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ON THE HYPOTHESIS OF COMFORTABILITY STIPULATION OF TUNA ASSOCIATION WITH NATURAL AND ARTIFICIAL FLOATING OBJECTS

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SUMMARY

The hypothesis of the comfortable stipulation of tuna association with floating objects was tested in the purse seine fishery off Sao Tomé. High stomach filling is chosen as a physiological correlative of comfortableness. Skipjack, young and adult yellowfin tuna, and yellowtail from by-catch, found at floating objects, had stomachs highly filled with fish not associated with floating objects. In the stomachs of other by-catch species, such sharks and dorado, small tunas were the main items. The available data confirm the hypothesis of comfortable pattern of tuna association with floating objects and feeding pattern of sharks and dorado association.

RESUME

L'hypothèse de l'état de confort des thonidés associés avec des objets flottants a été testée sur la pêcherie de senneurs au large de Sao Tomé. L'estomac très plein est choisi comme un corrélatif physiologique de confort. Le listao, l'albacore juvénile et adulte et le sériole de prises accessoires, rencontrés avec des objets flottants, avaient des estomacs très pleins, remplis de poissons non associés avec les objets flottants. Dans les estomacs d'autres espèces de prises accessoires, telles que les requins et la dorade, les petits thonidés étaient la principale espèce. Les données disponibles confirment l'hypothèse d'un schéma de confort des thonidés associés avec des objets flottants et le schéma alimentaire de l'association de requins et de dorades.

RESUMEN

Se ensayó la hipótesis de la condición de confortabilidad en la asociación de túnidos con objetos flotantes en la pesquería de cerco frente a Sao Tomé. Se eligió un alto contenido estomacal como correlación fisiológica de confortabilidad. Listados, rabiles juveniles y adultos, y serviolas procedentes de capturas fortuitas, encontrados en los objetos flotantes, tenían en los estómagos un contenido muy alto de peces no asociados a objetos flotantes. En los estómagos de otras especies procedentes de capturas fortuitas, tales como tiburones y dorados, el principal componente eran los pequeños túnidos. Los datos disponibles confirman la hipótesis de un esquema de confortabilidad en las asociaciones de túnidos con objetos flotantes, y un esquema de nutrición en las asociaciones de tiburones y dorados.

Introduction

The effect of tuna schools association with natural and artificial floatings have been utilized in purse fishery for a long time. However the mechanism of this phenomenon is still unknown. The available biological (see reviews by Magnusson, 1963; Sund, Blackburn, Williams, 1981; Fedoryako, 1982) and oceanological hypothesis (Fedoryako, 1982) applied to tunas, are questionable (Gooding, Magnusson, 1967; Holland, Brill, Chang, 1990). We consider the hypothesis of comfortability stipulation, described below, to be noteworthy.

The hypothesis of comfortabity pattern of tuna association with floatings appeared as a result of the author's own visual observations of little tunny (Euthynnus alleteratus) schools over Angolian shelf in September-October 1978/79. Tunas approached the drifting vessels, served as a kind of floating object, and became available for observation for a long period.

Schools approach at definite time of day (7.00-8.00 a.m.), swimming at one knot speed from vessel bows to stern and backward within one and a half - two hours, dense school structure with between-specimen space equal to 1-2 fish length, ignoring natural and artificial bait, frequent defecation and occasional display of "slip to a side" pose, the lack of signs of external stipulation for approaching the vessel, permit to identify this form of activity as a comfortability stipulated one.(Batalyants, 1986).

According to the known definition of comfortability stipulated activity as patterns of behaviour, related with physiological comfortability creation (Baskin, 1976), it is essential to reveal the physiological correlates for this state. As a possible correlate we take the state of "satiation", stipulated by a high degree of stomach filling. To check this assumption we analysed stomach filling of large pelagic tunas, including those caught by purse net at floatings and in "boiling schools" off Saô- Tome.

The results of analysis are presented below.

Materials

Observations were carried out in August-October, 1988. During the period of our residence on board the middle purse seiner it have been carried out 23 effective hauls, including 10 hauls (44%) oriented upon "birds" and "birds with splash", 9 hauls (39%) - upon natural and artificial floatings (tree trunks, coconut-tree leaves, wooden boxes, floats with buoys), and 4 hauls (17%) - upon "boiling schools". Table 1 shows species and size composition in effective hauls. Two tuna species - yellowfin and skipjack - dominated in catches. Little tunny and Auxidae constituted insignificant part of catch (less than 1%). Skipjack was observed in homotypical and heterotypic schools along with young yellowfin tuna. During the period of our observations young yellowfin association with skipjack was of permanent character. No homotypical yellowfin schools were observed. The ratio of skipjack and other component abundance of heterotypic schools was 2:1. In this case skipjack appeared to become a "patron"-species.

Large yellowfin tuna was observed in homotypical schools, produced ineffective hauls. Hauls at floatings and "boiling schools", characterized by homotypical and heterotypic (with young yellowfin) aggregations of large yellowfin and skipjack tuna schools, were effective. Floatings and significant amount of food items near surface, where appeared "boiling schools", are considered as external aggregating factors.

By-catch fish species and amount of fish analysed for hauls at floatings and in "boiling schools" are presented in Table 2.

Tuna and by-catch fish stomach filling was recorded using traditional 4-score scale. Stomach filling study for tuna from purse catches has some peculiarities, described below.

Actual data and discussion

The check of relation between stomach filling and residence at floating was started with by-catch species (Table 2).

The results of biological analyses of various shark species and dorado confirmed the supposed relation. However those species,

which had stomachs filled with food items associated (small tunas) and non-associated with floatings may be classified as having a feeding pattern of relation with floatings (feeding on tunas). Although there are direct evidence of shark feeding on tunas, stick in the netting (netting pieces observed in shark stomachs), another evidence shows that digestion of tunas have begun long before shark catching with a sein., i. e. tunas were grasped before a haul.

The analysis of yellowtail stomachs provided more convincing data to confirm a comfortable pattern of this species residence at floatings. Yellowtail, as well as tunas, is observed in hauls in free-swimming schools and at floatings, i. e. its association with floating is of temporal pattern. High degree of yellowtail stomach filling in hauls from "boiling schools" and at floatings supposes the following rhythmics - departure from floating to hunt and return to floatings with stomach filled. As in tunas, its food items consist of fishes non-associated with floatings (Table 3). Thus, the comfortable pattern of yellowtail association with floatings is evident. In 1990 in the central area of the Gulf of Guinea we often observed significant yellowtail schools near the board tuna-base with apparent signs of comfortable state. As a rule they followed whitefin sharks, keeping usually somewhat deeper, but close to the latter. The analysis of stomach filling appeared impossible due to ignoring the biat by yellowtail.

To record stomach filling of "purse-caught" tuna was much more difficult than for by-catch species. Tunas, caught shortly after active feeding, ejected food out of a stomach. This process is stimulated by small stomach volume relative body size as compared with other species, from one hand, and by extremely high sweeming activity in the disturbed state, from the other hand. We often observed food ejection by little tunny, caught with fishing rod and line from "popper" schools over the Angolian shelf. The stomach of knocking against the deck tuna became actually empty in 1-2 minutes. The same observed during skipjack and yellowfin tuna unloading from purse seine. Some food is ejected by tuna while being in sein during ringing the net, and is picked up by birds. The residual food is ejected directly on the deck. In such a case the deck is covered with a layer of the whole and partly digested small fish and invertebrates. Fishermen reported, that during ringing the tanks, where tunas caught were stored in brine, they observed a lot of small fishes, ejected out of tuna stomachs.

The ability to eject food at catching explains the fact that food is not always recorded in stomachs of tunas, even when the later have been caught in "boiling schools". In this context we suppose reasonable to relate tuna association with floatings and the satiation state, revealed by the availability of fresh and slightly digested food in some tuna stomachs and of small fishes from the food mass on the deck.

Among the hypothesis available to explain tuna association with floatings (Sund et al., 1984), the most convincing one considers floating objects as a food items concentrating agent. At the same time we support Holland's assumption (Holland et al., 1990), that food items concentration at floatings could not satisfy food requirements even of middle-size tuna school. However the latter hypothesis may appear valid for sharks and large dorado with small tunas contained in stomachs. Those tunas may be actually captured by predators near floatings. Taking in account the lack of external stipulation of tuna association with floatings, we assume at least two versions for physiological stipulation of the process. The first one is the association with object floating near surface as one of the behavioural thermoregulation means (Sharp, Dizon, 1979), following the prolong food searching at great depth and relatively low temperature. This can explain the association with floatings of adult yellowfin tuna, searching food within the lower limits of the mixed water layer.

The second version is association with floatings as a mean of regenerating the energy, exposed for successful (or unsuccessful) food search (comfortable state). This version explains the association of skipjack, young and adult yellowfin and other tuna species with floatings.

Our hypotheses can be identified as a special case of the second version, i. e. association with floating of "satiated" tuna, although we do not exclude the association with floatings

of "hungry" tuna required strength recovery after unsuccessful food search.

Comfortable activity as an inevitable element of the daily activity, must be realized within definite period of day. Temporal determination of tuna aggregations at floatings was checked by time of effective hauls at floats, carried out from two purse seiners off São-Tome during fishing season of 1988.

Relation of effective hauls at floatings with morning hours and hours just after noon is presented in Table 4. Two peaks of catches at floatings, specifically for skipjack, are considered to be the phenomenon of the same pattern as two feeding peaks for this species (Magnusson, 1963). The following relation is supposed - night feeding activity - comfortable state at early morning hours, noon feeding activity - comfortable state after noon. Further study of food mass composition is required to temporal aspects of specific food items availability for tunas. In our material stomachs of large yellowfin tuna from morning hauls at floatings contained beaks of small squid, represented night food items. Stomachs of tunas from day-time catches contained mainly flying fishes, hunting for which was often observed visually. Thus, temporal analysis of effective hauls at floatings confirms the comfortability stipulation of this phenomenon.

Association with floatings is not considered as the unique means of comfortable activity realization. Based on aircraft observations, (Petit, Stretta, 1989), the surface tuna schools of significant biomass are often recorded as dense dark patches. In such a case, fish made slow spiral movements, related, as we suppose, with comfortable activity. Samples from such schools can be also utilized to study physiological stipulation of comfortability.

Conclusion

The traditional assumption on continuous tuna movements for significant distances practically puts the problem of comfortability activity out of discussion. However the importance of comfortable element of diurnal activity rythmics seems paricularly apparent, taking in account the great energy costs and specific ecology of tunas. Tuna association with floatings indicates one possible version of comfortable state realization. The relation of tuna and other by-catch fishes stomach filling with floatings was analysed based on assumption of comfortable state as a "satiation" function. The relation seems quite valid. Temporal determination of effective hauls at floatings is considered as an additional factor to confirm comfortable pattern of tuna association with floatings. Further development of this hypotheses required analysis of temporal availability of some food items for tunas and peculiarities of comfortable state realization depending on feeding time.

Table 1

Species and size composition of tunas in purse catches off São-Tome in August-October of 1988 (based on observation from SST "Pteria")

Haul No.	Signs of schools	Number of specimen measured	Large yellowfin tuna: Size range	Large yellowfin tuna: $\bar{X}$	Large yellowfin tuna: S	Small yellowfin tuna: n	Small yellowfin tuna: Size range	Small yellowfin tuna: $\bar{X}$	Small yellowfin tuna: S	Skipjack: n	Skipjack: Size range	Skipjack: $\bar{X}$	Skipjack: S
1	2	3	4	5	6	7	8	9	10	11	12	13	14
13	birds	46	87-114	105.489	6.258	-	-	-	-	9	47-64	52.444	4.666
14	birds	-	-	-		21	39-47	41.523	2.015	50	43-57	48.540	3.387
16	birds	-	-	-	-	8	35-42	39.600	-	41	39-48	42.707	1.691
21	floatings	21	108-137	118.809	12.404	-	-	-	-	33	38-46	42.393	1.919
										52	48-64	55.326	4.601
22	birds	-	-	-	-	-	-	-	-	15	52-62	55.466	2.774
24	floatings	38	114-138	122.684	6.686	-	-	-	-	17	42-62	49.705	6.326
25	floatings	-	-	-	-	16	41-66	55.187	6.665	62	38-47	41.903	1.956
26	floatings	26	110-140	117.538	7.468	-	-	-	-	44	39-60	45.931	4.990
30	birds	-	-	-	-	-	-	-	-	32	57-69	62.875	2.210
31	birds splashes	-	-	-	-	-	-	-	-	33	50-62	54.030	2.530
32	birds	-	-	-	-	-	-	-	-	48	58-69	64.187	1.953
33	birds	-	-	-	-	-	-	-	-	40	56-68	62.675	2.411
34	birds	-	-	-	-	-	-	-	-	31	56-66	60.967	2.024
37	"boiling school"					41	35-55	44.341	4.180	52	40-52	45.076	2.721

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Table 1 (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
39	floatings	-	-	-	-	40	38-58	43.833	4.537	78	39-57	43.179	2.160
40	floatings	14	84-111	98.285	8.870	14	41-52	44.000	2.051	50	39-48	42.880	1.996
49	floatings	-	-	-	-	10	40-58	47.401	5.680	23	35-53	43.000	5.551
53	"boiling school"	23	117-148	126.304	8.120	50	39-57	46.560	3.470	52	37-57	46.980	4.704
54	"boiling school"	138	85-181	130.036	21.623	25	38-60	48.080	5.460	119	37-61	48.605	4.610
58	"boiling school"	34	100-167	126.730	19.422	-	-	-	-	70	40-60	48.628	3.652
59	floatings	-	-	-	-	30	39-58	44.766	5.695	58	38-54	46.100	3.823
60	birds	-	-	-	-	-	-	-	-	41	42-56	47.463	3.025
65	birds	-	-	-	-	30	39-57	46.933	5.457	64	42-57	46.296	3.430

Note: No little tunny and fregate mackerel, occasionally occured in catches (less than 1%), were included into the Table.

Table 2

Fish species clodged in meshes of purse seines for some hauls, carried out of Saô-Tome in August-October, 1988 (identified by Kukuyev E. A.)

Family	Species	Size (mm)	Occurence in stomachs
1. Trachipteridae	Zu cristatus	70	
2. Holocentridae	Holocentrus sp.	20	
3. Priacanthidae	Priacanthus cruinthatus	30-40	tunas, sharks
4. Carangidae	Vomer setapinnis	25-45	tunas
Carangidar	Trachurus sp.	30-40	tunas, sharks
5. Gempylidae	Diplospinus multiiatus	50-60	tunas
6. Nomeidae	Psenes sp.	25	
7. Cephalacanthidae	Dactylopterus volitans	30-35	tunas
8. Monacanthidae	Cantherinus sp.	55-60	tunas, yellowtail
9. Ostracionidae	Ostracion sp.	14	
10.Diodonthidae	Diodon holocenthrus	15-20	

Table 3

Major by-catch species in purse hauls at floatings and from freely swimming tuna schools off Saô-Tome

No.	Species, Family	Haul No.	Number of specimen	Size	Stomach filling (scores)	Association
1.	Carcharinus longimanus	49	1	300(AC)	4	floatings
	(Carcharinidae)	65	1	136(AC)	4	tipple
2.	Carcharinus fulciformis		1	210(AC)		tuna splashes, birds
	(Carcharinidae)					
3.	Carcharinus lencas	37	2	146, 146(AC)	4	
	(Carcharinidae)	41	1	110	4	"boiling schools"
		50	1	216	4	birds
4.	Sphyrna lewini	24	1	240(AC)	4	floatings
	(Sphyrnidae)					
5.	Sphyraena genia	21	2	70, 76		floatings
	(Sphyraenidae)	49	2	92,103	4	floatings
6.	Seriola lalandi	21	50		4	floatings
	(Carangidae)	24	17	47-77	4	floatings
		35	1	63	4	floatings
		37	2		4	"boiling schools"
		39	20	67-88		floatings
		40	11			floatings
		41	7	45-57	3.4	floatings
		49	4	61-89	3.4	floatings
		53	5	71-75	3.4	birds
		65	11	72-86	4	tipple
7.	Coryphaena hippurus	21	3			floatings
	(Coryphaenidae)	24	2	65, 64		
		26	25	48-102	3.4	floatings
		27	6		4	floatings
		39	4	54-67		floatings
		59	4	136		floatings

Table 4

Time of purse hauls at natural and artificial floatings off Saô-Tome, 1988

A. August-September, SST "Pteria"

No.	Haul No.	Date	Time of haul start	Catch (t)
1.	21	20.08	7.00	34.3
2.	23	21.08	6.40	emergency
3.	24	22.08	6.30	6.0
4.	25	22.08	14.40	8.0
5.	26	23.08	6.35	5.0
6.	27	24.08	6.50	specimen
7.	35	02.09	6.35	0
8.	39	07.09	6.50	14.0
9.	40	06.09	17.27	2.0
10.	41	07.09	16.30	0.5
11.	49	16.09	7.50	0.3
12.	59	26.09	8.20	7.0

B. June-September, SST "Marginella"

No.	Haul No.	Date	Time of haul start	Catch (t)
1.	1	23.06	15.25	5.0
2.	14	31.07	6.40	0
3.	19	04.08	6.50	2.0
4.	21	06.08	14.30	81.0
5.	22	07.08	14.10	79.0
6.	29	22.08	6.40	10.0
7.	30	25.08	9.40	10.0
8.	39	02.09	8.30	36.0
9.	40	02.09	14.05	4.0
10.	41	03.09	7.00	5.0
11.	42	03.09	11.40	2.0
12.	45	10.09	7.30	1.0
13.	60	29.09	7.00	30.0
14	61	29.09	14.55	50.0