (poor subsistence conjuncture) leads to launching an expedition in bad weather conditions such as low visibility at sea, which elevates the risks of turn the raft, being adrift, or slamming the raft into large objects at high seas, characterizing an efficiency – thoroughness tradeoff, ETTO (Hollnagel, 2012). In the last situation, the use of gas lamps (a dampening mechanism embedded in the navigation functions) might be insufficient to prevent damage in the hull. It may create serious seepage, damaging the hull to an extent it is not possible to repair, given fishermen's current expertise, as well as, the repairing tools and materials currently at their disposal on board. If there is no means to communicate with land or other vessels then, the situation can become even more dangerous to the fishermen.

Another instantiation occurs when imprecise information on sea conditions is inputted into the sensemaking function – an instantiation of FRAM sensemaking functions shown in Figs. 5 and 6 – leading fishermen to launch an expedition, or continue navigation in rough sea conditions. In such cases, fishermen's control over the water level at the raft's inner compartment (a dampening mechanism for the function "place nets, wait and haul them up") can become too challenging and fail. As too much water enters, in case the raft comes to capsize, righting it could prove to be an arduous task. All these FRAM instantiations and details on things to do ensure an adequate outcome in each instantiations were discussed and reflected during the workshops on safety-related expertise.

In summary, the artisanal fishing with rafts' work system seems to clearly display that safety should not be perceived by the records of its absence (number of accidents). Instead, this study has shown that safety measures to be applied should be developed according a Safety-II perspective (Hollnagel, 2014) focused in dampening potential output variability without hampering the system's adaptive behavior capabilities (Morel et al, 2008), because such fishermen's adaptive capacities are the source of the system safety and resilience. These findings are according to the previous recommendations coming from ergonomic field studies (Jaeschke, 2010; Jaeschke and Saldanha, 2012), and the Diegues' (2002) description of fishermen activity.

Table 3 summarizes the practical, useful and applied safety measures that guided the projects and actions underway at Ponta Negra community, answering the last research question, on how safety can actually be improved considering the artisanal fishing environment. As a result of being formulated in a participatory way within action research iterative process, the safety measures are able to offer direct support to dampening mechanisms at specific functions from those modelled through FRAM for capture expeditions, depending on how instantiations of the general model unfold. This can be exemplified in the cases of the aforementioned two instantiations, which account for resonance between output variability in poor sensemaking and downstream functions.

For instance, regarding the instantiation on navigating in rough sea conditions, the "fish handling" and "aspects and recommendations aimed at improving management" aim at reducing the occurrence of sacrifice dilemmas due to subsistence needs, thus unbiasing the individual sensemaking, and reducing its potential variability. In addition, the "lightning" project – new lamps charged by electric batteries instead of the old and dangerous gas lamps – increases the illumination capabilities of the raft, affording a better surveillance and the identification of large objects in collision route. The projects "maintenance of the vessel" and "workshops on safe-related expertise" includes ways to reflect and share strategies to respond and make sense on possible incidents during routine navigation, a definition of a spare parts and tools that can support fishermen in case of repairs during navigation, and many other safety-related issues.

Regarding the second example mentioned, the projects, "navigation technology" and "search and rescue" – a collaborative communication system based on cellphones, in which the community can assess situations where rafts are adrift – can improve communication among fishermen to foster more precise information on sea conditions, affording more possibilities to combine sensemaking modes. Additionally, control of the water level in the inner compartment might be supported by modifications in raft design ("new raft" project). Finally, if the raft overturns, changes in its design can also ease the righting process, while the workshops held can improve expertise of novice fishermen concerning this process while still using the actual rafts.

6. Conclusions

This research, carried out according to the Safety-II perspective, aimed to enhance as much as possible ways in which "the things can go right" at various levels of the artisanal fishing system. FRAM shows that the variability in sensemaking functions is due to the inherent task domain characteristics: dynamic, sometimes difficult to predict decisions influenced by behavioral issues and many different clues. The analysis highlighted that the sensemaking variability is needed to provide a repertoire of adaptive behaviors to create system resilience. However, even being "an activity difficult to learn" as already cited by a fisherman, there are some task characteristics that favor the expertise acquisition, such as the possibility of inadequate decisions (errors) corrections and tolerance on decision errors, the availability of outcome feedbacks, repetitive tasks, understanding and solving problems on-the-fly (small maintenance on the raft). The detailed analysis of fishermen activities showed that captains have rich repertoires of patterns on coping with weather and sea conditions as well as sophisticated mental models on how the raft is functioning and maintaining. Therefore, they are able to make fine discriminations to support safety decisions, and have the resilience to adapt to dangerous situations, such as the relatively common situations of overturned rafts. However, the safe-related decisions – to abort or to go back – are not based only on the external clues or environmental conditions. As shown in the FRAM diagrams, there is a constant trade-off between the need to fish to survive and the actual safe conditions to do so.

Since its very beginning, the art of navigating and fishing has relied on cultural and traditional aspects, being passed on through the years from fishermen to apprentices, and from one generation to another. Along with navigating and fishing techniques, fishermen have learned how to identify hazards, how to deal with risky situations, and how to react in case of incidents and accidents. In short, safety in artisanal fishing has always been a condition based mainly on the expertise of fishermen. Such expertise feeds and is fed by a continuous learning process portrayed by practical work. Therefore, it does not look like a good strategy to improve safety in such work activities by adopting safety management systems to change the way people do things. Conversely, it seems to be a good strategy to adopt Safety-II as an effective approach to really improve the work-safety in artisanal workers communities.

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