PRELIMINARY RESULTS OF TUNA DIET STUDIES IN THE WEST EQUATORIAL INDIAN OCEAN.

by

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ABSTRACT.

In the framework of the Thetis project, a trip on board a purse seiner was done in the West equatorial part of the Indian Ocean. 112 stomachs have been collected and analyzed. The paper presents the preliminary results of that study.

The number of empty stomachs was high among the fish caught from floating objects schools. The ratio empty/filled stomachs was greater in the small size classes than in the large size.

The composition of the stomach content differs according to the species and the size. Crustacean preys dominated in the diet of Skipjack caught either from free schools either from schools associated with floating object. For the individuals caught on free school, crustacean constitute the exclusive prey. Whilst its proportion decreased on FADs.

Fish was the main prey for yellowfin. When the size of the individuals increased, crustaceans were replaced with cephalopods in the diet. This latter prey item dominated in the stomach contents of bigeye but very few individuals of this species have been studied.

These results could be linked to different behaviour (with emphasis on vertical migration) among the species and the size of the individuals. The fishing zone was characterized by the presence of large free schools of skipjack that were feeding actively. The crustaceans were essentially represented by a small size stomatopod (Natosquilla investigatoris). The abundance of this prey among the forage might explain the low occurence of large size yellowfin and bigeye free schools in the area.

RESUME

Dans le cadre du projet Thetis un embarquement à bord d'un senneur a été réalisé dans l'ouest de l'océan Indien équatorial. 112 estomacs ont été récoltés et analysés. L'article présente les premiers résultats de cette étude.

Le nombre d'estomacs vides est élevé parmi les échantillons provenant de poissons capturés sous objets flottants. Le ratio estomacs vides/estomacs remplis est plus fort dans les petites classes de taille que dans les grandes.

La composition du contenu stomacal diffère suivant les espèces et la taille. Les crustacés sont dominants dans les estomacs des listao que ceux-ci soient capturés sous bancs libres ou sous objets flottants. Cependant si pour les individus de bancs libres cette proie est l'élément exclusif du régime alimentaire, pour les individus sous radeaux sa contribution est moindre.

Les poissons sont les proies principales de l'albacore. Chez cette espèce, lorsque la taille augmente, les crustacés sont remplacés dans la diète par les céphalopodes. Ces derniers dominent largement dans les estomacs de patudo mais très peu d'individus de cette espèce ont pu être étudiés.

Les disparités ainsi observées semblent liées à des comportements différents selon l'espèce et la taille. La zone de pêche était caractérisée par la présence de gros bancs libres de listao. Au moment de la prospection, elle représentait sans doute une zone de nourrissage pour cette espèce. La prédation s'effectuait exclusivement sur une squille (Natosquilla investigatoris) de petite taille présente en grandes quantités. La dominance de cette proie

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dans la communauté des proies présentes localement pourrait expliquer la quasi absence de bancs d'albacore et de patudo de grande taille dans cette même zone.

INTRODUCTION

The predator-preys interactions play an important part in the structure and the dynamics of multispecies communities. Facing the dramatic increase of the catches of tunas and related species in the Indian Ocean, it becomes necessary to assess the impact of the fisheries on the pelagic ecosystems. The implementation of research activities leading to a better knowledge of the trophic ecology of apex predators will provide such an ecosystem point of view that has to be considered nowadays in high seas fisheries management.

The THETIS program (Marsac, 1999) implemented by IRD in 2000 is made of four research components, one of these focusing on the predator-preys interactions in some high seas pelagic ecosystems of the Atlantic and Indian oceans. These interactions are based on stomach content analyses, Carbon and Nitrogen stable isotope ratios and acoustic surveys.

In this paper we present the first results of an analysis of tuna stomach contents collected during a trip at sea done in May-July 2000 on board a purse seiner.

MATERIAL AND METHODS.

Usually it is difficult to collect large number of stomachs on commercial purse seiners because the fish has to be eviscerated and cannot be frozen in good conditions for trade. Hence, we took the opportunity that a purse seiner equipped with a small processing unit could great us to undertake our sampling.. The processing unit fillets the big yellowfin enabling the sampling on high value fish that is not possible on other platforms. During the trip, an area located in the Northwest of the Seychelles Islands, offshore of the Somali coast has been prospected.

The trip went off in three parts :

- During the first two weeks, the survey focused on the search of FADs. Those seeded during the previous trip were visited and new ones were set at sea. First the search was done in the northern part of fishing zone and went southwards reaching 4°South.
- In the second part, the fishing concentrated on free schools of skipjack (*Katsuwonus pelamis*) found around the equator between 50° and 52°East. This part lasted one week. During a set the seine was damaged and required calling in Victoria harbour during one day.
- At the end of the trip a fast survey of the FADs seeded during the first week was done. No fish was found but free schools of skipjack were present in the area.
- Thirty sets have been done during the cruise. Their location is given in Figure 1.

On board :

Stomachs were collected when fish is brailed on board. Sampling is made in the steerage of the vessel. When the fish is on the conveyor belt, it is easy to spot damaged fish of which the stomachs can be collected. Skipjack, bigeye and yellowfin (< 30kg) are sampled there. The big individuals of yellowfin (>30Kg) sampling is done during the filleting of the fish. To remove stomach from fish the abdominal cavity is opened. Stomach is collected by cutting it at the last gill level and after the pyloric valve.

Following information is then noted :

- Species,
- Size of the fish
- Weight
- Sex and maturity
- Filling index of the stomach
- Hour of cutting.

The stomachs are put in a ceiled plastic bag and stored at –20°C. A label with the main characteristics is enclosed with the bag. For one stomach the operation lasts around 5 minutes. To reach the objective of ten stomachs per set, the time to spend is around 50 minutes.

At the laboratory :

Stomachs are defrost 24h before the analysis which is made in three steps:

1) stomach with contents on one side, and contents only on the other side, are weighted. Then the content is sorted by large categories (fish, molluscs, crustaceans). The weight of each category is noted.

2) the different items constituting the groups are sorted and counted. For each items remarkable organs are used to determine the number of preys in the stomach. For fish the number of mandibles, or parasphenoids or the maximum number of either left or right otolith was assumed to reflect the total number of fish prey in the stomach. Similarly the greatest number of either upper or lower beaks is used as an indication of the number of cephalopods prey in the stomach. For crustaceans, telsons or pleopods are used.

3) different items are determined to the lowest taxum. The reconstituted weight of the food meal will be done by calculating regressions relating dimensions of remarkable organs to the weight of the items. For example, total fish length and weight are related to otolith, mandibles or parasphenoids sizes, and squid weight and dorsal mantle length to beak dimension.

For the present paper, we used the results obtained at the end of the second step. They were tested by a Kruskal-Wallis test (1952) in order to see if differences occur in the diet among the different species caught under FADs and among skipjacks between FADs and free schools.

An Index of Relative importance (IRI) (Pinkas *et al*., 1971) was calculated for each species, where :

IRI = (%number+%weight)x%frequency occurrence

The graphical method developed by Costello (1982) was also used in this paper.

Results.

During the trip, 13 sets have been sampled (Fig. 2) and 112 stomachs collected. The table I summarizes the distribution of the collected stomachs by species and daytime. The size distribution of the fish of which the stomachs have been collected is given in Figure 3.

Table I*. Distribution of the stomachs by species, type of school, and daytime .*

Type	Species \ hour	6	7	8	9	10	11	12	13	14	total
Free school	Skipjack		5	8		10	10		5		38
	big eye			6						2	8
	Skipjack		17	4				4	5		30
	yellowfin <10 kg	1	8					5		1	15
FAD	10-30 kg		8	6				1			15
	> 30kg		3								3
	Auxis	2									2
	Marlin	1									1

The 3 auxis and marlin stomachs were empty. Out of the 109 tuna stomachs, 46 were completely empty, and 63 contained preys remainings (Fig. 4). For skipjack the percentage of empty stomachs was low (15%) when caught in free schools but increased a lot for individuals caught under FADs (70%). For yellowfin the frequency of empty stomachs decreased with the size of the individuals (54% for fish less than 90 cm FL, 30% for individual greater than 90 cm). For bigeye, the percentage of empty stomachs was high (75%).

Crustaceans turned to be the main prey for skipjack. They contributed over 95% in weight of the overall skipjack prey on free schools (Fig. 5). Crustaceans were determined as *Natosquilla investigatoris* (Squillidae) a pelagic species only reported from the western Indian Ocean. This species was also the main item of the skipjack stomach contents on the FADs located near the free schools fishing zone. Crustaceans represented only a small part of the yellowfin diet and were not found in the bigeye stomachs.

Fish was the most abundant group preyed upon by yellowfin (90 to 95%) whatever the size of the individuals. This percentage was lower for skipjack (30%) and bigeye (7%). Among the fish prey, mesopelagics (Myctophiids), epipelagics (Exocoetidae) species and fish linked to FADs (Balistidae) were found.

Part of the Cephalopods in the contents was low except for bigeye where it represented 93% of the ingested preys. For yellowfin, the weight of Cephalopods increased with the size of the individuals (0 to 8%). They were represented by species belonging to the Ommastrephidae and Onychoteutidae families.

The results found with the number of preys are rather similar (Fig. 6). The percentage of the crustaceans increases a little bit in the contents of fish caught under FADs. For skipjack this increase is done at the expense of cephalopods, and for yellowfin at the expense of fish prey.

The test of Kruskal-Wallis show no significant difference among the diet of the species caught under FADs. But significant differences appear in the relative importance of prey species for skipkjack between FADs and free schools (tab. II).

Table II. Results of the Kruskal-Wallis test performed according to the species and the type of school.

Variables		Species under FADs	Type of school
Fish	H	5.27	1.25
	p <	0.261	0.265
Crustaceans	H	2.82	34.93
	p <	.588	0.000
Cephalopods	H	7.99	2.77
	p <	0.092	0.095

Except for skipjack associated with FADs, the IRI shows great variations between prey items (with a dominant category) within each tuna species. For skipjack on free schools, yellowfin and bigeye, dominating preys are respectively crustaceans, fish and cephalopods (Tab. III).

Table III. Index of Relative Importance (IRI) calculated for each species.

		Free school skipjack	FAD's skipjack	YF <90cm	YF >90cm	Big eye
IRI	fish	7,49	3600,25	15687,03	9948,19	1105,59
	crustaceans	19909,35	5510,18	727,91	2425,52	0,00
	cephalopods	0,25	1600,54	0,00	628,24	18894,41

Diagrams built by the Costello method give results similar to the IRI index.

Under FADs fish was the dominant prey in the contents of the yellowfin, cephalopods not being represented in the diet of small individuals. For skipjack, no category emerged (Fig. 7).

In the stomachs of skipjack on free schools the crustaceans were the dominant preys, fish and cephalopods being rarely reported (Fig. 8).

DISCUSSION.

These preliminary results show that the skipjacks caught under free schools were eating on huge concentrations of mantis shrimps and their stomachs were filled with that prey exclusively. Individuals of that species caught under FADs exhibit a more opportunistic diet with a mixture of fish, crustaceans and cephalopods. But among individuals caught under FADs in the vicinity of the free schools, the mantis shrimp *Natosquilla investigatoris* was still the main item of the prey. It seems to show that individuals aggregated under FADs can feed on prey not found exclusively under the FADs, as previously showed in an area of the Equatorial Atlantic (Ménard *et al*., 2000). Same results can be seen for yellowfin as fish prey do not consists exclusively in the fauna linked to the FADs (if there is any?).

The distribution of the prey among the different categories are in accordance with the results obtained in other regions (Dragovich, 1970 ; Buckley and Miller, 1994). Crustaceans were dominant in the diet of skipjack while fish was the most important diet component for yellowfin. For that species, the part of the cephalopod prey in the diet increased with size. Cephalopods seemed to be the preferred prey for small size bigeye. But the number of individuals of that species with non-empty stomachs is very low and does not allow us to conclude at this stage of the study.

The number of empty stomachs was high under FADs. It is particularly marked for skipjack and for small size yellowfin and bigeye. For the large yellowfin this number is not so important. This result suggests that fish concentrated under FADs exhibit different behaviour (vertical migration) according to their size and species.

ACKNOWLEDGEMENTS

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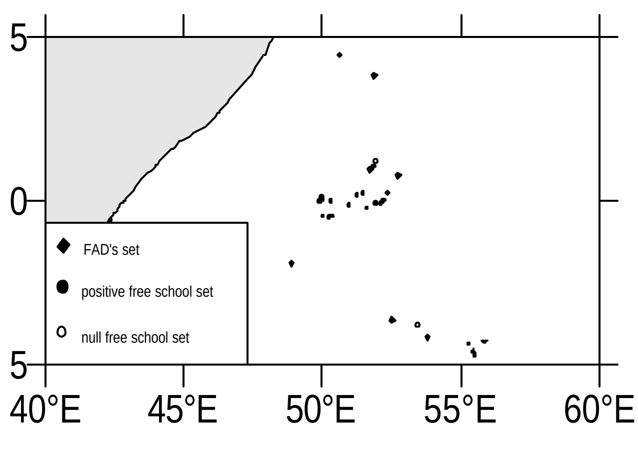

Figure 1. *Location of the purse seine sets.*

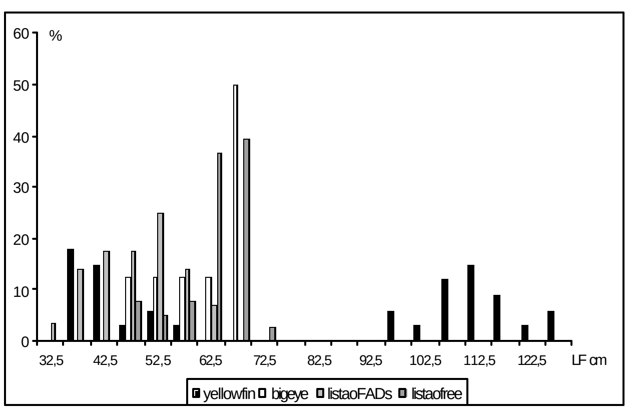

Figure 3. *Size distribution, according to the species, of the fish of which the stomachs have been collected.*

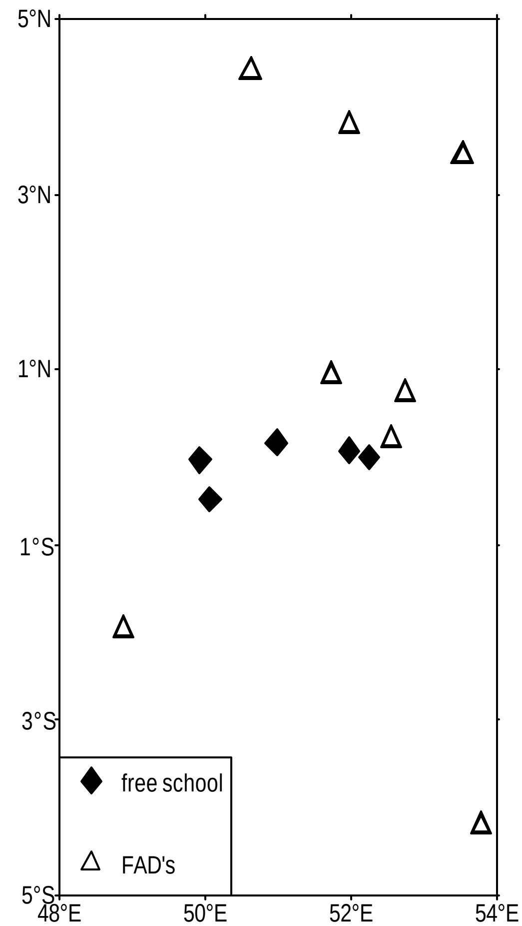

Figure 2. *Location of the sets sampled during the trip.*

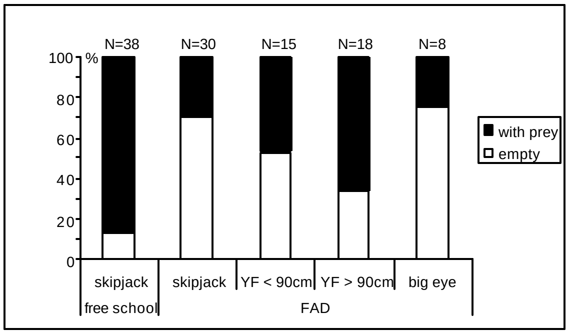

Figure 4. *Distribution of the stomach contents (in percentage) according to the tuna species and the types of school.*

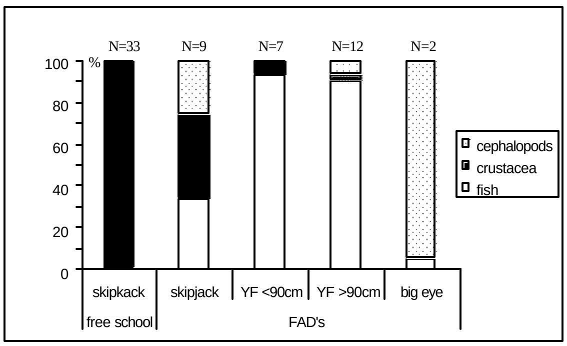

Figure 5. *Distribution (in weight) of the different groups according to the species of tuna and the type of school.*

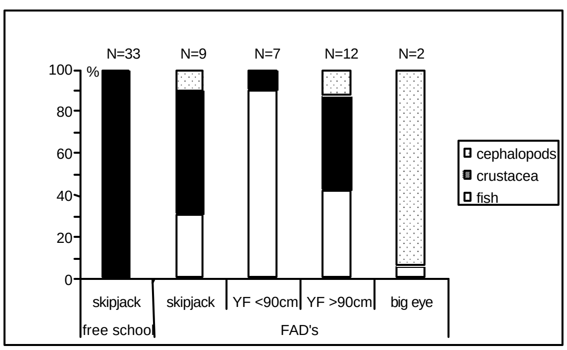

Figure 6. *Distribution (in number) of the different groups according to the species of tuna and the type of school.*

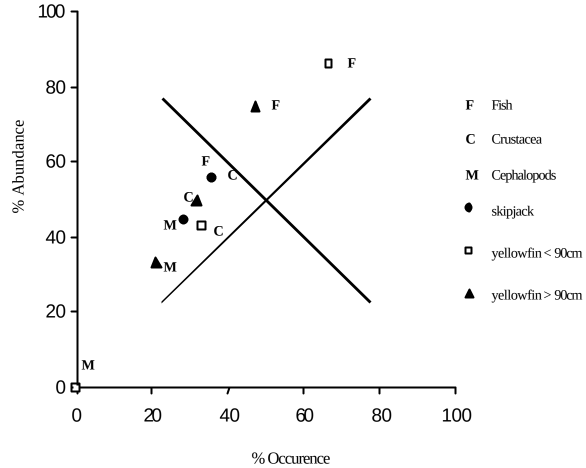

Figure 7. *Costello diagram. Distribution of the preys from different species caught under FADs.*

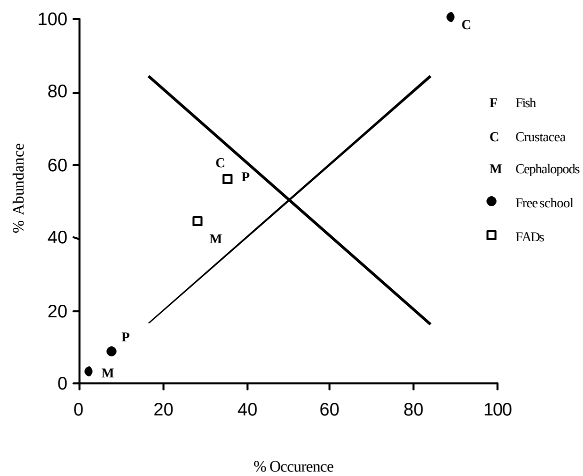

Figure 8. *Costello diagram for the skipjack caught under FADs and in free school*