ON-GOING RESEARCH ACTIVITIES ON TROPHIC ECOLOGY OF TUNA IN EQUATORIAL ECOSYSTEMS OF INDIAN OCEAN.

by

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ABSTRACT

In the framework of the Thetis project, eight trips on board purse seiners and the R/V l'Amitié were done in the western equatorial part of the Indian Ocean. Among 529 stomachs collected 232 have been analyzed. The paper presents the main results on trophic ecology of tunas.

Most of the stomachs have small contents (< 100g) and the number of empty stomachs is high among the fish caught from floating objects schools.

Crustacean preys dominated in the diet of most tunas caught from May to October either from free schools either from longline catches. The main crustacea prey is the stomatopod Natosquilla investigatoris. This species, endemic of the west Indian Ocean, form some years pelagic swarms which invade all the region. At that time, the stomatopod becomes the main diet item for many fish even demersal ones. However it has not been observed in the stomachs of swordfish and sailfish.

The migrating behaviour of the Natosquilla seems very similar to the one observed by Zamorov et al.(1991) for the swimming crab (Charybdis edwardsi). This crab has a pelagic phase during which it matures and spawns. During this phase (October to March) the swimming crab is one the main prey of tunas.

The diet of tunas seems opportunistic, but seasonally this diet relies on a dominant species if this one is abundant and shoaling. In the equatorial western Indian Ocean it seems this role is played by crustacea for most part of the year. There might have relatively short food chains leading to tuna. This hypothesis can serve as a basis for modelling the ecosystem.

RESUME

Dans le cadre du projet Thetis huit embarquements à bord de senneurs et du palangrier de recherche de la SFA l'Amitié ont été réalisés dans l'ouest de l'océan Indien équatorial. Parmi les 529 estomacs récoltés 232 ont été analysés. L'article présente les principaux résultats obtenus à ce jour sur l'écologie trophique des thons.

Pour la plupart des estomacs le poids du contenu est faible (< 100g) et le nombre d'estomacs vides est élevé parmi les échantillons provenant de poissons capturés sous objets flottants.

Les crustacés dominent dans la diète de la plupart des thons capturés de mai à octobre que ce soit en bancs libres ou capturés à la palangre. Ce groupe est représenté presque exclusivement par le stomatopode Natosquilla investigatoris. Cette espèce endémique de l'ouest de l'océan Indien forme certaines années de gros essaims pélagiques qui envahissent la région. Les stomatopodes deviennent alors la proie principale de nombreux poissons pélagiques et démersaux. Cependant elle n'est pas observée dans les estomacs d'espadon et de voiliers.

Le suivi des modes dans le temps semble montrer une croissance concomittante à un déplacement des essaims de l'ouest de la région vers l'est. Le comportement de cette espèce peut être rapproché de celui observé précédemment dans la même région par Zamorov et al., (1961) pour le crabe nageur Charybdis edwardsi. Cette espèce, comme la squille, a une phase pélagique pendant laquelle le crabe mature et pond. Les larves sont alors reprises par les courants et ramenées vers le plateau continental est-africain. Lors de sa phase pélagique (octobre-mars) le crabe est une des proies principales des thons.

L'alimentation des thons semble opportuniste, mais saisonnièrement elle peut dépendre d'une proie dominante si celle-ci est abondante et forme des essaims pélagiques. Dans l'ouest de l'Océan Indien équatorial les crustacés semblent jouer ce rôle la plus grand parti de l'année. Cette hypothèse peut servir de base pour une modélisation de l'écosystème.

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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.

This research is based on a comparative approach of selected areas of the two oceans which have for the tunas the same ecological pattern. In this paper we present the on-going research on trophic ecology of tuna in equatorial ecosystems of the Indian Ocean.

MATERIAL AND METHODS

The paper is based on the study of the stomachs collected since May 2000 in the equatorial part of the western Indian Ocean. This area has been covered during eight cruises (Fig. 1), four on board purse seiners and four on board the R/V l' Amitié owning to the SFA (Seychelles Fishing Authority). This vessel is a longliner of 20m long.

During the trips, 529 stomachs have been collected (Tab I.) and 25 species have been sampled (Fig 2.). Among the 529 stomachs, 232 have been analyzed following the method described in Potier *et al.* (2001) and summarized in figure 3. The preys have been sorted by main groups and some identification until species level has been done.

RESULTS

For the three species of tuna, most of the stomachs contain less than 100g of preys. The percentage of empty stomachs is high among tunas caught under FAD's. It reaches 70% for skipjack (*Katsuwonus pelamis*) and big eye (*Thunnus obesus*). The value is lower for the yellowfin (*Thunnus albacares*). Well filled stomachs are found among individuals caught from purse seines (free schools) and longline (Fig. 4).

Table I. Number of stomachs collected during trips on board purse seiners and the R/V l' Amitié since March 2000.

date	purse seine	longline	troll	total
May/June 2000	88			88
January 2001	42			42
May-June 2001	85			85
August 2001		100		100
October 2001	25	49	1	75
November 2001		71	2	73
February 2002		52	1	53
March 2002		13		13
	302	285	4	591

Seasonally, the specific composition of the stomach content is dominated by the stomatopod *Natosquilla investigatoris*. This species is endemic of the western Indian Ocean. Some years, numerous pelagic swarms of *Natosquilla* are found in the area (Losse and Merret, 1971). At that time, they form the main prey item of many fish species even demersal ones. Since 1999, from May to October, they form the bulk of the diet of tunas (Tab. II) and the lancet fish (*Alepisaurus ferox*).

The length-frequency distribution of the specimens found in the stomachs shows the presence of distinct modal groups in May (6-7 mm) and October (10-14mm). It seems to exist a trend in the growth rate between May and October associated to a migration of the stomatopod from the western part of the sampled area to the eastern part. In May, Natosquilla is found in stomachs collected between 50°E-52°E, in October between 55°E-57°E.

It must be compared to the migrating behaviour of the swimming Crab (*Charybdis edwardsi*) in the same area (Zamorov *et al*., 1991). During their pelagic phase, crabs form swarms. Driven by currents from the east African shelf, they seem to spawn in the eastern region of the western Indian Ocean. Larvae are then driften by currents to the shelfs. Occurrence of this crab in the stomach of tunas is high since October to February (Zamorov *et al*., 1991). These crustacea species are not found in the diet of swordfish (*Xiphias gladius)* and sailfish *(Istiophorus platypterus)*.

Table II. Percentage of occurrence of Natosquilla investigatoris in the stomachs collected in October 2001, on board purse seiner.

Predators	No of non-empty stomachs	Preys *Natosquilla*	*Charybdis*
Yellowfin	33	93.9	3.0
Skipjack	11	100.0	0.0
Bigeye	11	90.9	0.0
Barracuda	3	33.3	0.0
Dolphin fish	4	100.0	0.0
Rainbow runner	9	100.0	11.1
Shark	5	100.0	0.0
Lobotes	3	100.0	33.3

Among fish prey, the cigar fish (*Cubiceps sp*.) is the main item. This fish and related species of the family of Nomeidae have been recorded as important in the diet of the yellowfin in the Eastern Pacific (Olson and Boggs, 1986), in eastern Tropical Atlantic (Ménard *et al*., 2000) and in eastern equatorial Atlantic (Bard *et al*., 2001). Juveniles tunas have never been found in great number in the stomach

contents. Cannibalism seems low in this region compared to the eastern Pacific Ocean.

The Costello diagrams show that most of the species of tunas are opportunistic in their diet but with a dominant prey which can change according to the season (Fig. 5). The lancet fish and the swordfish exhibit the same trend. Among tunas, only the big eye seems to have a specialized diet based on fish. But this result must be taken carefully as the number of stomachs analyzed is low.

Crustacea are the dominant prey for skipjack caught from free schools and for skipjack, yellowfin and lancet fish caught from longline. For yellowfin, fish prey is the dominant item for individuals caught from free schools and under FAD's. For the skipjack caught under FAD's no dominant species appears.

DISCUSSION

Seasonally the feeding behaviour of tuna can be directed to a single species if this one is abundant and shoaling. It is the case in the Indian Ocean for *Natosquilla investigatoris* and *Charybdis edwardsi* and in equatorial Atlantic Ocean with the cigar fish (*Cubiceps pauciradiatus*).

There might have relatively short food chains leading to tuna (Fig. 6). There is an order of magnitude between prey size and predator size.

In Atlantic, the mean size of the cigarfish ingested by the yellowfin tuna (1-1.2 m Fork Length) is small (5.7cm). They are juveniles which don't perform diel migrations. Usually, the juveniles concentrate in a constant layer of 20 to 40 m thick found between 40 and 70 m deep. This layer is found all along the day and does not disappear at night. This layer dispersed when a predator chases. In Indian Ocean, Natosquilla plays the same role with individuals comprised between 4 and 7 cm long.

Opportunism would be a dominant feeding strategy based on the co-occurence of the preys and predators. Such hypothesis can serve as a basis for modelling ecosystem. Shin (2000) proposes the Osmose model in which the predation is constrained by space-time co-occurrence and size adaptation for prey selection. The objectives of the model are to understand the ecosystem structure and assess the fishing effects on ecosystems.

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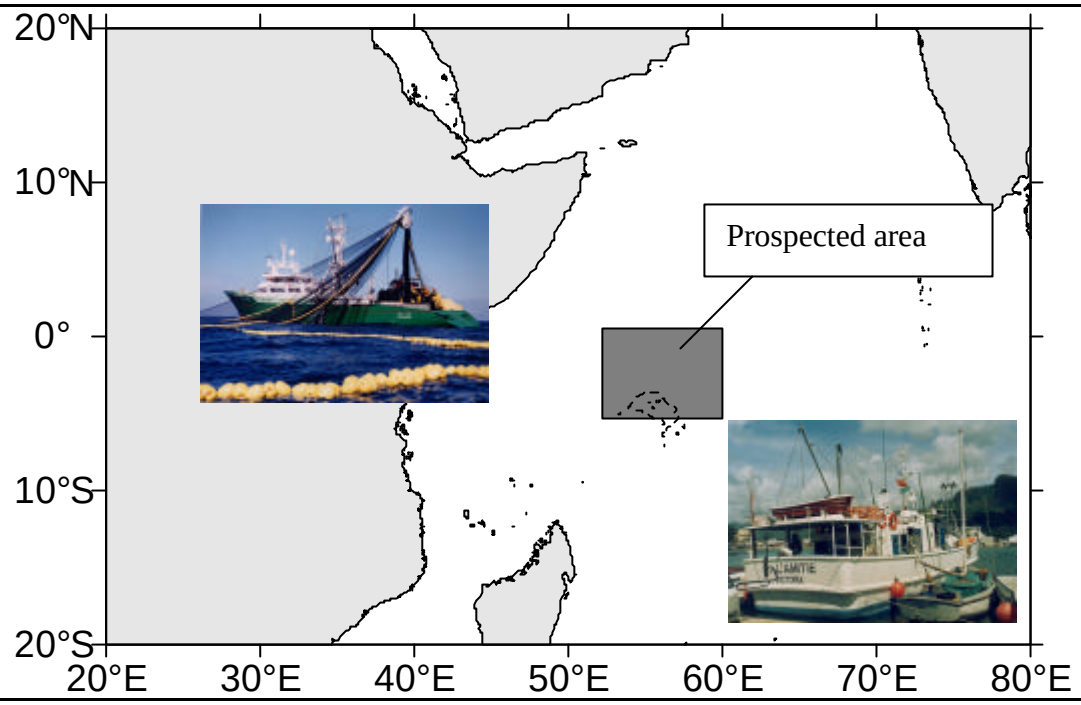

Figure 1. Equatorial area prospected since May 2000 with purse seiners and the R/V l'Amitié.

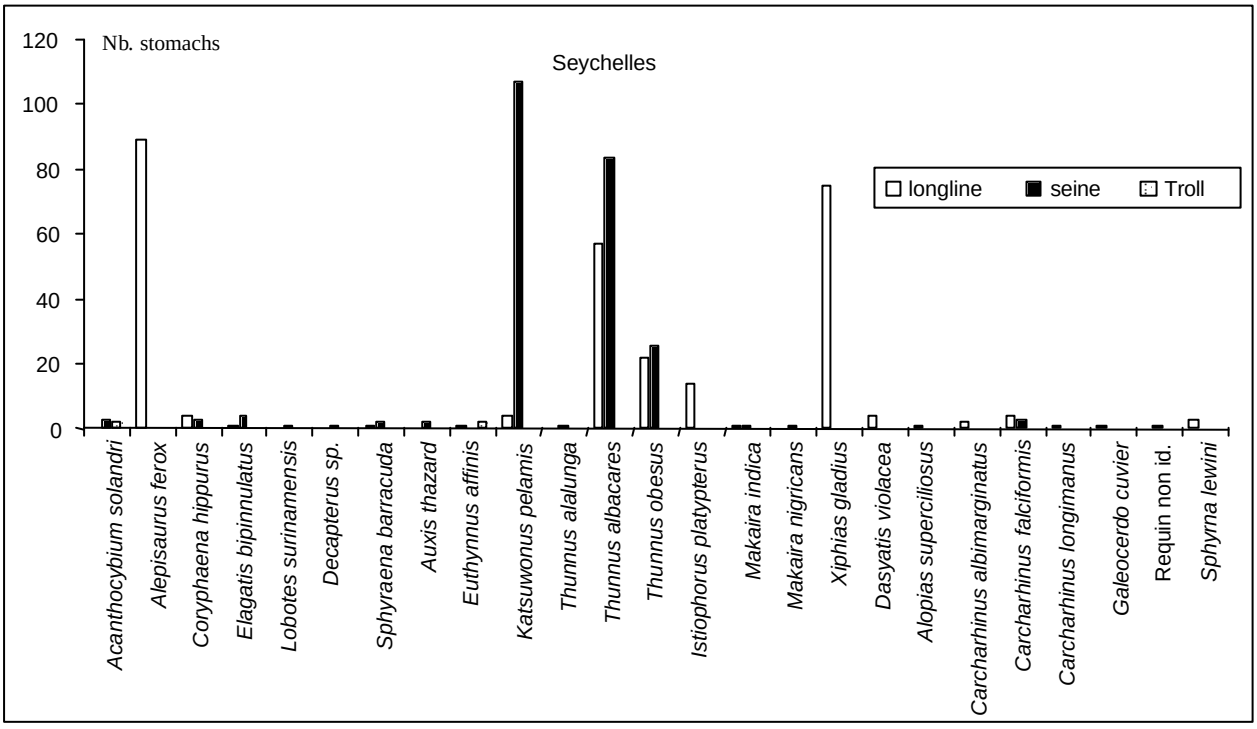

Figure 2. Number of stomachs collected by species during the trips made in the equatorial western Indian Ocean since May 2000.

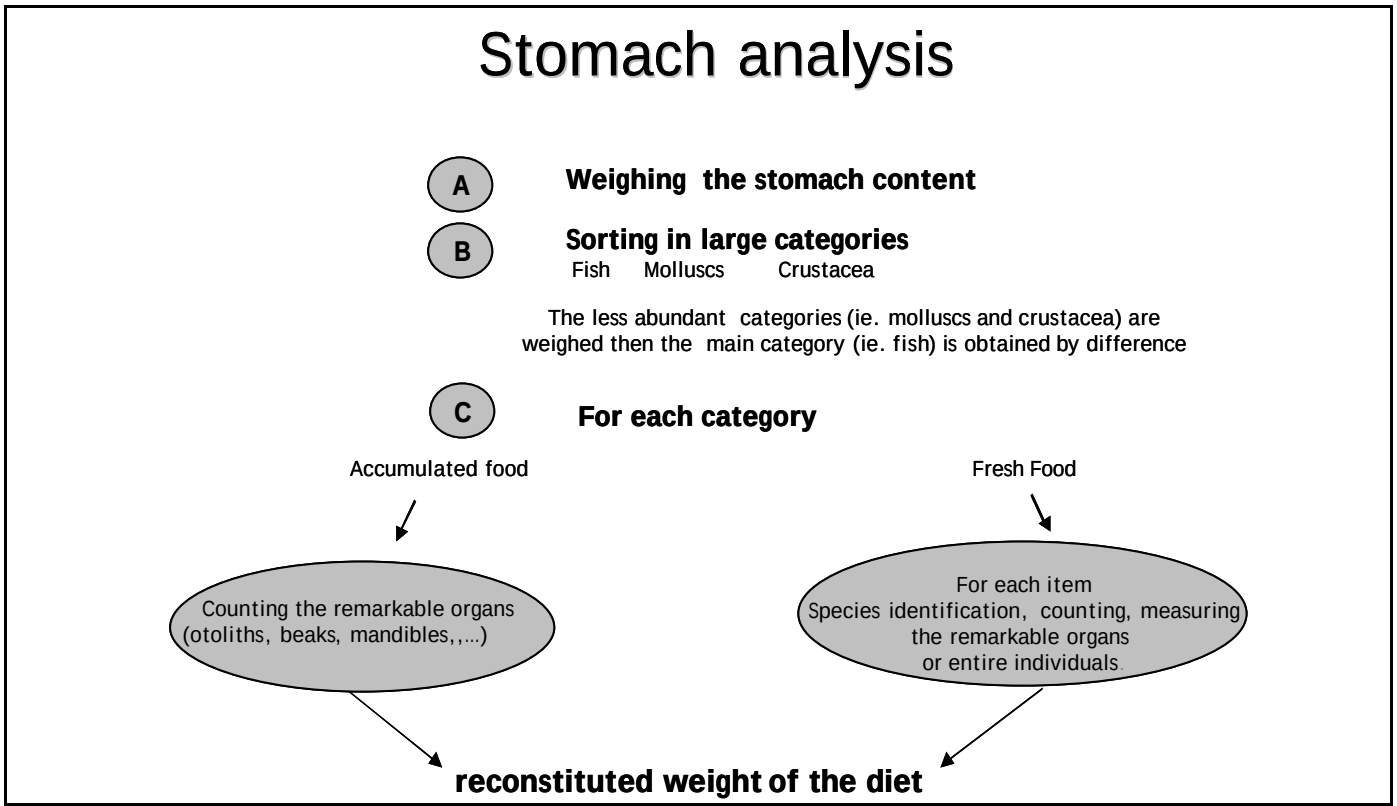

Figure 3. Method used to analyze the stomach contents in the Thetis program.

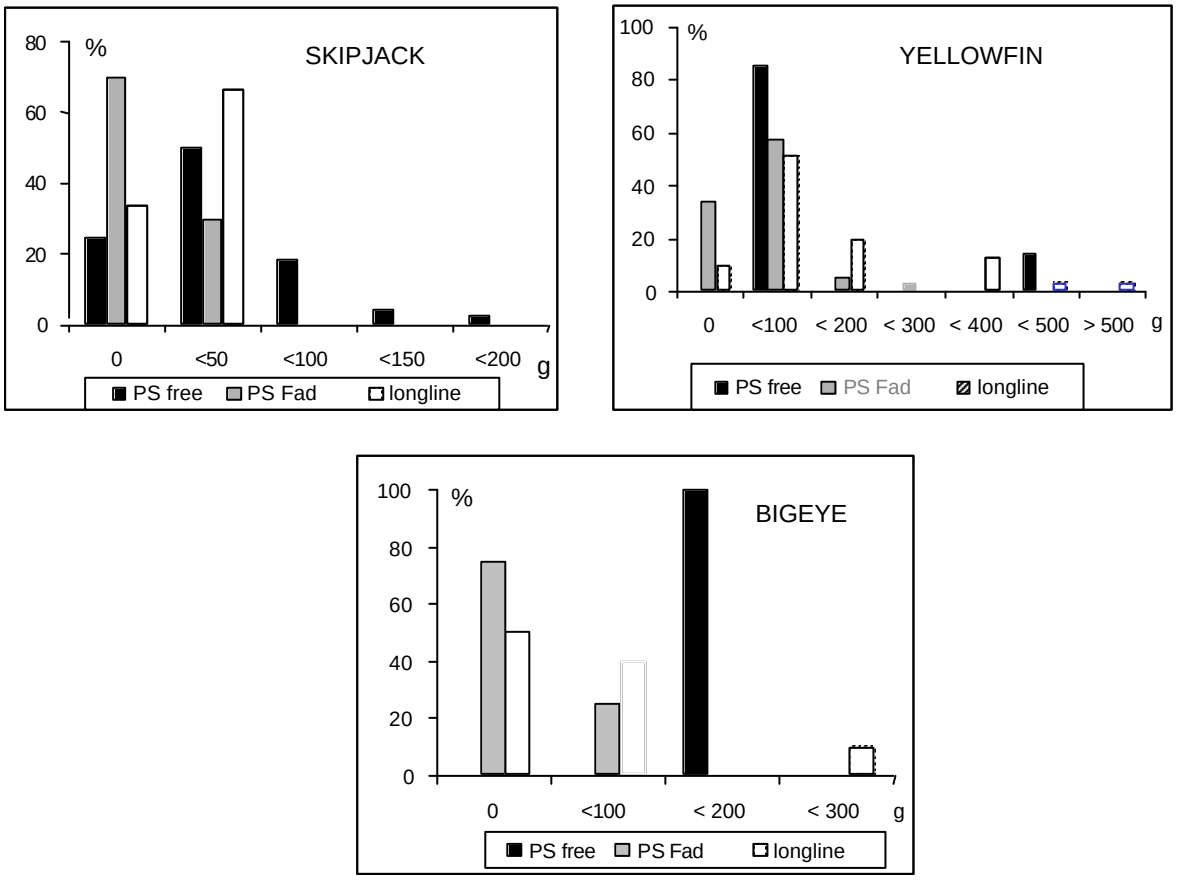

Figure 4. Stomach contains (in weight) for the three species of tunas sampled from May 2000 to March 2002 on board purse seiners and R/V l'Amitié.

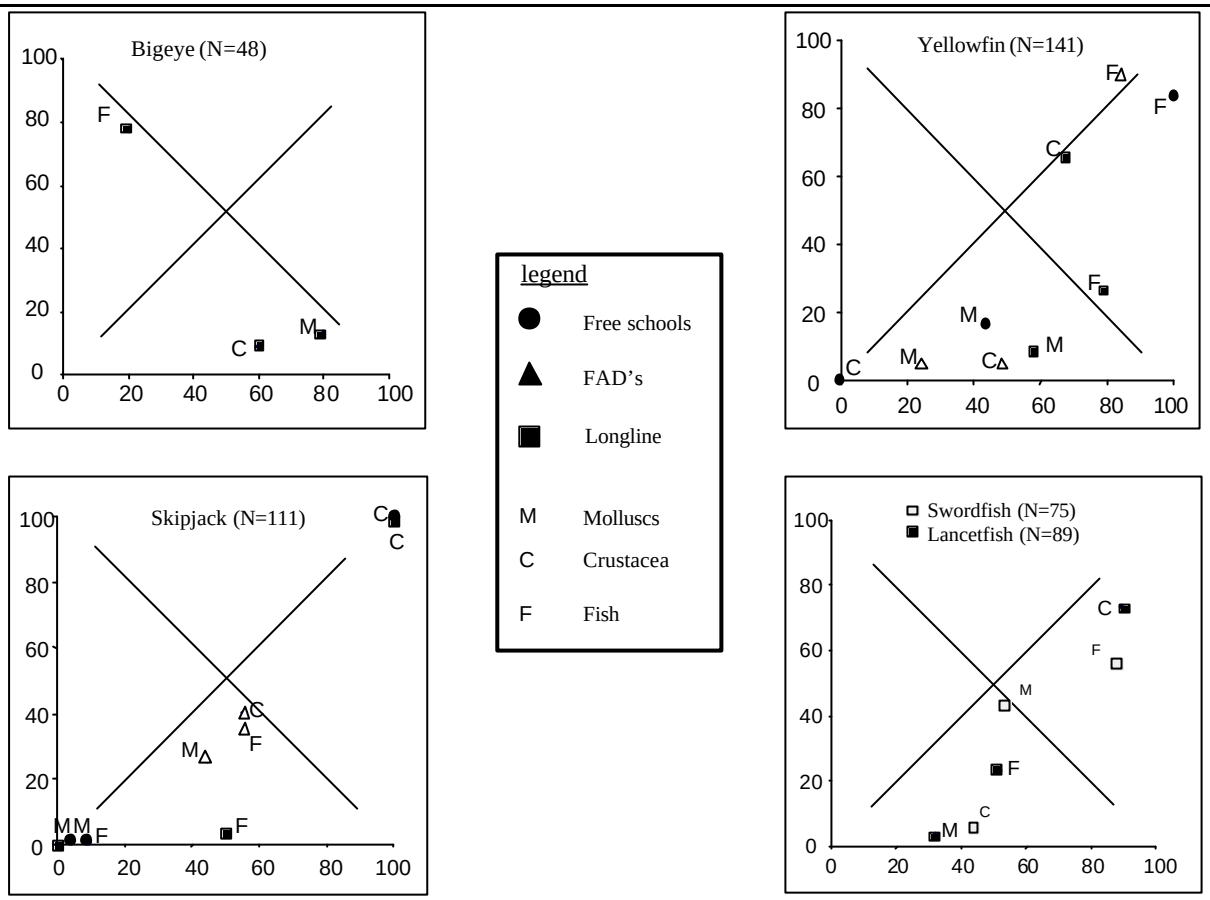

Figure 5. Costello diagrams for the three species of tunas, the swordfish and the lancet fish sampled from May 2000 to March 2002,

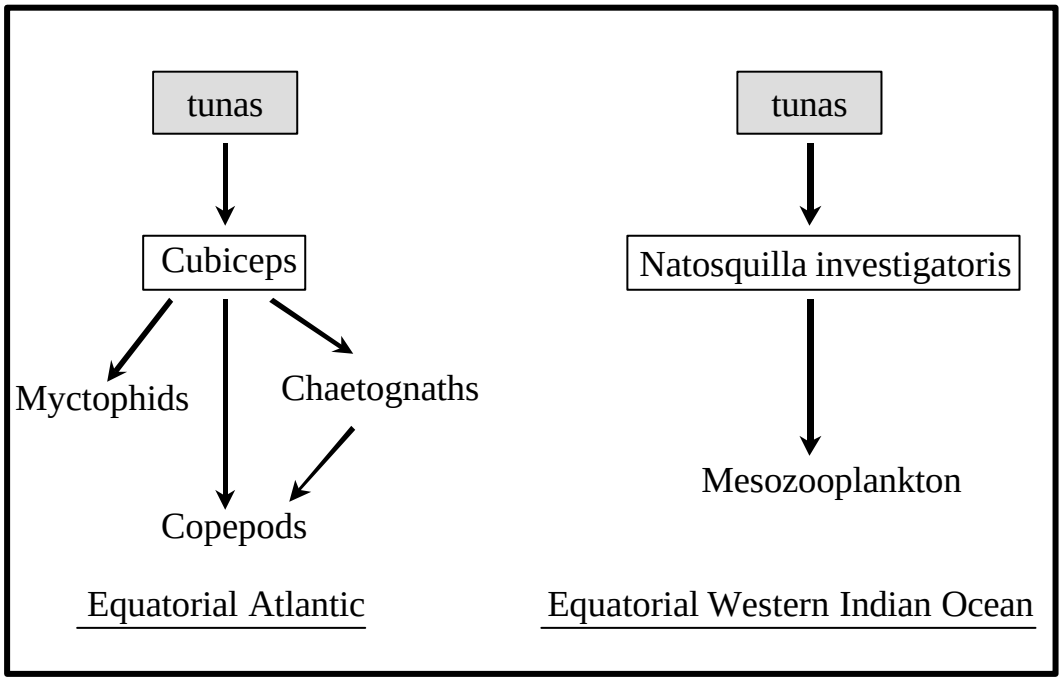

Figure 6. Hypothetical food chains leading to tunas in the equatorial regions of Atlantic and western Indian ocean.