ON TROPHIC RELATIONSHIPS AT HIGHER LEVELS OF THE FOOD CHAIN IN THE TROPICAL PACIFIC OCEAN
(Abstract)

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This article tentatively synthesizes recent studies of the trophic relationships within the equatorial and tropical pelagic community by the team of the "Centre ORSTOM" - Nouméa (Nouvelle-Calédonie).

All data was collected during cruises of the R.V. "CORIOLIS" in the Equatorial and South Tropical regions of the Central and Western Pacific Ocean. More than 1500 samples have been collected using a 10 feet Isaacs-Kidd midwater trawl and a one-meter plankton net attached (0.33 mm mesh width), from average depths of 1100 m, 850 m, 550 m, 270 m, 130 m and 70 m, during periods of daylight and darkness. Additional sampling was done using a closing-opening ORI-33 (Mouth diameter : 1.6 m) and a pelagic trawl for larval fishes (50 m^2 surface opening). Tunas and Alepisaurus were caught using troll-lines, horizontal long-lines fitted and set in the Japanese way, and vertical long-lines.

I. - VERTICAL ZONATION OF THE PELAGIC FAUNA :

Part one describes diel changes in the vertical distributions of the plankton, micronekton and nekton principal components; species by species when it was possible (Fishes, Amphipods, Euphausiids), and according to various taxonomic groupings for other organisms. Some details are given on

the sampling procedures out at sea and on the processing of the samples in the laboratory : different methods for analysing data from oblique hauls are briefly discussed.

On the whole, the micronektonic fishes were caught only below 450 m in the daytime and up to the surface layers during the night. According to their diel changes in vertical distribution those tropical and equatorial micronektonic fishes may be classified into two ecological groups, i.e. :

1/ - deep non-migrants : three species of the genus Cyclothone, C. alba, C. acclinidens and C. pallida, which together account for 62% of the total number of micronektonic fishes, and the hatchet-fish Sternoptyx diaphana, apparently undertake only low range vertical migrations, their maximum density being located day-and-night between 500 m and 800 m.

2/ - midwater migrants : the habitat of which is confounded with that of the non-migrants species during daytime, and which move at night to the upper layers and even to the surface. There is no difference between the day and night catches in the column of water 1200 m-deep for most of the Myctophids studied : Lepidophanes photothorax, L. longipes, Lampanyctus hubbsi, Ceratoscopelus warmingi, Diaphus termophilus, D. fulgens, D. fragilis, D. regani, D. lutkeni, Diogenichthys laternatus, D. atlanticus, Hygophum reinhardti and H. proximum. Differences observed for Vinciguerria nimbaria, Lampanyctus niger and Symbolophorus evermanni may be due to daytime avoidance and juveniles escapement through the meshes, combined with possible diel changes in the spatial distribution and patchiness. The range of the vertical migration varies from 200 m (e.g. Diaphus regani and D. fulgens) to 700 m (e.g. Ceratoscopelus warmingi and Symbolophorus evermanni), and in most cases only one part of the population of a migrant fish do ascend at night, the other part staying at its daytime level. Distribution patterns may change with location and time of the sampling, with physiological events and generally speaking with growth of the fishes (e.g. Lampanyctus niger).

Variations of the vertical distribution with the size of the animals were also noticed for larvae and post larvae of the family Cranchiidae (Cephalopoda) : young larvae being constant surface dwellers while deeper sub-adults migrate at night from 900 m up to 300 m. Some Onychoteuthidae may have reverse migration.

During the night, 75% of the total biomass of the thirty or so Euphausiids identified is concentrated in the 0-150 m layer. In the daytime the small size species have a tendency to stay in that layer, while larger species are more abundant between 450 m and 700 m. The principal species have been classified into four ecological groups according to their vertical distribution :

1) small-size epipelagic species which occupy the upper 200 m layer : Stylocheiron carinatum, Euphausia tenera, S. affine;

2) midwater non-migrant species which inhabit the 50-500 m layer : S. abbreviatum, S. longicorne, Nematoscelis tenella, S. maximum;

3) deep non-migrant species : S. elongatum (300-600 m), Nematobrachion boopis and Thysanopoda cristata (300-800 m), Bentheuphausia amblyops (600-1000 m);

4) migrating species which move at night from their daytime level (400 m to 800 m) up to within the mixed layer, E. diomedae, T. tricuspidata, T. aequalis, E. paragibba, or in a broader layer including the D.S.L., N. microps, N. gracilis, T. pectinata T. monacantha, T. orientalis and N. flexipes.

Amphipods of the outstanding family Phronimidae are constant surface dwellers, being absent below 450 m and most abundant day and night in the 0-110 m layer. The range of their diel vertical migrations may not exceed a dozen meters (e.g. Phronima atlantica) while the range of others (e.g. P. sedentaria and Phronima semilunata) may be larger.

Day and night vertical distributions are also given for some other typical groups of the micronekton : midwater larger Copepods, Carids, Sergestids, Peneids, Mysids, Heteropods, Pteropods and meroplanktonic organisms.

Thus the micronektonic organisms are far from being uniformely distributed in the surveved waters, and most of them are concentrated in usually well limited layers. The depths of the concentration levels vary on a diel basis and following their respective positions, the components of the micronekton collected with a 10 ft. Isaacs-Kidd midwater trawl were arranged into three faunas :

- superficial fauna : surface to 450 m, day-and-night,
- deep fauna : below 450 m, day-and-night,
- interzonal fauna : below 450 m by day, and between the surface and about 950 m by night.

Thunnus alalunga, T. obesus and T. albacarres were caught virtually from the surface down to 400 m and even deeper, the hooking rates being fairly uniform all through that layer. The lancet-fish Alepisaurus ferox possibly has a maximum around 150 m.

II. - TROPHIC INTER RELATIONSHIPS OF THE PELAGIC FAUNA

Part two gives a provisional account of the feeding habits of some micronektonic fishes, of the organisms eaten by tunas and of tunas themselves.

About 2000 fish stomach contents have been analyzed, and the micronektonic fishes collected with a 10 ft. Isaacs-Kidd trawl are shown to feed on a wide variety of preys, with a marked predominance of Copepods and small Euphausiids for the smaller species and the smaller sizes, and of large Euphausiids, Fishes and Fish larvae while their size increases. Myctophids display rather different nutritional rythmes, for instance Lepidophanes, N. valdiviae and D. lutkeni feed all day long with the same intensity, while T. microchir and L. hubbsi feed at night, the former at the beginning and the latter at the end of the night. The Gonostomatid V. nimbaria also feeds in the early night and its digestion is almost completed before dawn. As it is the case for some species (e.g. S. diaphana and D. multistriatus) the weight of the stomach content may increase with the body weight, following a logarithmic law.

Fishes preyed on by tunas, and from whom only larvae and post-larvae are collected with nets, may be classified into three categories according to their diets :

- Centropyge and Anthias prey on copepods,
- Taractes, Collybus, Pteraclis and young Alepisaurus feed on larger Crustaceans and on Fishes,
- Pseudoscopelus, Lestidiops and Scombrolabrax are strictly ichthyophagous.

The ichthyofauna eaten by the latter two categories is almost entirely composed of superficial organisms, such as the larvae of deep-water and interzonal fishes, as well as the young stages of surface fishes. The genus Stylocheiron supersede the other Euphausiids in the stomach contents thus giving some ground to suggest that those fishes feed mainly by day, from the surface down to 400 m.

It is deduced from these observations that both fishes from the Isaacs-Kidd midwater trawl and fishes from the tunas stomach contents commonly feed in the upper layers : the former being night-feeders and the latter day-feeders.

The fauna found in the stomachs of the deep-swimming tunas which inhabit the tropical regions surveyed is far different from the micronekton sampled with a 10 ft. Isaacs-Kidd midwater trawl, as already noticed by various authors. Cephalopods are much more numerous in the stomachs than in the nets, and on the contrary Crustaceans, which compose between 30% and 40% of the total biomass collected with the trawl, are almost absent from the stomach contents. Coastal fishes, most of them in post-larval or juvenile stages, are important food items for the tunas caught by long-lines : 30% of the total number of ingested fishes for T. alalunga, 60% for T. albacarres. Off-shore pelagic fishes belonging to the families Bramidae, Ostracionidae, Alepisauridae, Paralepididae, Gempylidae, Chiasmodontidae, Molidae, Anoplogastridae, Exocoetidae, Scombrolabracidae, Thunnidae and Caristiidae are collected in very small numbers by the nets while they form more than 60% of the pelagic fishes eaten by the deep-swimming tunas. Only 18 species of off-shore fishes have been found, at

adult or sub-adult stages, both in the nets and in the stomach contents : the principal common species being Sternoptyx diaphana, Argyropelecus olfersi, Hoplolatilus sp, Diplospinus multistriatus and different species from the genera Psenes and Cubiceps. With the exception of Vinciguerria nimbaria, interzonal fishes, mostly Gonostomatidae and Myctophidae, are seldom encountered in tunas stomach contents. It was observed that Alepisaurus ferox feeds on that migrant ichthyofauna much more than tunas do. Moreover tunas consume a large variety of other organisms : large females of Phronimidae, Stomatopods and Scyllarids larvae, Leptocephals, Annelids, Heteropods, Pteropods... the importance of which varies a lot according to seasons and regions, but they feed only negligibly on Euphausiids and large Crustaceous species - Ingested Cephalopods and Fishes were measured and proved to be of a larger size and in later stages than those caught by the nets.

Along with the failure of night long-lining to catch tunas, these feeding habits clearly indicate that the deep-swimming tunas of the Central and Western Pacific feed during day-time, from the surface down to 450 m and perhaps deeper.

CONCLUSIONS

The pelagic fauna from these regions have been diagrammatically divided into two ecosystems, following the vertical distributions and the trophic relationships hereby described :

1) The superficial system, the lower limit of which in estimated to be 450 m, includes almost the whole of zooplankton, the superficial micronektonic and nectonic fauna, and at night the migrating part of the interzonal fauna. Tunas feed exclusively within that system and their predation is limited to the large day-available species.

2) The deep system, beneath 450 m, includes a very poor amont of zooplnakton,a part of the deep micronektonic fauna, and by day the whole interzonal fauna.

The superficial system includes the phytoplankton as a whole and then possesses its own source of energy, the deep system, on the contrary, does not have any primary production that could be compared to that of phytoplankton and derives most of its energy from the superficial system through the medium of the interzonal fauna.

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Legand Michel, Bourret Philippe, Fourmanoir Pierre, Grandperrin René, Guérédrat Jean-Alfred, Michel Alain, Rancurel Paul, Repelin Roger, Roger Claude (1972)

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