Modifying the Drifting Fish Aggregating Devices to Mitigate Sea Turtle Mortality: A SEAFDEC Initiative

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This article is based on the Preliminary Report on the Study of Ghost Fishing Phenomena by Drifting Fish Aggregating Devices (DFADs) in the Eastern Indian Ocean, which aimed to assess the accidental mortalities of marine animals around the Drifting FADs in the Eastern Indian Ocean. The study was conducted from December 2002 to January 2003 during the shipboard purse seining cruise of the M.V. SEAFDEC, where data on the accidental catches of marine mammals and other marine fishes were collected from drifting and abandoned FADs. Results of the study indicated that marine turtles comprised the highest number of incidental catch from the drifting FADs followed by marine fishes such as leather jackets, triple tails, rainbow runners, sea chubs, wahoo, skipjack, barracuda, and remora as well as sharks and porpoises.

Tuna resource is one of the most important marine resources in the world. In 2006, FAO recorded about 6.5 million mt of tunas, bonitos and billfishes produced around the world. Purse seine is the major fishing gear used for catching tunas in the countries' EEZs as well as in the high seas, where tuna purse seine fishers apply various techniques to maximize their catches. These include fishing the free swimming tunas when tuna schools are feeding near the sea surface; fishing tunas in association with porpoises but this has been abandoned to protect the dolphin population; and using drifting objects such as drifting flotsams, drifting logs, drifting garbage, and the like, that could aggregate the target fish species.

Although considered a difficult operation, fishing the free swimming tunas does not produce any unwanted or incidental catch. In the case of fishing with porpoises, the Inter-American Tropical Tuna Commission (IATTC) has imposed a sanction against the importation by the US of tunas caught with porpoises. The only option left for the tuna industry is the use of fish aggregating devices (FADs)[1] to attract schools of tunas and maximize tuna catch. FADs may be drifting (DFADs) or anchored (AFADs), which was originally known in the Philippines as *payaos*.

Issues and Concerns

The Eastern Indian Ocean covers the fishing area from Chagos Archipelago in the Maldives to Western Sumatra in Indonesia (**Fig. 1**). In the world's tuna fisheries, the Eastern Indian Ocean is considered less significant than the Western Indian Ocean. While the latter accounts for about 18% of the world's total tuna production, the former contributes only about 7%. However, the Eastern Indian Ocean (Area 57) encompasses an important fishery resource for exploitation by some Southeast Asian countries such as Thailand, Myanmar and Indonesia.

During the last decade, most tuna purse seiners operating in Area 57 were mainly tuna research vessels including those from Thailand and Japan. Drifting Fish Aggregating Devices (DFADs) and *payaos* have become the most important tools for gathering tuna schools in Area 57 because free-living tuna schools are rarely sighted in this part of the Indian Ocean.

Most research vessels operating in Area 57 therefore make use of the DFADs and *payaos* for their tuna purse seine fishing trials. During such fishing trials however, juveniles of yellowfin tuna were also observed to aggregate near the

Fig. 1. Eastern Indian Ocean indicated as FAO Fishing Area 57

[1] FAO defines fish aggregating devices (FADs) as artificial or natural floating objects placed on the ocean surface, often anchored to the bottom, to attract several schooling fish species underneath, thus increasing their "catchability".

payaos and were eventually caught in the fishing operations, making the use of *payaos* a non-selective technique.

Once abandoned or lost, the DFADs and *payaos* in the ocean surface could enhance ghost-fishing[2] together with lost or abandoned fishing gears. Reports have indicated that the most common fishing gear known to ghost fish are the gill nets and crustacean/fish pots. Other fishing gears and their parts (such as trawls, seines and long-lines) abandoned or lost in the sea, could also get involved in ghost-fishing adding to the environmental problems in the oceans. Abandoned purse seine can also become a ghost gear while the *payaos* used in tuna fishing operations can also facilitate ghost fishing due to the nature of their design and construction.

DFADs Used by SEAFDEC

One of the main functions of SEAFDEC is to develop responsible fishing technologies and practices for the sustainable use of the marine fishery resources in Southeast Asia, which include the development of responsible tuna and skipjack fisheries. Since 1993, the SEAFDEC Training Department (TD) has been conducting tuna purse seine fishing operations in the Eastern Indian Ocean specifically in the waters adjacent to the fishing grounds of Thailand (**Fig. 2**) using the M.V. SEAFDEC (**Fig. 3**). Recognizing the fact that schools of free swimming tunas are rarely found in the Eastern Indian Ocean, SEAFDEC also makes use of aggregating techniques by deploying FADs to attract the schools of tunas.

From the point of view of the tuna fishing industry, the use of fish aggregating devices (FADs) is necessary to achieve maximum tuna catch. Although the use of FADs is mainly aimed at enhancing the aggregating performance, the rationale behind the development of the FADs is anchored in two major concepts. In the first concept, some sessile organisms such as barnacles could attach to some parts of the FADs, where primary consumer fishes gather around resulting in the establishment of pelagic habitats that serve as source of food for the tunas. Secondly, the enmeshed and entangled small preys at the net part of the FADs serve as baits for other predator fishes that swim around the FADs. Although the latter concept could also enhance the development of pelagic habitats, accidental deaths of unwanted fishes could occur. Nonetheless, non-intentional or unwanted catches are mostly realized from ghost fishing by the abandoned FADs, considering the many reports which indicated that about 10-20% of FADs are lost every year in the open sea.

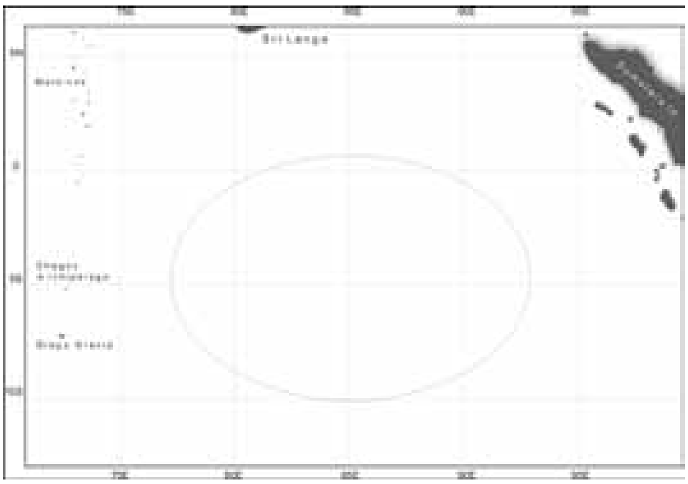

Fig. 2. Fishing area in Eastern Indian Ocean where SEAFDEC/TD conducted tuna purse seine operations from December 2002 to January 2003

Fig. 3. The M.V. SEAFDEC (tuna purse seine research/training vessel) used by SEAFDEC/TD to conduct tuna purse seine operations in the Eastern Indian Ocean

During the tuna purse seine fishing operations of SEAFDEC/TD, FADs were used to attract the schools of fish. Trials on the appropriate types of FADs were carried out, namely: the anchored fish aggregating device (AFAD) and drifting fish aggregating device (DFAD). In terms of accessibility, the DFAD was more advantageous than the AFAD because the distance of the fishing ground (300 nautical miles from port of Phuket in Thailand) makes maintenance and monitoring of the AFAD inconvenient. Furthermore, the anchor line of the AFAD could be cut or lost during storms and strong water current. Thus, SEAFDEC/TD opted to use the DFAD for gathering schools of tuna and skipjack in the deep and vast Eastern Indian Ocean.

The DFAD used by SEAFDEC was patterned after the original design for the Japanese purse seine vessel, the R.V. Nippon Maru during its tuna fishing and research operations in the same fishing ground. From such original DFAD design, two types of DFADs were designed by

[2] Ghost-fishing refers to the ability of fishing gear to continue fishing even after all control of the gear has already been abandoned or lost by the fishermen.

SEAFDEC/TD such as the raft type and curtain type, which have the same purpose of maximizing the aggregation of large schools of tuna and skipjack.

The raft type is square shaped, 2.4x2.7 m (**Fig. 4**). The square frames of the raft as well as the supporting bar of the frames are made of iron pipes. Bamboo poles are tied together with the frame of the raft, and purse seine floats are fixed at each corner to support buoyancy. Covered by a sheet of nylon net or polyethylene, this DFAD design is durable and convenient to be carried on board the vessel and can be redeployed many times during the fishing period from 8 to 10 months.

The second type of DFAD is the curtain type, also using bamboo poles tied together (**Fig. 5**). Supported by purse seine floats for buoyancy, the floating part is also covered by sheets of nylon net as in the raft type. Although this design could be more fragile than the raft type, its construction is easier and more convenient particularly when done onboard fishing vessels with limited working space.

Both types of DFADs are fixed with purse seine net panels, also known as "skirts" and tightened below the floating part. The skirt panel is made from recycled purse seine net sheets or trawl nets. The lower edge of the skirt net is tightened with weights, *e.g.* chain, concrete or old steel wires. Four skirt net panels are set under the raft type of the DFAD where each side is attached with a sheet. For the curtain type, only the skirt net panel is installed. Radio buoys or GPS positioning buoys are attached with all DFADs to monitor their direction and to determine their positions during retrieval after drifting in the ocean for at least one month.

In the case of the SEAFDEC DFADs, after having been positioned in the Eastern Indian Ocean for one month, monitoring was conducted to determine and record the data of the species caught including the composition, length, weight and number of accidental catch, and also to determine the relative proportion between the accidental and the target catch by the DFADs.

Modification of DFADs by SEAFDEC

During the SEAFDEC tuna purse seine trial operations, it was observed that not only tunas aggregate near the DFADs but other marine animals as well, such as several species of marine turtles (mostly the Hawksbill and Ridley's turtles) and unwanted fishes that were accidentally killed when they become entangled in the skirts of the DFADs. Thus, it was necessary to modify the designs of the DFADs used by SEAFDEC in line with its efforts to conserve the marine turtles in the Southeast Asian region.

For the fishing season in 2002-2003, SEAFDEC improved the aggregating efficiency of its DFADs by modifying the accessories and skirt parts, replacing the net skirt sheets with Spanish mackerel gillnet materials that were no longer used. Such modification was aimed at enmeshing the small fishes around the DFADs, which could serve as forage of

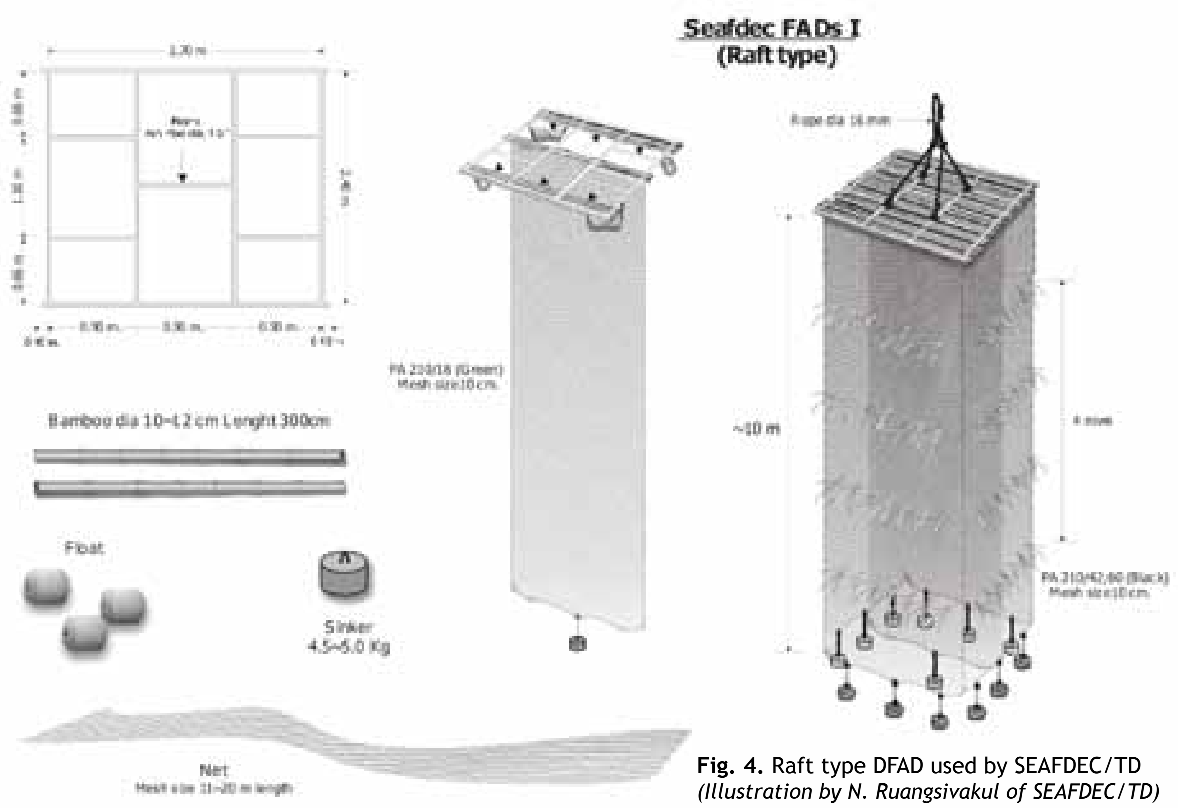

Fig. 4. Raft type DFAD used by SEAFDEC/TD *(Illustration by N. Ruangsivakul of SEAFDEC/TD)*

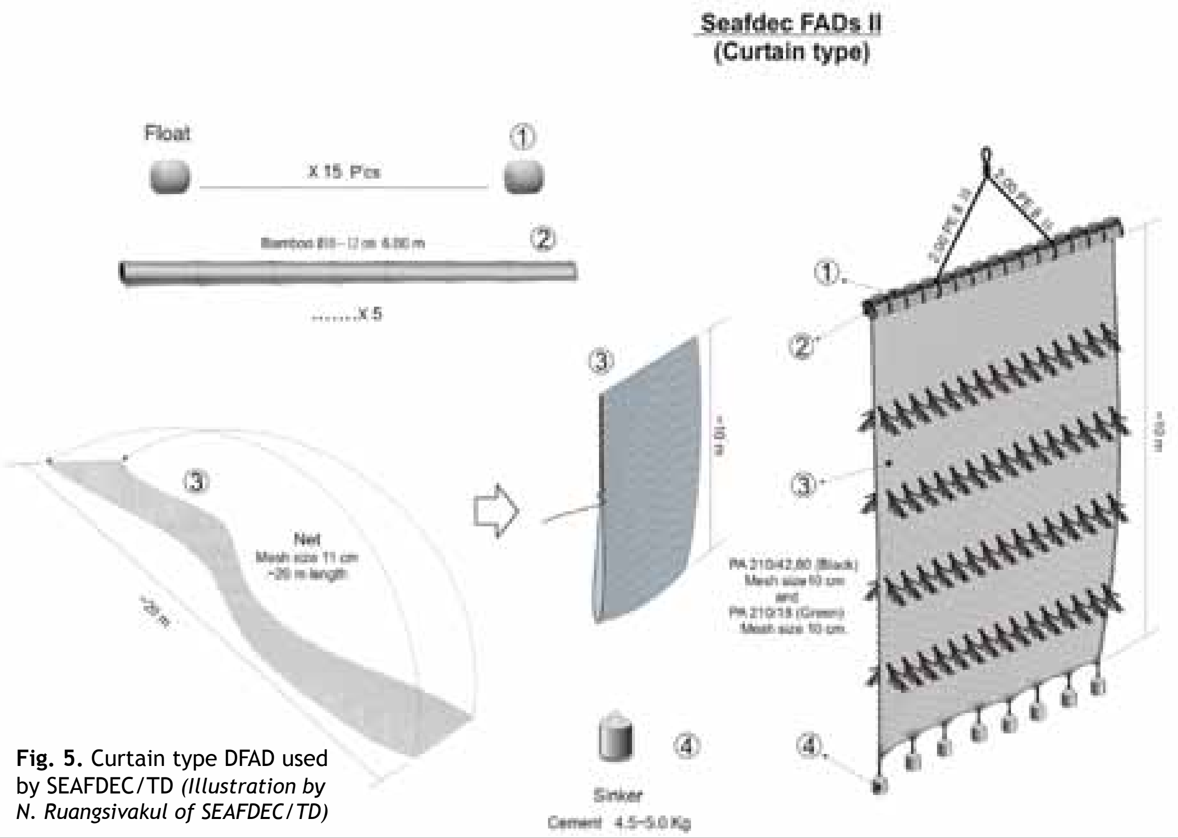

Fig. 5. Curtain type DFAD used by SEAFDEC/TD *(Illustration by N. Ruangsivakul of SEAFDEC/TD)*

other small fishes as well as enhance the aggregation of more small fishes around the DFADs and finally attracting more tunas and skipjacks to feed on the small fishes.

The modified SEAFDEC DFADs were deployed in the East Indian Ocean in December 2002 and after one month only 17 DFADs could be located and checked for fish schools while the other five (5) DFADs were lost in the ocean. The 17 SEAFDEC DFADs and another three (3) unidentified abandoned DFADs were detected visually and also by using hydro-acoustics equipment. The purse seine fishing operations conducted near the 11 SEAFDEC DFADs yielded a total catch of 54.4 tons of tuna and skipjack without any sea turtle incidental catch. In the area surrounding one SEAFDEC DFAD, the total catch of tuna and skipjack was 19.0 tons with the leather jackets as the only incidental catch. However, during the fishing trials, 11 sea turtles were sighted to have been entangled in abandoned DFAD nets and drifting garbage near the SEAFDEC DFADs.

During the whole fishing trials conducted by SEAFDEC, it was observed that 30 sea turtles were incidentally entangled by the three (3) SEAFDEC DFADs and three (3) unidentified abandoned DFADs. The 30 marine turtles comprised two main species, namely: Hawksbill (16), Ridley's turtles (5), and another 9 sea turtles which could not be identified for these were already in advance state of decomposition. The live sea turtles were immediately released into the sea after extricating them from the nets and other objects. As for the SEAFDEC DFADs, 11 marine turtles (2 Ridley's turtles and 9 Hawksbill) were incidentally entangled with the drifting garbage, of which five (1 Ridley's turtles and 4 Hawksbill) died before these could be released to the sea.

A worst incident occurred when a number of sea turtles were found entangled in three (3) unidentified abandoned DFADs that drifted with garbage in the ocean at Latitude 02º27´N to 02º29´N and Longitude 087º16´ E to 087º18´E. Seventeen sea turtles were entangled in the skirt nets of the abandoned DFADs, 14 of which were still alive but the other 3 were already dead. Since the live turtles seemed to be exhausted the crew of the M.V. SEAFDEC released them immediately without identifying the species. There were still at least 6 sea turtles that the SEAFDEC researchers could not disengage from the drifting garbage because the garbage was too heavy to be hauled up onboard the M.V. SEAFDEC.

Based on the experience of the SEAFDEC researchers during the M.V.SEAFDEC purse seine fishing trials in the Eastern Indian Ocean, mortality of sea turtles occurred in mainly two (2) processes. Firstly, mortality could occur during tuna purse seine operations when sea turtles stay around the DFADs and get entangled in the net parts. In some cases, sea turtles could survive for long period during the net hauling because the net circle is widely spaced. When the net is hauled up to the vessel and upon reaching the bunt part where the net circle is narrower, the entangled sea turtles could be rescued by carefully and manually extricating them and immediately releasing them back to the sea. However, injuries could still happen when their flippers get entangled with the net twine during net hauling.

Secondly, mortality could also result when some body parts of the sea turtles, *e.g.* head, flipper or shell get entangled in the net skirt of the DFADs. Thus, modifications were made by SEAFDEC for its DFADs in order to minimize if not avoid mortalities of sea turtles during the tuna purse seine operations. As experienced by SEAFDEC researchers (A. Munprasit in 1992 and I. Chanrachkij in 2001) onboard the Japanese research vessel, the R.V. Nippon Maru during its fishing operations around their DFADs, no sea turtles were incidentally caught. The DFADs used by the R.V. Nippon Maru were also the raft type (3x3 meters, square shape, little bit bigger than the SEAFDEC design) with the net skirt made from nylon with bigger sized twine but seemed more rigid than the SEAFDEC design.

In order to reduce the mortality risks of sea turtles from tuna purse seine operations using DFADs, selecting the most appropriate rigid net material for the net skirt of DFADs should therefore be one of the major concerns. In addition to using big size twines of nylon material, Polyethylene (PE) twines could also be used for assembling the net skirt of DFADs. However, PE net twine could be less efficient in aggregating the bait fishes than with the nylon material because it would be difficult for the sessile organisms, *e.g.* barnacles to attach themselves on the net twine. Lately, the use of all materials for constructing drifting gillnets have been prohibited in putting together the AFADs or DFADs, consistent with the recommendation of the Indian Ocean Tuna Commission (IOTC), which indicated that tuna netting materials used to cover the DFADs should be replaced by other more functional and efficient materials. As a result, many tuna fishing operations no longer experience the presence of incidentally caught sea turtles in their DFADs (Delgado de Molina *et al*., 2005).

Another important cause of the mortality of sea turtles had been observed from lost and abandoned DFADs. Although most DFADs are installed with radio buoy or GPS buoy, the buoys could become non-functional at sea due to broken antenna or the position of the DFADs could be beyond the effective range of radio signals or the buoys could have been destroyed or sunk. The lost DFADs could drift with the oceanic current and finally settle in the ocean's garbage zones.

Since schools of bait fishes that also congregate in the garbage zones could also serve as food for sea turtles, it is not surprising that many sea turtles could be found in the garbage zones. There is therefore very high possibility of sea turtles being entangled with the floating and flexible materials in the garbage zones such as old net sheets, twines, filaments, and the like. Considering that lost and abandoned DFADs could increase the amount of entangling materials in the ocean particularly in the garbage zones, the use of locating techniques such as efficient electronic equipments as well as the design and construction of the DFADs should be improved. Moreover, in designing the DFADs, focus should be made on the concept of durability in rough sea conditions and with efficient buoyancy.

Unidentified abandoned DFAD with dead sea turtle and shark caught in a curtain-type DFAD

Control and Limitation on the Use of DFADs

The use of DFADs in tuna purse seine operations is very widespread in the vast oceans and high sea fishing grounds of the world. Considering the present crisis in tuna fisheries, *i.e.* high fuel cost and low price of tuna, the ultimate goal of the purse seine operators would be to catch as much as possible a full vessel load of tunas within a short period of time. Thus, the use of DFADs has been considered a very important technique in order for them to survive in the midst of the rough tuna purse seine industry. Even the very skillful and extremely talented European Union (EU) purse seiners adopt the DFADs technique as a primary fishing strategy in surrounding the free swimming tunas (Itano *et al*., 2004). Undoubtedly, any attempt to prohibit or control on the use of DFADs during tuna purse seine operations in the high seas would never succeed.

Nonetheless, the increasing numbers of DFADs used could also lead to increased number of lost or abandoned DFADs in the vast oceans. Consequently, indirect mortality of sea turtles could also possibly increase. It is therefore critical that lost or abandoned DFADs should be minimized or avoided by utilizing modern techniques such as high efficiency radio/GPS buoys and much durable construction materials for the parts of the DFADs. Moreover, the use of biodegradable materials such as coconut or palm leaves could be re-introduced for the construction of DFADs. Research on the design of non-net materials for the DFADs should therefore be carried out.

Furthermore, the information on the number of deployed and lost DFADs by tuna purse seiners should be collected by coastal states and regional fisheries management organizations (RFMOs). The number of deployed DFADs in all fishing grounds of the world could be used to roughly estimate and access the rate of sea turtle mortalities in the oceans. Campaigns for retrieving abandoned or lost DFADs in the sea particularly in the garbage zones should also be promoted.

Full of confidence, many fishing technologists including SEAFDEC researchers agree that mitigating the mortality of sea turtles by the DFADs, had considerably progressed from the viewpoint of enhanced fishing technology as well as from the fisheries management aspect. However, another concern being put forward by SEAFDEC based on observations during its purse seine fishing trials, is the catching of juvenile tunas by the DFADs. SEAFDEC therefore is encouraging the coastal states and RFMOs to develop technical strategies that could eliminate the catching of juvenile tunas by the DFADs that are being used by large-scale tuna purse seiners as well as to establish the appropriate policies to this effect. Continued adoption of one of the accepted techniques for filtering adult skipjacks which is associated with the presence of juvenile tunas around the DFADs, could lead to an acute diminishing tuna population in the future.

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