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Paper - 24

SCHOOLING BEHAVIOUR OF TUNAS IN LAKSHADWEEP WATERS

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ABSTRACT

The paper describes nine kinds of schooling patterns of the Skipjack tuna *(Katsuwonus pelamis)* and the yellowtin tuna (*Thunnus albacares*) in the Pole and line (live bait) fishing grounds, as identified by the fishermen of Lakshadweep, particularly of Minicoy. These are described here as schooling patterns I to IX after giving their local names and some clue to their identification from fishing boats. The surface or subsurface nature of occurrence of the school, its leaping, feeding and swimming activity, baiting habit, vulnerability to the gear, size of the school, approximate size and species composition of the school, and the association of the school with water discolouration, flotsam, sea-birds, predators etc are described. The paper also describes four different approaches of the tuna pole and line (live bait) boat to the different kinds of tuna schools.

INTRODUCTION

Scientific investigations on the schooling pattern of tunas would enhance catchability of different types of tuna schools. In Lakshadweep (Latitude 8°N and 13°N and Longitude 71°E and 73°E), the Skipjack tuna, *Katsuwonus pelamis* and the yellowfin tuna, *Thunnus albacares* form about 90% and 6% of the catch taken by the tuna pole and line (TPL) with live bait which forms the principal gear operated. Others like the little tunny *(Euthynnus affinis)*, frigate tuna (*Auxis thazard*), dogtooth tuna (*Gymnosards unicolor)*, black shark *(Eulamia* *melanoptera)*, rainbow runner *(Elagates bipinnulatus)* and the dolphin fish (*Coryphaena hippiurus*) form the rest of the TPL catch. Silas and Pillai (1982) observe the existence of two kinds of tuna schools, *viz.*, the 'breezing' and 'boiling' schools from the experimental purse seining grounds in the Laccadive sea. Madan Mohan (1985) observes the existence, ecology, catch pattern and behaviour of tuna schools associated with flotsam in the Minicoy waters, based on his observations on the landings of tuna during the 1982-83 season.

In the Japanese waters, Van Campen (1952) describes 15 different kinds of schools of tuna based on earlier works. Eighteen types of tuna schools have been recognised by the Californian tuna fleet (Scott 1969). A comparative work of the above kinds to serve as a basis for further investigations on the schooling behaviour of tunas in Lakshadweep and a practical guide to local TPL (live bait) fishermen is lacking in literature. Therefore, the various kinds of tuna schools commonly being recognized by the local fisherman experts in Lakshadweep, are described for the first time. with special reference to the Skipjack and yellowfin tunas of Minicoy TPL (live bait) fishery. Four different kinds of approach of the TPL (live bait) boat to the identified tuna schools also are described in this paper. The present work is based on enquiry with local fishermen experts and on practical observations from commercial TPL (live bait) boats. Details of study area, material and method and description of the TPL (live bait) boat, the gear and its technique of operation are given already in Livingston (MS).

SCHOOLING PATTERNS OF TUNA

A tuna school is locally called *mas auiin* in the local *Mahal* dialect in Mincoy and *Choora kottam* in Malayalam in the other Islands. As soon as it is detected, its schooling pattern is identified by the chief fisherman before he gives necessary instructions to the rest of the crew onboard regarding appropriate action to be taken to catch the school. Nine major patterns of schooling of tuna are locally identified, based mainly on their behaviour like swiming activity, feeding frenzy, biting of hooks, leaping and association with sea-birds and live bait packs naturally accuring in the sea.These schooling patterns are described below briefly, giving the local name in *Mahal* in Parantheses.

Pattern I (Madu):- This kind of school consists of a dense surface pack of tuna of almost equal size. Fish are orderly arranged in several layers of vertical thickness· Two to three vertical layers of tuna are clearly visible under water to naked eye observation from the boat. This school moves very close to surface and hence its local name, *madu*. Individual fish of the upper most layer produces a characteristic track of tiny uniform waves, each about 5 to 7 cm high, at sea surface by the flipping action of the first dorsal fin. The characteristic whitish streak present in the erect first dorsal fin of *Katsuwonus pelamis*, becomes clearly visible when the fin is in its flipping action at the air-water interphase. The waves formed by the innumerable individuals of the school at the sea surface, give the sea along the track of the school, a characteristic rippling appearance and a black discolouration detectable from about 0.5 to 1 km distance.

The pattern described above may be considered as the typical one. Due to the diagnostic behaviour of the school in exposing the first dorsal fin, this kind of school is locally distinguished from other variations of this kind as *Kothari kolla*. In a second variation of this pattern locally distinguished as *rhy kolla*, the individual tuna shows a characteristic pinkish tint superimposed especially upon the steel-blue dorsal regions of the body. A third variation is locally distinguished as *hudhu kolla*, in which individual tunas in the school, intermittently and gently turn their left and right sides of abdomen upwards, and downwards in a rhythmic manner while swimming forward gently. No live bait pack or dense bird flock is found associated with this flipping school. Stray number of sea-birds may be found flying over the school at a level of about 2 to 3 m, high from sea surface, on certain occasions. Typically it is a slowmoving school of tuna with moderate to good appetite for supplied live bait and with good fisheries prospects. The second variation of this kind mentioned above, shows the best response to chumming and gives the best catches. It is found near or away from island. Eventhough it occurs throughout the tuna season from middle of August to middle of May, it is more frequently encountered during the beginning quarter of the tuna season, when the sea is less clam, cold and turbid. Proper access to the school by the boat and chumming with live baits are obligatory for catching this school. At times, schools take an enormous size, capable of supporting the entire daily catch of even five to ten boats at a time. from the same area.

Pattern II (Uma Kolla):- This may be considered as the *rippling school*. It is a surface pattern in which the top most layer of tuna swims at about 0.5 m below sea surface. To closer naked eye observation, the rippling school appears as a compact pack of equal sized tunas of several vertical layers thickness. The track of this school is characterised by gentle rippling of the sea surface produced by the school which often superficially resembles the rippling caused by gentle breeze on sea surface. From a distance, the sea surface over the track of the school appears as a clam area when compared to the surroundings. This makes it easier to detect and identify the track of this school, especially when the sea is a little choppy. Leapings of individual tuna in the school is rarely met with. It is a slow-moving school, major part of which remains at subsurface depths invisible to naked eye. Tunas rise to surface only when chumming with live bait starts. Therefore, chumming with live bait is a must to catch this school. No natural live-bait pack or dense sea-bird flock is found associated with this chool which is moving constantly towards any one direction in good appetite. It is frequently encountered near the Island. It ensures a good fisheries prospects especially during the postmonsoon months.

Pattern III (Bandedhu furung). The sea surface along the track of the school gives a sandy whitish discolouration detectable as a patch of whitish area from a distance of about 0.5 km. It is a slow-moving sub-surface school, often occurring below visible depth levels. However, the school as a whole, appears as a submerged whitish object As the school rises upto visible levels under water, individual fish are found to swim with their ventral side turned upwards and hence its local name. The school is a unispecific seggregation of oceanic skipjack; the individual fish are uniformly large in size, in advanced stage of maturity, and in good condition (fatty appearance). No natural live-bait pack or sea-bird flock is found associated with this tuna school. This tuna school shows relatively poor appetite and hence poor response to chumming with live-bait. The fishery prospects are less predictable. Sometimes, some individual fish at any one part of the school come to their erect and normal swimming posture when live bait is supplied and this results in a good tuna fishery. At other times, the school does not come to normal swimming posture and it does not rise to surface to bite the hooks even after it is chummed with lavish quantitites of live bait, or distrubed with trolling lines with baited or lured hooks. Commonly found in the more oceanic realm, this schooling pattern is frequent in occurrence towards the end of the tuna season from April onwards when the surface water becomes warmer.

Pattern IV (Emmus hummelafi). This schooling pattern is characterised by very sparse and highly infrequent or stray number of leaping of tunas in ones and twos and hence its local name. The skipjack tuna and the bigeye tuna, living at invisible depths, leaps at surface once in half an hour to one or two hours' interval, from widely scattered points in the sea surface. The approximate size or direction of movement of the school is not detectable with any amount of accuracy. Sea-birds proper are absent in the tuna grounds, except isolated individuals of the relatively near-shore sea-bird, *Sterna bengalensis* straying solitarily in the vicinities. Tuna schools, are found mostly in the near-slope waters around the Island where predators like the wahoo and sail fish abound. Tunas rising to surface do not stay long at surface to support a good fishery due to fear of the above mentioned predators. Such a frightened tuna school is the only one commonly available for fishing during middle of August to middle of October, in which season the near-shore tuna waters remaining turbid and cold are usually exploited. Response to the chum though good, biting of hook being rather poor, the trolling line is also used to take a mixed fishery consisting of a few tunas and their predatory games.

Pattern V (Hummelafi). When compared to the previous case of subsurface school, in this schooling pattern, leaping of individual tuna in gangs of a few numbers can be sighted, more frequently, here and there in the vast fishing ground which in this case is situated relatively more seaward. Oceanic species of sea-birds like *Anos stolidus, Sterna anaethetus* and *S. hirundo* are found in patchy hovering flight, somewhat above sea surface and they aggregate at random into small flocks diving to points of sea surface where the leapings of tuna abound. Yellowfin tuna as well as Big eye tuna of 8 to 10 kg individual weight which are too heavy for the pole and line gear to lift, abounds in the school. Occasionally, enoromously large schools of these species with fish of 30 to 60kg individual weight, show leaping amuck and at random over a vast area of sea surface studding it with innumerable whitish splashes. Biting of the chum and biting of hooks, in general are poor; however a moderate fishery may be obtained on certain days from waters nearer the insular slope during dusk hours in which biting of the chum and biting of hooks are better. Several boats return to port with nil or very poor catches. This is the most commonly found schooling pattern during spells of moderate and poor tuna catch, intervening spells of good catch, within the fair tuna season from middle of August to middle of May.

Pattern VI (Adige or *Adi bodu)* This pattern of schooling is found at subsurface depths around 2m from where individual skipjack tuna of about 40-50 cm total length appears to naked eye observation from onboard, as tiny tots of moving objects just 10 to 15 cm long. Flocks of sea-birds in soaring flight at higher levels in the sky are found associated with this kind of tuna school. The bird flock dives to sea surface whenever the tuna school rises to surface in search of prey. Only when the tuna boat plies over the track of the tuna school, fish of the main school moving at subsurface depths become visible to naked eye. Leaping of only stray number of tunas is found. No natural live-bait pack is found at the sea surface. It is a slow moving school tending to rise to nearer surface when chumming starts. A good fishery is possible only for about 10 to 15 minutes on any single school of this pattern, the appetite and feeding frenzy of tuna and the biting rate reducing afterwards. Therefore, a good fishery prospect is only a matter of chance. This kind of school also occurs throughout the tuna season at different spells with poor to moderate tuna catch.

In a variation of this schooling pattern which is locally distinguished as *dhuvva mas auin*, the tuna school at the subsurface depth level of about 1 m, are found progressing at high speed. The school is often quite extensive. No fish leaps over water. Only by a lavish supply of live bait in chumming operations, this tuna school can be made to follow the tuna boat, in a sustained manner. Good fishery prospects are uncertain. This pattern of schooling is met with from March onwards, during spells of uncertain tuna catch in which the local seasonal drifts become weak.

Pattern VII (*Badithala*). It is a pattering school in feeding activity. Tunas in innumerable numbers are distributed rather in a loose manner over a vast area of the sea in which are distributed ball-like aggregations of natural live-baits packs, here and there to get scattered as prey for tuna. Tuna swim between neighbouring live-bait packs in haste to form small aggregations. Scores of leapings of individual tunas and the resultant whitish water splashes, can be found within a short while, from any direction in the schooling area. Sea-birds are also found hovering in more abundance here than in any other pattern of schooling and they are actively diving frequently at closer points while flying from one to another live-bait pack, Birds produce a chracteristic chirping noise and they do not rise above a height of a few meters from the sea surface. A noice similar to that of falling rain drops, is characteristic in the area. There being plenty of natural prey at the sea surface itself, response of tuna to chumming with live bait from onboard is rather poor. The biting of hooks and fishery prospects are moderate. This schooling pattern is observed especially in the beginning of the tuna season proper, ie around mid-November, when the sea becomes very calm, warm and clear and enormous quantities of drifting natural live-bait packs become available in the oceanic tuna grounds.

The only interesting variation of this pattern is described below. The feeding activity is maximum around each naturally occurring live-bait pack when the aggregation of tuna around the pack becomes large. The black shark, (with its mouth wide open for prey in certain schools) is commonly found circumventing the live-bait pack, along with the skipjack tuna and the yellowfin tuna which bounce upon the scattered live baits very vigorously. Other predatory species such as the rainbow runner, little tunny, freigate tuna and dolphin-fish, are also present in the feeding assemblage. Tuna of small and medium size groups mix in this feeding ground. The predators, in general do not dare to swim over the individual live-bait pack; but they swim around it, waiting for a chance to feed upon any few small fish which may get scattered away from the main pack. The sea birds with a characteristic chirp, dive vigorously and very frequently around the live-bait pack, forming cluster-like densest feeding aggregation around each individual pack. Bird-flocks in the air overcast the area considerably. No chumming proper with live bait is required to catch tuna of this schooling pattern. The school is very slow moving as the live-bait packs are to be carried away only by the water drift which is often slow during this season. Tuna exhibit good appetite and take hooks vigorously giving a good fishery only if there is no disturbance from larger predators which may abound in more number around some live-bait packs. This actively feeding and slow moving tuna school of relatively large aggregations is distinguished from the typical hastly main school of confused small aggregations scattered over a large area as *happa mass auiin* by local fishermen.

Sailfish and marlin are the common predators which are chasing tunas of this actively feeding school, The speedier plight of the tuna school is a sure indication of these predators chasing the tuna school. Tunas often come very closer to the stern and quarters of the boat to hide and these predators furiously dash their beak against the hull of the boat at times. Ocassionally, tunas approaching the rudder blades get cut into pieces and float at the wake of the boat. Stray leaping of individual tuna to heights of a few meters in air is found when the tuna school gets frightened by the above mentioned predators. The shadow of the leaping fish is followed underwater by the predator which catch the prey. Individual tuna being pierced, lifted up and tossed in air at the tip of the beak by the sail fish also is found at times. Tuna when scared by the predator swim hastily to escape. Biting of hooks becomes poor due to the urge for escape from the predator. Such a scared tuna school takes a zig-zigr oute, swimming speedily, making it difficult for the boat to follow the school. The tuna school associated with the black shark in feeding on the natural live-bait pack are calm with no fear for the shark and with no fright in fishing them.

Dead specimens of large yellowfin tuna in stray numbers, have been taken in fresh or semi-spilt condition from the natural live bait packs in the sea by local fishermen at Minicoy. Such natural mortalities seem to be due to accidential swimming over of the predator on the compactly arranged live-bait pack which is often several scores of fish thick vertically.

Pattern VIII (*Ethikandu*). This is a tuna school associated with flotsam. In this pattern of schooling, generally, tunas of small size (0.5 to 1.0 kg) are found to form large aggregations around floating objects, such as logs and timber and a variety of other salvages like coconut-and other Palm leaves, pieces of rubber, plastic, synthetic nets etc. The submerged surface of the floating object, is found with colonies of *Lopas*. Polychate worms are also found in crevices of the timber. An assemblage of small fishes such as the young ones of rainbow runner, dolphin fish, the dotted leather jacket etc. are found associated with the floating object. These in turn are surrounded by a dense aggregation of different species of tunas and the black shark which appear to feed on these small fishes when the prey get scattered from the main aggregation. The entire assemblage is moving slowly along the drift together with the floating object. According to the position of the Sun, the entire assemblage of fishes including tunas, orients itself and concentrates towards the leeside of the floating object where its shadow falls. Tunas of the assemblage become sparsely distributed and spread loosely around the floating object when the individual fish move away for feeding. But whenever any disturbance or fear from enemies comes the entire assemblage once again becomes densely aggregated below the floating object. Tuna being found along the peripheral zone of the assemblage, individual fish appear rather lean and poor in condition, as if they are underfed due to over crowding. Among tunas, the Skipjack tuna and the yellowfin tuna predominate in the assemblage with little quantities of the other tunas. The skipjack tuna abound in some parts of the assemblage while the yellowfin tuna predominates in some other part of the same assemblage of fish, associated with the flotsam.

Sea-birds only in stray numbers may be found perching or hovering over the floating object. When present, Sea-birds are found to take a slow hovering flight from side to side within a limited areas and they may dive to Sea-surface perriodically. They are found at a very lower level closer to sea surface. Chumming with live-bait is often not necessary. A few leapings of tuna with whitish splashes of water may be present. The fishery prospects, in general are very promising; often each tuna school is so large and rich that it supports the catches of two to three boats full of tuna simultaneously. Unlike form any other schooling pattern, considerable numbers of the species of fish other than the oceanic skipjack and the yellowfin tuna, also are caught. Tunas are locally reported to from much large aggregations around the coast-going sailing crafts also. Such dense accumulations of tunas below the vessel is considered to be helpful in the navigation of the vessel by the contribution of the dense school in increasing the calmness of the waters around the vessel in plight.

A variation of this typical schooling pattern is distinguished locally as *oi valung.* In this the floating object is missing as a primary or secondary condition; fishermen themselves remove the floating objects such as logs of timber and coconut leaves etc towards the end of the day's fishing Timber obtained from this source is removed for industrial purpose also. The remainder school of tuna now devoid of any floating object to depend on, readily moves along the current boundaries where the flotsam existed. This school follows the boat itself, once the boat plies into the area. A handsome tuna fishery is expected from such a school of tuna which is easily identificable in frontal zone locally called *oi dhandi.* Presence of salvaged floating objects if any, behaviour of stray sea-birds and leaping tuna in the same manner as described above, help in detecting this school of tuna. Tuna taken from the school associated to flotsam are always lean in appearance, small in size and are eager to feed with almost empty stomachs. Therefore, experienced local fishermen are capable of detecting the presence of this school of tuna, even from a single fish taken by the trolling line which is used as a test line in places where the floating object is not visible primarily or it is removed by other fishermen already. This kind of tuna school is caught intermittently throughout the fair tuna season.

Patter IX (Bodu-mas mas auiin). This kind of school is associated with the black whale and hence its local name. The skipjack tuna is the species reported locally to follow the whale which appears to the observer as a black rock in the sea surface. This kind of school is not caught. As soon as the whale is sighted at a distance, the boat changes its course to avoid the whale-associated tuna school owing to fear of the local fishermen for the whale which according to them may cause the boat to capsize. This kind of tuna school is met with in the summer months off the west coast of Minicoy.

APPROACHING A TUNA SCHOOL BY THE BOAT

Correct approach of the boat to a tuna school is a must in successful TPL (live bait) fishing. Once a tuna school is scouted and the schooling pattern identified, the correct course of the boat in relation to the tuna school is achieved by correct approach tactics of maneuvering the boat. A wrong approach of the boat to any tuna school results in the abrupt disappearance or rapid scaring away of the tuna school. For a correct access with regard to a tuna school of any of the above described schooling patterns, the chief fisherman at the steers fixes the loading-or head end of the tuna school as his main target of observation throughout the period of fishing from that school. The direction and speed of plight of the boat are adjusted according to the speed and direction of movement of the head of the school only. For scouting the leading end of the school initially and then pursuing it up continuously, one or more of the surface observations such as (1) the direct visual scouting on moving individual tunas at the head of the school, (2) leapings and splashing of tunas ahead of the boat, (3) speed and direction of general flight and diving position of sea-birds, come to the aid of the chief fisherman.

Courses of approach. The general course of approach of the tuna boat to a particular identified tuna school may be described conveniently under the four kinds *viz.,* (a) Lateral approach (b) Central approach (c) Peripheral approach and (d) criss-cross approach.

(a) *Lateral approach:* This is a straight line approach of the tuna boat to a tuna shoal along the side of the school. This method of approach is generally applicable to a tuna school which may pick up excessively high speed at any moment. Fast moving school under schooling patterns I to VI are aften approached by this method. Here, the tuna school often being in relatively moderate or less appelite, abrupt entry of the boat over the school, often results in either the abrupt sinking and disappearance of the school or in its picking up of so enormous a speed that the boat with even all its capacity is not able to cope up with; the school taking an undesirable swimming position always in front of the boat and not abaft it (which lattern condition is a must for chumming the school to the Pole and line gear).

The approach along side may be effected in five different ways as shown in Fig. 1 (a) to (e), depending upon the initial direction of the course of the boat when the tuna school is just encountered. However, the method as shown in Fig (a) is mostly preferred to other methods because it gives more chumming feasibility with regard to the port side quarters of the fishing platform where are found the most able crew from among those who operate the pole and line gear (leading fishermen).

Whenever, two or more boats aim at approaching the same tuna school so as to get their fishing access into the same school, as a general convention, the priority in the time of approach is considered as a matter of right of each boat to go nearer the school. The first boat approaches the tuna school by adopting any one of the five courses shown in Fig (a) to (e), and each subsequent boat according to its order of priority takes its rear positions alternatingly either to the right or left of its predecessor boat which is fishing just in front (Fig. e). None of the subsequent boats is supposed to overtake its predecessor boat while fishing from the same tuna school. Any serious violence of this conventional practice is a punishable crime amongst the local fishermen brotherhood. This practice comes from the fact that whenever a boat is overtaken hurriedly by another boat, due to the disturbance in water caused by the latter boat, the school being chummed by the former boat gets distracted or disappers altogether.

(b) *Central approach:-* This is a straight line approach of the tuna boat to a particular tuna school, in which the boat plies over the centre of the school, as shown in Fig. (f). This method is used to get an uncertain access into a slow moving surface or subsurface tuna school which exhibits poor appetite under schooling patterns III-VII. Initially (especially when no tuna has been caught for the day), special care is taken to see that the boat does not overtake the school lest it disappears abruptly. However, in a situation in which tuna do not take the chum even after repeated chumming with live-bait, the boat plies over the school with minimum care about the sinking of the school, yet with some hope of improvement in the appetite and chumming response of tuna. In the typical schooling pattern VII, in which numerous confused schools of small sized

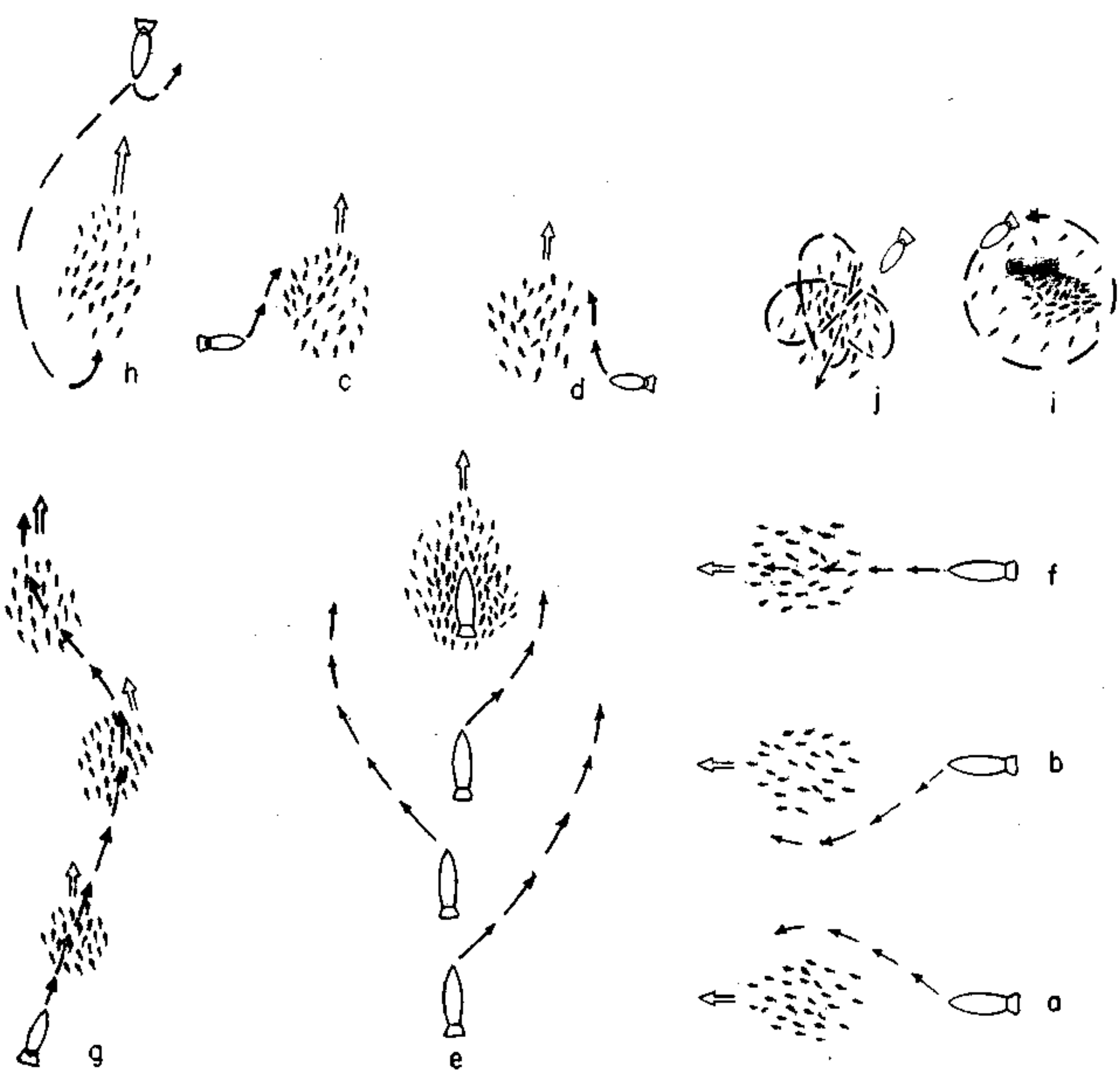

Fig. 1

aggregations of tunas occur over a large area of the fishing ground, the boat plies over individual tuna schools in a straight line, one after another (Fig. g).

In an encountering situation as depicted in Fig. h in which the tuna school and the boat are moving in opposite directions, extreme care is taken to keep a safe distance between the boat and the school, until the boat begins to approach the school from behind as indicated by the long and thin arrows in the figure. The short and thin arrow in the same figure shows another alternative and safe method of approach in the same kind of encountering situation of the school; here the direction of plight of the boat is turned to about 180° as soon as the school moving in the opposite direction is sighted at the farthest distance which permits the identification of the school. This turning of the boat should be made before the school is disturbed by the wake or by the physical presence (shade) of the boat, lest the school disappears.

(c) *Peripheral Approach*:- It is a circular line approach of the tuna boat to an identified tuna school, by the boat plying repeatedly around the periphery of the school (fig 1). This method is applicable to schooling pattern VIII and to varieties of actively feeding larger aggregations under schooling pattern I *(hudhu kolla)*. The orientation of the school to sunlight is taken into account in this method of approach, especially if the object is fairly large in size. As better concentration of the fish is found at the shady side of the floating object, the boat plies around the object in such a way that the object is maintained more towards the sunward periphery of the circle of plight. The fish associated with the floating object are swimming rather loosely in search of food, in the vicinities of the floating object and they form dense accumulation around the floating object as soon as the boat comes nearer. Therefore, initially the boat makes a wider circle around the entire loose aggregation of fish associated with the floating object and then gradually reduces the radius of the circle of plight as the fish forms a thick aggregation around the floating object. The floating object is seldom disturbed or removed until the boat is loaded to capacity with tuna caught from the school. Whenever, two more boats are fishing from the same school, it is always the first boat that plies along the inner circle and no subsequent boat is supposed to come still closer to the school without the permission from of the chief fisherman of the first boat; such a permission being given often only when the first boat is packed to capacity with tunas taken from the school.

(d) *Criss-cross Approach*:- In this method of approach, the boat plies over the identified tuna school repeatedly along a semicircular path placed one over the other in a rather criss-cross manner (Fig. j). It is used to slow moving varieties of tuna school of good appetite under schooling patterns I *(rhy Kolla)* and VIII *(happa mas auiin)*. Here, the feeding frency of the tuna school is aggrevated by scattering the school wich is otherwise compact. The live bait packs (around which tunas accumulate for feeding), also are shattered and the live baits in the pack are scattered into fractions of a few individuals by the repeated criss-cross plight of the boat over the schools of tunas and live baits.

DISCUSSION

The present investigation reveals for the first time that there are 14 different kinds of tuna schools coming under nine major schooling patterns in the Minicoy waters. Out of these only four kinds of schooling patterns *viz.*, Pattern I, II, VII and VIII are commonly reported locally from the remaining nine inhabited Islands (Chetlat, Bitra, Agatti, Kiltan, Kadmat, Ameni, Kavaratti, Androt and Kalpeni) in Lakshadweep. The first three of these schooling patterns in order, are locally distinguished as *Kunuth pondathe*, *Umikindathe* and *Pathakindathe* in these Islands. The 'breezing' and 'boiling' school of tuna observed by Silas in Silas and Pillai (1982) from the Laccadive sea appear to be the same as patterns II and VII of the present description.

A comparison of the present 14 kinds of tuna schools of Lakshadweep, with different kinds of tuna schools reported by Uda (1933), Van Campen (1952) Tominaga (1957) and Tomyama and Hibiya (1976) from the Japanese waters and Scott (1969) from the Californian waters indicates the following interesting facts. The skipjack tuna schools associated with bait-bed, sharks and drifting wood and the unassociated school, met with in the Japanese waters appear to be similar to schooling patterns VII (*badi* and *Happa*), VIII (*Ethi-kandu* and *oi-valung)*, in order, described here in Lakshadweep. Further, the 'Silver flow', 'Calm ones' 'Sednetary fish', 'Jumbers' and 'Sleepers' of Japanese waters resemble Patterns I *(Hudhu)*, III, IV, VI and VII (*Happa*) respectively of the present observation. The *Namura* and bottom-*Namura* of Japan represent the surface and sub-surface tuna in general in Lakshadweep, irrespective of the schooling pattern. The surface school types *viz.* Breezer, Finner, Jumber, Boiler of foamer, Smoker and Log-school of the Eastern Pacific resemble Patterns II *Uma kolla*, I (*Kothari)*, IV *(Emmus Hummelafi)* V (*Hummelafi*), VII *(badi)* and VIII (*Happa*) of Minicoy waters. Thus, there is a fundamental similarity in surface schooling patterns of the Skipjack and the yellowfin tunas in Lakshadweep, Japanese and Californian waters. However, more precise and standard Scientific terminology to denote tuna schools on an universal basis is required in this connection.

However, pattern III with Skipjack tuna of fairly large individual size swimming upside down, resembles very much both the 'shiner' and the 'whitebellies' in the Californian waters. This needs further confirmation. This pattern has also similarity with the 'Resting skipjack' of Japanese waters in which the fish refuse to take the chum (live-bait) as at Minicoy. The migrating type of tuna schools resembling the northbound 'ascending Skipjack', the southward returning 'descending Skipjack', the open sea school of 'Rowing Skipjack' and the 'adventitious fish' proper etc., reported from the Japanese waters are yet to be reported, if available, in Lakshadweep. The luminescent night schools reported by Purse seiners in Californian waters also are to be searched for in Lakshadweep. Further, in the eastern Pacific, Skipjack and Yellowfin tunas are reported to be associated with mammals like the Pacific spotted dolphin (*Stenella graffmani*), Spinner Porpoise, *S. longirostris* and the common dolphin *Delphinus delphis* In Minicoy waters, however, *D. delphis* could be observed on several occasions in stray numbers, upto six at a time near the boat; but no surface tuna school was found associated with this mammal. The tuna school in this case may be a subsurface association which needs further investgations to develop tuna purse-seining for such schools. *Cetorhinus* sp and *Rhineodon* sp are the two common sharks reported to be associated with tuna Schools in the Eastern Pacific. But in Lakshadweep, *Eulamia melenoptera* is the only common species of shark found associated with tuna schools.

As quoted by Nakamura (1969) from Tominaga (1957) it is clear that in the Japanese waters the skipjack tuna which bite well maintain an orderly formation, an unvarying speed and a uniform direction; they create small, uniformly spaced ripples on the surface of the sea, and expose no more than the tip of their dorsal fins; one or two fish at the head of the school may jump out of the water; the fish are not frightened by an approaching vessel. This is found to be true with schooling Pattern I (*Kothari*) of Lakshadweep. Further, according to the above work, poorly biting schools are: those with a disorderly formation direction of advance is not fixed, the school tends to break into smaller schools, and waves on the surface are large and unevenly spaced; fish leap near the middle or at the rear of the school; and fish sound and reappear repeatedly when approached by a vessel. This also is generally true with the behaviour of the Skipjack tuna in Lakshadweep, however, more acurate observations are required in this connection. Air spoting of tuna in the New Zealand waters revealed the breezers and the flashers or shiners of foaming or boiling school of the Skipjack tuna (York, 1977). These ressemble schooling Patterns II and III of the Lakshadweep waters.

The exact causes for the formation of the different kinds of schools formed by the Skipjack tuna and the co-occurring young yellowfin tuna in Lakshadweep are not known. After examining the various hypotheses explaining the causes for the association of tunas with the floating objects, Madan Mohan (1985) concludes that this association is nothing but merely a coincidence and that the floating objects appear to serve only as companions drifting at the same direction with the tuna school. However, the present onboard observation indicates that the association of the medium-sized individuals of the Skipjack tuna with the drifting floating dead-objects, wooden sailing vessels, whales and sharks etc,; is an ecological adapatation for a pelagic mode of life at the surface of the Sea where the waters are relatively of high transparency for a visual mode of feeding. Observations from an underwater viewing chamber on tuna behaviour made in the Hawaiian waters reveals that when compared to large individuals (70-80 cm), medium - sized (45-65 cm) Skipjack tuna show more frenzied activity, better formation of feeding schools, and very active pursuit of the prey with rapid surface dashes (Stransbury and Yuen 1958). Van Campen (1952) reveals that the Skipjack tuna in the Japanese waters do not have very good vision obliquenly to the rear. Experimental feeding under captivity in Hawaii shows that the Skipjack tuna do not feed down the botton, they always accept feed from the surface (Nakamura 1962). The Minicoy fishermen report that large sized individuals of Skipjack tuna lose their eye sight during certain spells of the year and they can not feed at such times. All these prove that medium-sized Skipjack tuna prefers the surface layers to the sub-surface of the euphotic zone for its visual feeding. The drifting dead object serves as a visual mark of identity for tuna to determine their feeding range around the abject. These drifting objects being accumulated along frontal zones of abundant tuna forrage, tunas are taken to better feeding grounds. The importance of temperature, transparency and forrage as conditions congenial for the normal distribution and commercial concentration of tuna is dealt with in Blackburn (1962).

Only maturing Skipjack tuna (stages II and III) are found associated with the drifting objects at Minicoy. It is at these stages in life history, the feeding activity is more vigorous. This also indicates that the tuna aggregate around the drifting object mainly for feeding purposes. When the fish grow to maturity stage IV and above, they give up the floating object and descend down to form sub-surface schooling patterns (III, IV, V and VI) and come to surface only erratically. Large individuals also form surface schools as under schooling patterns I, II and VI. The abundant availability of forrage organisms at the surface appears to be the main cause for the formation of these patterns also.

The co-occurrence of the young yellowfin tuna with the skipjack tuna also appears to be an adaptation for the pelagic mode of life. The whitish streak present in the errected first dorsal fin of the Skipjack tuna appears to attract the other individuals of the same species and of the young yellowfin tuna. Owing to difference in swimming speed, small and large individuals cannot cope-up with medium-sized tuna while swimming, aiming at the distinct first dorsal-white streak of the leading fish in front in the school. This may be the cause for the formation of schools consisting of similar sized fish. Brock (1954) observes that swimming speed is perhaps the cause for the size-wise seggregation of tuna even in mixed schools. Joseph and Barratt (1963) observes that the Skipjack tuna is of an erratic and excited behaviour and that it becomes clam when it co-occurs with the yellowfin tuna which is of a mere subdued behaviour. Skipjack tuna becomes more vulnerable to purse seines when these two species co-occur in mixed schools. This appears to be true with regard to the vulnerability of these two species to the TPL (live bait) gear at Minicoy also.

With regard to vulnerability of the different kinds of the tuna school to the Skipjack TPL (live bait) gear, it is clear that the surface schools in general (Patterns I, II, VII, VIII and IX) show a relatively good fishery prospects. The vulnerability of the surface school associated with whale (Pattern XI) could not be observed because this school is not being fished at present. Biting of the hook and of the chum, in general is relatively good with regard to schooling patterns in the surface (Patterns I, II, VII and VIII). These schools show relatively good appetite and feeding frency in comprison to those of the sub-surface layers (Patterns, III IV and V). There is considerable economy in live-bait with regard to surface schooling patterns. Considerable part of the Japanese catch is reported to come from Log-Schools ressembling pattern VIII.

Therefore, it is advisable to use alternative type of fishing gear such as the Tuna Purse seine, Tuna long line and TPL (live bait) with the two-poles, three-poles etc team gear to catch the sub-surface schooling patterns (III, IV, V and VI) in these waters where at present these schools are being exploited only at a very nominal level. Tuna purse seine provided with special safety measures for the release of whales, may be used for catching surface pattern IX, associated with whales which now remains virtually untapped. The schools of the yellowfin tuna and the big-tuna of individual fish weighing 8-10 kg, coming under schooling pattern V are at present a menace to the Skipjack TPL (live bait) gear, because of large scale breaking and loss of poles, as it is commonly found at spells of occurrence of these heavier tuna which are too heavy to be lifted by the presently used bamboo Poles. Only a very negligible fringe of this particular resource is being exploited at present by means of the trollingline (auxiliary fishing) gear operated from TPL (live bait) boats in these Islands.

The school of large yellowfin and Big eye tunas with individual fish weighing 30-60kg (*Vide* Pattern V), represent the best part of our exploitable tuna resources which at present is undergoing the most collossal waste owing to regrettable underfishing. Eventhough enormously extensive surface schools of such monstrous fish are detectable at certain spells from the surface leapings and surface dashings of individals of voluminous giants at closer intervals in time and space, no exploitation is being made at present owing to lack of suitable fishing gear. However, one or two stray specimens are being taken by the hand line, trolling line or shark long line, in different Islands to attract a large crowd of spectators to have a look at these monstrous games. Catching these stocks as early as possible is a must, because these appear fairly aged and hence more vulnerable to natural mortality and these may migrate beyond our Exclusive Economic Zone to support fisheries to other nations which are liable to compete with us in tuna fishing and trade. Tuna purse seine, Trolling lines (operated with the help of special boats with booms) and TPL (live bait) with three-men, four-men etc. team gear may be used to catch these stocks from the surface. Tuna long line meant specially for yellowfin tuna and that adapted for catching the Big eye tuna can be used to exploit these resources from depths. The behaviour of these stocks imbalancing and capasizing the country crafts operating hand lines in the deep waters lying between Ameni and Kadmat is locally reported.

It is interesting to note in this connection that high hooking rate leading to commercial feasibility of longlining yellowfin tuna of 30.0 31.8 kg average weight is reported from off Karnataka, Lakshadweep and West of Lakshadweep and Maldives in fishing areas; 14-72, 13-73, 12-70 and 1-69, during the September-January season. Bigeye tuna also recorded high hooking rate in the Equatorian Indian Ocean south-west of Lakshadweep and Maldives, in areas 3-77, 5-68 and 7-91 (Varghese *et al*, 1984; Joseph, 1984 and 1986; Sulochanan *et al*, 1986 and Swaminath *et al*, 1986): High Values of Yellowfin tuna hooking rates comparable to those of Japan, Taiwan and Korea is reported for the Basses de Pedro Bank areas 12-73, 13-72, 14-71 and 14-72 during the January-March Season with northerly migration of tunas from October to March and the possible acting of this Bank as a FAD with its immense availability of tuna forrage, mostly, squids and cuttle fish, also is reported recent by (Sivasubramaniam, 1985; Swaminath *et al*, 1986 and Sivaprakasam and Patil, 1987).

With regards to econoimic utility of tuna taken from the different schooling patterns, it is clear that the tuna caught from pattern VIII rejected by the local canning factory at Minicoy owing to the uneconomic small individual size of tuna. However, this catch is preferred to tuna taken from other kinds of schools, by the local people of Minicoy, for producing *mas-min* a local product comparable to *Katsubushi* of Japan. The soft-tissue of this tuna gives more pliability to the product which is considered superior in quality to that produced from large individuals. The yellowfin tuna in general is less prefered to Skipjack tuna for making *mas-min* owing to higher loss in weight of the former during processing and drying. But both these fetch the same price in the canning factory in fresh condition. Therefore, mixed schools of Skipjack tuna and yellowfin tuna are fished preferencially for skipiack tuna, if the catch is meant for *mas-min* making. Catches taken from the erratic sub-surface schools which delay the return trip of boats owing to the greater loss of time spent in fishing, get rejected in considerable numbers (about 30% of the catch) by the canning factory. This is because, as the time lag between retrieval and landing of the fish increases, fish which get injured due to heavy fall onboard from the gear, get gradually deteriorated before it reaches the canning factory. The rejected part of the catch thus goes for making it into *mas-min*. In this connection also, it is better to use alternative fishing gear to catch the sub-surface schools Patterns III-v). The catches taken from the surface schools, on the other hand are obtained at a relatively short time duration and hence keeps quality. More than one trip also becomes possible at certain spells from these schools thus making fishing more lucrative; time loss in searching for schools being the minimum.

The four different methods of approach of the boat to the identified tuna schools, described in the present paper are of considerable value for commercial fishermen to remove their doubts and superstitious fear regarding the reported bad effect caused by the toot of the engine or mechanised TPL (live bait) boats on tuna schools in Lakshadweep waters. According to some fishermen at Minicoy, the tuna schools in general, approach the sailing traditional tuna boat *(mas-odi)* more readily and sustain behind this boat for a longer duratian to support better tuna catch than it is in the case with the meceanised fishing boats. The bad effect of the noise produced by the engine under poor maintenance in fishing boat also is reported from elsewhere by researchers. Such studies are required for Lakshadweep. In this connection, the present observation on the correct method of approach to be followed with regard to different kinds of tuna schools is of special value, both for commercial fishermen and for researchers.

According to Ben Yami (1980) several factors such as the wind direction, sea condition, tuna school behaviour and direction of school movement, swimming speed of the prey (live bait) species, and the position of the fishing vessel are to be tken into account for approaching a tuna school correctly by the boat. The method of 'Peripheral approach' described here for schooling pattern VIII agrees with the normal method suggested by the above author for approaching the tuna school around floating objects. The present 'Lateral approach' also agrees with the above authors 'correct' method of approach illustrated in fig. 116 in Ben Yami (1980). The 'wrong' method of approach illustrated in the above figure by the above author also is found to be correct for approaching the school under certain situations as under schooling PatternVII (vide Central approach) described in the present work.

The traditional knowledge regarding the identification of the various schooling patterns of tuna and the correct approach of the TPL (live bait) boat to the identified individual tuna school, remains to be the valuable trade secret of only a handful of chief fishermen of the Island of Minicoy where only the Skipjack TPL (live bait) fishing technique exists since the long traditional past. These chief fishermen hail mostly from the *Thakrufan* and *Thakru* sub-castes. Majority of the common fishermen in Minicoy and in the remaining Islands do not possess this valuable traditional knowledge. Since the introduction of mechanized fishing boats in all these Islands and the extension of the skipjack TPL (live bait) fishing technique from Minicoy in the remaining Islands since 1962, these is a great demand for skilled tuna fishermen in all the Islands. Since recent years, many youths belong to the non-traditional tuna-fishermen sub-castes like *Manickfan* anp Raveri in Minicoy and *Koya, Malmi* and *Melacheri* in the remaining Islands, have taken to TPL (live bait) fishing. These new generations of fishermen are ignorant of the schooling patterns of tuna and the correct approach of the boat to the school. Therefore, there is urgent need to impart proper training to the local fishermen in all these Islands, on the identification of the tuna schools and the correct methods of approach of the boat to identified tuna schools, as part of the local fishermen training programme on Skipjack TPL (live bait) fishing technique.

Some modern lines of research on the schooling behaviour of the skipjack tuna are given below In an interesting review of field observations on tuna behaviour such as feeding, schooling, sounding in relation to the thermocline, associations with other organisms and objects, swimming speeds, attraction to surface disturbances and repulsion by sound and light with reference to Pole and line, trolling, longline, and Purse seining fisheries for tuna is made by Nakamura (1969) in Ben-Tuvia and Dickson (1969). Lines of work such as: (1) Experimental feeding of schools of the Yellowfin tuna and the Skipjack tuna with non-traditional live-baits (say for e. g, with mackerel and Sardine), artificial lures, and chopped cabbage, as done in the Eastern Pacific (Stransburg and Yuen, 1959), Japan (Van Campen, 1952) and in New Guinea (as quoted by Nakamura, 1969); (2) Experimental studies on the effect of water sprays on the response of the skipjack tuna as done in the Hawaiian waters (Yuen, 1959); (3) measurement of swimming speeds of the Yellowfin tuna and the Skipjack tuna as done by Yuen (1959) in Hawaiian waters; (4) studies on the swimming characteristics of tuna under different depth-levels and migration in different current zones, as done in the Japanese waters and (5) sounding behaviour of tuna in relation to the thermocline as reviewed in Nakamura (1969) would be interesting. Medium and large-type Pole and line (live bait) vessels in whose bait well skipjack tuna and the yellowfin tuna can be confined for observation (Joseph and Barret, 1962) is the immediate requirement to start such studies. Additional facilities such as viewing chambers attached to or built into a research Vessel (Stransburg and Yuen, 1960), raft to survey ecological and behavioural interactions of tunas and other species of fishes which are attracted by drifting objects in the open ocean, as used in the Equtorial Pacific (Gooding, 1965), Portable fish tank used for transporting tuna from Pole and line fishing ground in the Sea to a pool on shore as used in Hawaii (Nakamura 1962), small two-man submarine (quoted in Nakamura (1969), large on-shore tanks for keeping tuna under captivity (Magnuson, (1963) etc, are to be added gradually.

Some more lines of investigations on tuna and live bait schooling behaviour required for improving the Lakshadweep tuna fisheries include: (1) Searching for bait-fish packs ('meat ball's) of pattern VIII as indicators of tuna schools feeding on them and catching this bait-fish stock using modern nets like lampara and small purse seine for utilization in TPL (live bait) fishing; (2) aerialspotting of live baits and tuna schools; (3) use of accoustic gear like the Sonar to detect Sub-surface pelagic fish schools in open Ocean fishing where reflections from the Sea bed do not overshadow the fish echoes, and Echo sounders to pick up echoes from bait-fish schools (directly beneath the boat) on which tuna feeds; (4) detection and attraction of tuna schoos from sounds made by tuna and associated animals; (5) spotting tuna and live-bait schools from onboard crow's nest raised above deck level; (6) detecting tuna schools using temperature-Recorders like Mercury thermometers and Probe thermometers (Roberts *et al.*, 1972) and (7) investigating with long lines the different depth levels in which different species of tuna form schools in fishable concentrations.

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