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# The Role of Slender Tuna, *Allothunnus fallai*, in the Pelagic Ecosystems of the South Pacific Ocean

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**Abstract** Gonad condition and stomach contents were examined in 2257 specimens of *Allothunnus fallai* (463–896 mm fork length) caught by surface driftnets from the high seas of the South Pacific (20–54°S, 74–150°W) during 1985–1987. Subtropical waters and the Peru Current north of 31°S were considered to be the spawning grounds of slender tuna during October, November and December. From November to February, feeding grounds were located in subantarctic waters and the Peru Current south of 38°S, where slender tuna preyed mainly upon euphausiids, squids, copepods, young myctophid fish and amphipods. The dominant species in the diets were *Euphausia vallentini*, *E. lucens*, *Thysanoessa gregaria* and *Neocalanus tonsus* throughout the subantarctic waters. Young of the squid, *Martialia hyadesi*, dominated in the Southeast Pacific and *Moroteuthis* spp. were common in the subantarctic waters of the central South Pacific. Hyperiid amphipods, *Primno macropa* and *Themisto gaudichaudii*, were common but gravimetrically much less important in the diet. Adult slender tuna were preyed upon by *Isurus oxyrinchus*, *Prionace glauca*, *Xiphias gladius* and *Makaira mazara* in subtropical waters, but not so in subantarctic waters. *Allothunnus fallai* was considered to be a highly migratory species, with a life-style adapted to the seasonally fluctuating biomass of zooplankton in subantarctic epipelagic waters.

Slender tuna, *Allothunnus fallai* Serventy, is an oceanic species endemic to the southern hemisphere, although with two unusual records reported from the North Pacific; i.e., Los Angeles Harbor, California and off Palau Island (Mori, 1972; Collette and Nauen, 1983). A monotypic genus, *Allothunnus* was transferred from the tribe Sardini to the Thunnini by Cressey et al. (1983). A series of driftnet surveys by the Japan Marine Fishery Resources Research Center (JAMARC) from 1982 to 1989 revealed that the species is very abundant in South Pacific subtropical and subantarctic waters.

Many South Pacific oceanic fishes have closely-related species or counterparts in the North Pacific, e.g., *Lamna nasus*–*L. ditropis*, *Brama brama*–*B. japonica*, *Pseudopentaceros richardsoni*–*P. wheeleri*. The lack of a North Pacific congener of *A. fallai* poses a question regarding its role in pelagic ecosystems.

Diets of *A. fallai* have been based on a relatively small number of specimens obtained either from subtropical (Mori, 1967) or coastal waters (Olsen, 1962; Fitch and Craig, 1964; Wolfe and Webb, 1975), euphausiids, amphipods, small fishes, squids, miscellaneous other planktonic animals and the 'ocean strider' (*Halobates*) reportedly being eaten. On the basis of these observations and brain morphology (Uchihashi, 1970), together with the presence of well-developed gill rakers (Nakamura and Mori, 1966), Warashina and Hisada (1972) concluded that *A. fallai* is an epipelagic plankton feeder. The feeding habits of the species on the high seas, however, have not been documented.

The present paper describes trophic relationships of slender tuna in the high seas of the South Pacific and discusses some characteristics of South Pacific pelagic ecosystems.

## Materials and Methods

Epipelagic fishes were collected with 10 m deep surface driftnets. Stretched mesh size of the nets ranged from 104 to 216 mm, but was mostly between 150 and 180 mm, reportedly the most effective size for capturing *Allothunnus fallai* of about 63–82 cm fork length (FL) (Yatsu and Watanabe, 1987). In a typical fishing operation, nets of length about 22 km were set at dusk and retrieved early in the following morning. A total of 137 fishing operations were

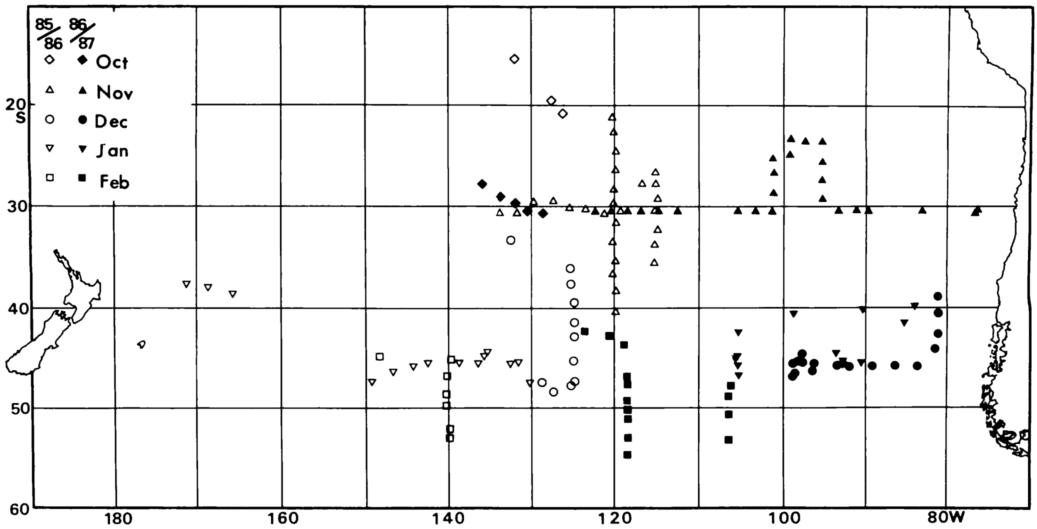


**Fig. 1.** Location of driftnet fishing operations by month and year.

conducted from September 1985 to February 1987 in international waters of the South Pacific (Fig. 1) where *A. fallai* were caught within 20–54°S, 74–150°W. The 132 stations with positive catches of *A. fallai* were divided into four hydrographic regions based on Sverdrup et al. (1947) and Hofmann (1985): Peru Current North (east of 84°W and north of 31°S), Peru Current South (east of 88°W and south of 38°S), Subtropical (west of 88°W and north of 40°S) and Subantarctic (west of 88°W and south of 40°S). For the stomach content analyses, the Subantarctic region east of 125°W, corresponding to the 1986/87 survey area, was further divided into five subregions bounded by latitude 48°S, and longitudes 100°W and/or 110°W: NE (north-east), NC (north-central), NW (north-west), SC (south-central) and SW (south-west).

During each fishing operation, about 20 specimens of *A. fallai*, representing the range in fork length of the catch, were sampled for biological investigations on board the vessel. In all, 2257 specimens of *A. fallai* (463–896 mm FL) were examined, data including fork length, body weight, gonad condition, weights of stomach contents and gonads, and stomach contents being recorded. Ovaries with transparent eggs and testes with running sperm were interpreted as mature. A gonadal somatic index (GSI) defined as the percentage of gonad weight per total body weight was determined. Stomach contents were recorded under the following taxonomic categories: copepods, amphipods, euphausiids, squids, fishes, and miscellaneous. Wet weights for each of the above categories were measured to the nearest gram during the 1986/87 survey, whereas only total weights of stomach contents were recorded during the 1985/86 survey. Subsamples were taken from stomach contents and fixed in 5% buffered formalin for subsequent laboratory examination.

Each subsample was transferred to 50% isopropanol in the laboratory and prey items identified to the lowest possible taxon generally based on Sweeney et al. (1992) for squids, Gon and Heemstra (1990) for fishes, Owre and Foyo (1967), Brodskii (1972) and Bradford and Jillett (1974) for copepods, Bowman and Gruner (1973), Bowman (1978) and Schneppenheim and Weigmann-Haass (1986) for amphipods, and Kirkwood (1982) and Baker et al. (1990) for euphausiids. Although neither number of prey individuals nor weight of each taxon was recorded due to the high individual numbers, their abundance was estimated and rated on a scale as cc (very common), c (common), r (rare) or rr (very rare).

To detect geographic differences in the composition of stomach contents, Somerton's (1991) nonparametric method (DIETTEST) was used, wherein statistical differences in the gravimetric proportions of major prey items (euphausiids, copepods, squids and fishes in this study) between areas are evaluated

**Table 1.** Fork length, percentage of specimens by gonad condition, GSI, and percentage of empty stomachs and stomach content weight per body weight (SCW/BW in percent) of slender tuna by area, year and sex

| Area | Year | Sex | *n* | Fork length (mm) | | | Gonad condition (%) | | | | GSI | | Empty stomachs (%) | SCW/BW* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Range | Mean | SD | Immature | Maturing | Mature | Spent | Mean | SD | | Mean | SD |
| Subtropical | 1985/86 | Female | 321 | 690–881 | 781 | 36 | 0 | 37 | 48 | 15 | 6.71 | 2.86 | 87 | 0.004 | 0.038 |
| | | Male | 296 | 632–820 | 731 | 26 | 2 | 7 | 90 | 1 | 4.80 | 1.95 | 83 | 0.015 | 0.123 |
| Subtropical | 1986/87 | Female | 257 | 707–896 | 781 | 37 | 0 | 35 | 54 | 11 | 8.14 | 2.70 | 77 | 0.006 | 0.081 |
| | | Male | 253 | 650–838 | 725 | 28 | 0 | 0 | 99 | 1 | 5.50 | 1.92 | 70 | 0.003 | 0.019 |
| Peru Current North | | Female | 11 | 698–893 | 798 | 53 | 0 | 82 | 9 | 9 | 4.92 | 2.14 | 82 | 0.025 | 0.056 |
| | | Male | 6 | 612–812 | 721 | 64 | 17 | 0 | 83 | 0 | 4.29 | 1.76 | 33 | 0.572 | 1.088 |
| Peru Current South | | Female | 62 | 494–879 | 762 | 106 | 21 | 18 | 0 | 61 | 1.09 | 0.97 | 50 | 0.326 | 0.601 |
| | | Male | 29 | 463–787 | 675 | 99 | 66 | 0 | 28 | 7 | 0.61 | 1.03 | 48 | 0.212 | 0.401 |
| | | Unsexed | 2 | 491–505 | 498 | 10 | 100 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 1.566 | 0.559 |
| Subantarctic | 1986/87 | Female | 269 | 532–883 | 771 | 55 | 13 | 4 | 0 | 84 | 0.93 | 0.90 | 25 | 0.459 | 0.703 |
| | | Male | 229 | 533–807 | 726 | 43 | 78 | 0 | 21 | 0 | 0.55 | 0.77 | 27 | 0.481 | 0.774 |
| | | Unsexed | 2 | 517–542 | 530 | 18 | 100 | 0 | 0 | 0 | 0.01 | 0.00 | 50 | 0.025 | 0.035 |
| Subantarctic | 1985/86 | Female | 242 | 503–873 | 765 | 60 | 13 | 5 | 0 | 81 | 0.93 | 0.59 | 36 | 0.560 | 0.908 |
| | | Male | 278 | 511–794 | 721 | 36 | 85 | 2 | 4 | 9 | 0.38 | 0.70 | 29 | 0.711 | 1.002 |

* Values of empty stomachs were included in calculating mean and standard deviations of SCW/BW.

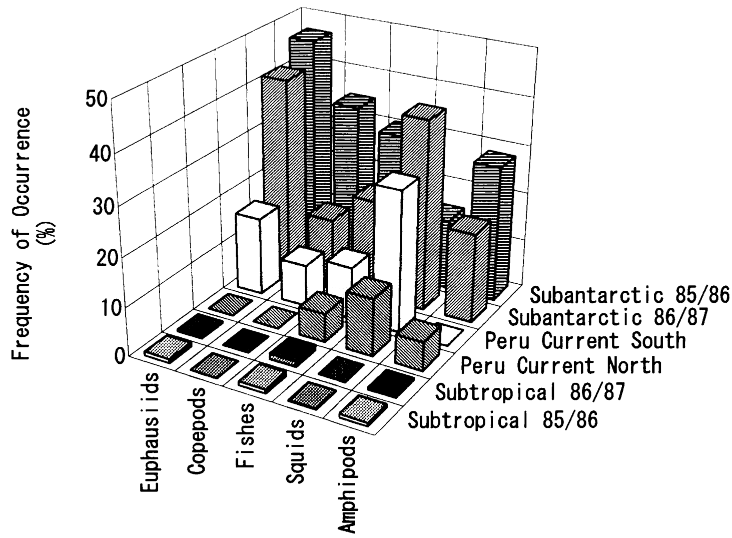


**Fig. 2.** Percentage frequency of occurrence of major diets of slender tuna by region and year.

by a thousand iterations of random resampling of the original data set. Since data on diet composition by weight were available only for the 1986/87 survey, the method was adopted for the Peru Current South region and the five subregions in the Subantarctic region east of 125°W. Because the very low numbers of copepods in subregions NW, SC and SW prevented successful completion of the algorism of DIETTEST for these areas, data on three major prey items other than copepods were used.

To identify predators of *A. fallai*, stomach contents of the following incidentally-caught species were examined and frequency of occurrence of each prey item recorded: *Isurus oxyrinchus*, *Lamna nasus*, *Prionace glauca*, *Xiphias gladius*, *Makaira mazara* and *Gasterochisma melampus.*

## Results

### Gonadal somatic index and stomach condition

Size variations between regions were negligible for each sex, mean fork lengths varying by region from 762 to 781 mm (females) and 675 to 731 mm (males) (Table 1).

The GSI values for male and female *Allothunnus fallai* were high in the Subtropical and Peru Current North regions, where most of the samples were taken during October and November, in contrast to very low GSI values among fish caught in the Subantarctic and Peru Current South regions (Table 1). In the former regions, percentages of mature males and females were also high (Table 1).

The percentage of empty stomachs was high in the Subtropical region, moderate in the Peru Current North and South regions and low in the Subantarctic region (Table 1). The mean weight of stomach contents per body weight of fish was high in the Subantarctic region, moderate in the Peru Current regions and almost zero in the Subtropical region (Table 1). The frequency of occurrence of each prey class was also high in the Subantarctic region and very low (<1.2%) in the Subtropical region (Fig. 2). Although the sample size was small in the Peru Current North region, frequencies of occurrence of squids, fishes and amphipods were 12%, 6% and 6%, respectively.

On the basis of the combination of GSI and stomach condition results, the study area could be divided into spawning grounds (Subtropical and Peru Current North regions) and feeding grounds (Subantarctic and Peru Current South regions).

### Stomach contents of slender tuna

A list of the species identified from the stomach contents of *A. fallai* is shown in Table 2, along with their approximate abundance.

Euphausiids were the most frequently recorded

**Table 2.** List of taxa collected from stomachs of slender tuna, with approximate abundance in the diets

| Taxa | Abundance |
|---|---|
| Mollusca | |
| Gastropoda | |
| Atlantidae | |
| *Oxygyrus* sp. | rr |
| Cephalopoda | |
| Ommastrephidae | c |
| *Martialia hyadesi* | c |
| Onychoteuthidae | c |
| *Moroteuthis ingens* | c |
| *M.* spp. | c |
| Gonatidae | c |
| Brachioteuthidae | |
| *Brachioteuthis picta* | r |
| Cranchiidae | c |
| *Teuthowenia pellucida* | r |
| Crustacea | |
| Copepoda | |
| *Neocalanus tonsus* | cc |
| *Euchirella rostrata* | r |
| *Pleuromamma* sp. | rr |
| *Euchaeta* sp. | rr |
| Amphipoda | |
| *Lanceola* spp. | r |
| *Themisto gaudichaudii* | cc |
| *Phronima* spp. | r |
| *Phrosina* spp. | r |
| *Primno macropa* | cc |
| *Brachyscelus*? | r |
| Euphausiacea | |
| *Euphausia vallentini* | cc |
| *E. lucens* | cc |
| *E. similis* var. *armata* | r |
| *E. longirostris* | r |
| *E.* spp. | r |
| *Thysanoessa gregaria* | cc |
| *T.* spp. | c |
| *Nematoscelis megalops* | r |
| *N.* spp. | r |
| *Stylocheiron maximum* | c |
| *S.* spp. | c |
| Chaetognatha | |
| Sagittoidea | c |
| Tunicata | |
| Thaliacea | c |
| Vertebrata | |
| Osteichthyes | |
| Bathylagidae | r |
| Paralepididae | r |
| *Arctozenus risso* | rr |
| *Lestidium* sp. | rr |
| *Paralepis* sp. | rr |
| Anotopteridae? | rr |
| Myctophidae | c |
| *Anoplogaster cornuta* | rr |
| *Trachurus* sp. | rr |
| Gempylidae | r |
| Aves | |
| Unidentified bird feather | rr |

cc, very common; c, common; r, rare; rr, very rare.

diet from the Subantarctic region, being found in 41% and 46% of stomachs examined in 1985/86 and 1986/87, respectively (Fig. 2). They were found in 16% of the stomachs from the Peru Current South region, but were absent from the Peru Current North region. Dominant species were *Euphausia vallentini*, and *Thysanoessa gregaria*, found south of 46°S between 96°W and 140°W, and *Euphausia lucens*, found within 44–53°S, 96–140°W.

Squids were identified in 39% and 29% of stomachs examined from the Subantarctic region in 1986/87 and Peru Current South region, respectively, and in 15% of stomachs examined from the Subantarctic region in 1985/86. Dominant species in 1986/87 were young *Martialia hyadesi* and other unidentified ommastrephids (20–102 mm mantle length [ML]; usually 20–60 mm), young onychoteuthids (10–30 mm ML) and gonatids (18–35 mm ML). *Martialia hyadesi* was found within 44–48°S, 81–118°W. *Moroteuthis ingens* and *M.* spp. (ca. 11–80 mm ML) were common in the Subantarctic region in 1985/86.

Copepods were the second most frequently occurring prey item (34% of stomachs examined) in the Subantarctic region in 1985/86, but only fifth (14%) in 1986/87 and fourth in the Peru Current South region (9%). The copepods identified mostly comprised fifth copepodites and adult females of *Neocalanus tonsus.*

Fishes were the third most frequently taken prey with frequencies of occurrence, 30%, 21% and 10% among the stomachs examined from the Subantarctic region in 1985/86 and 1986/87, and the Peru Current South region, respectively. *Anoplogaster cornuta* and *Trachurus* sp. were the only fish species identified in the samples taken from the Subtropical region. Myctophid subadults (ca. 20–50 mm SL) dominated in the diets of slender tuna in the Subantarctic region within 44–51°S, 81–142°W.

Amphipods ranked fourth in prey frequency, comprising 28% and 18% in the Subantarctic region in 1985/86 and 1986/87, respectively. They were absent from samples taken from the Peru Current South region. *Phronima* spp. were eaten primarily by slender tuna caught between 40°S and 46°S, with a single record of predation from 30°S, 90°W. *Primno macropa* and *Themisto gaudichaudii* were more commonly consumed than *Phronima* spp., being found in the diets of fish caught between 41°S and 53°S and south of 44°S, respectively.

Gravimetrically, squids were the most important dietary item in 1986/87 in the Subantarctic and Peru

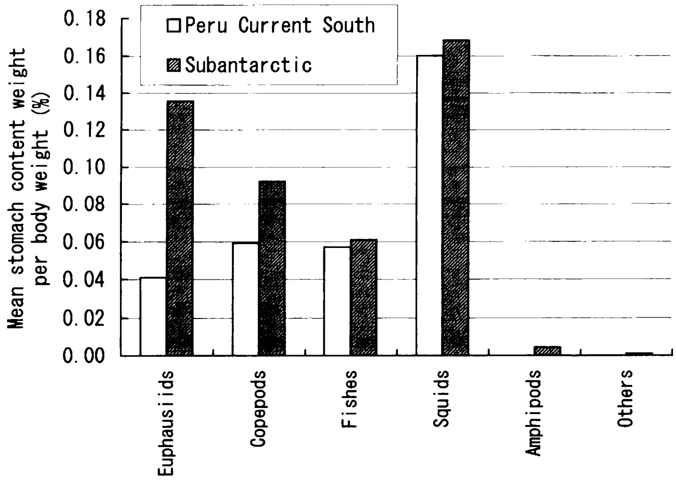


**Fig. 3.** Percentage weight of food items in the diet of slender tuna by region in 1986/87.

Current South regions (Fig. 3). Euphausiids and copepods were more frequently consumed in the Subantarctic region than in the Peru Current South region, whereas squids and fishes were at similar levels in both regions. Amphipods accounted for only 1% of the diet by weight in the Subantarctic region. The composition of major prey items, however, differed considerably among the subantarctic subregions (see below).

Table 3 includes the gravimetric composition of major prey items and related information for the subregions within the Subantarctic region and in the Peru Current South region covered in 1986/87. Euphausiids were more dominant in the western and southern subregions, whereas squids were more abundant in eastern areas, including the Peru Current South region. Copepods were most dominant in subregion NC and were moderate in eastern areas. Fishes ranked second in subregion SW and were moderately abundant in other areas.

The results of the statistical tests indicated significant differences in the gravimetric compositions of major prey items between all combinations of subregions, with the following exceptions: between Peru Current South and NE, between NC and SC, and among NW, SC and SW (Table 4). Thus, the study

**Table 3.** Number of stomachs examined, percentage of empty stomachs and mean weight per body weight (%) of major diets of slender tuna by region in 1986/87

| Region/subregion | | *n* | Empty stomachs (%) | Mean diet weight per body weight (%)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Euphausiids | Copepods | Fishes | Squids | Others | Total |
| Peru Current South | | 93 | 54 | 0.041 | 0.059 | 0.057 | 0.160 | 0.000 | 0.317 |
| | | | | (13) | (19) | (18) | (50) | (0) | (100) |
| Subantarctic | NE | 252 | 33 | 0.053 | 0.061 | 0.036 | 0.359 | 0.004 | 0.513 |
| | | | | (10) | (12) | (7) | (70) | (1) | (100) |
| | NC | 91 | 54 | 0.047 | 0.300 | 0.029 | 0.010 | 0.003 | 0.389 |
| | | | | (12) | (77) | (7) | (2) | (1) | (100) |
| | NW | 50 | 36 | 0.354 | 0.002 | 0.062 | 0.107 | 0.004 | 0.529 |
| | | | | (67) | (0) | (12) | (20) | (1) | (100) |
| | SC | 40 | 20 | 0.422 | 0.010 | 0.025 | 0.026 | 0.025 | 0.508 |
| | | | | (83) | (2) | (5) | (5) | (5) | (100) |
| | SW | 67 | 15 | 0.188 | 0.001 | 0.129 | 0.008 | 0.002 | 0.328 |
| | | | | (57) | (0) | (39) | (3) | (1) | (100) |

* Values in parentheses are percentage composition of the diets.

area could be divided into three subareas in terms of diet composition; i.e., eastern subarea (characterized by the dominance of squids), north-central subarea (copepods) and western subarea (euphausiids).

**Diets of large predators**

The short-fin mako shark, *Isurus oxyrinchus*, is a temperate-tropical species, feeding primarily on pelagic fishes. Adult *A. fallai* were recorded in mako shark stomach contents only in subtropical waters (Table 5), although some of the former were considered to have been scavenged from the fishing nets due to their having scars or "net marks," which were probably caused by prior entanglement in the nets. In addition, the author once witnessed a large individual *I. oxyrinchus* attacking the driftnet catch and successfully swallowing several fishes during the net retrieval operation. The diet of the porbeagle, *Lamna nasus* (common only in the subantarctic waters) consisted only of *Trachurus* spp. and squids, *A. fallai* not being recorded. The blue shark, *Prionace glauca*, is a cosmopolitan species, being abundant in epipelagic waters from equatorial to subantarctic waters. Prey items varied from salps to nekton. Adult *A. fallai were* consumed by this species only in subtropical waters, almost all of them being considered to have been scavenged from the fishing nets (see above).

The swordfish, *Xiphias gladius*, and blue marlin, *Makaira mazara*, also preyed on adult *A. fallai* in subtropical waters, along with a variety of nekton (Table 5). *Gasterochisma melampus*, an endemic Southern Ocean scombrid, preyed on fishes and squids, but *A. fallai* was not recorded.

**Table 4.** Probability levels associated with randomization tests of difference in gravimetric diet composition of slender tuna by area. For details, see text

| | Peru C. South | Subantarctic | | | |
|---|---|---|---|---|---|
| | | NE | NC | NW | SC |
| NE | 0.178 | — | | | |
| NC | 0.000* | 0.000* | — | | |
| NW | 0.000* | 0.000* | 0.002* | — | |
| SC | 0.000* | 0.000* | 0.382 | 0.082# | — |
| SW | 0.000* | 0.000* | 0.005* | 0.118# | 0.102# |

*$p < 0.05$; # tests excluding copepods.

**Table 5.** Frequency of occurrence of food items in diets of large predatory fishes by latitude

| | *Isurus oxyrinchus* | | *Lamna nasus* | | *Prionace glauca* | | *Xiphias gladius* | *Makaira mazara* | *Gasterochisma melampus* |
|---|---|---|---|---|---|---|---|---|---|
| Collected latitude (S) | 23–31 | 38–45 | 30 | 38–55 | 23–31 | 38–46 | 23–31 | 23–31 | 40–47 |
| No. of stomachs examined | 31 | 4 | 1 | 63 | 27 | 33 | 19 | 4 | 18 |
| No. of empty stomachs | 15 | 1 | 1 | 6 | 11 | 7 | 4 | 1 | 1 |
| Precaudal length (cm) | | | | | 98–215 | 85–205 | | | |
| Body weight (kg) | 3–267 | | 108 | 8–138 | | | 26–225 | 150–282 | 5–130 |
| Food item | | | | | | | | | |
| Thaliacea | | | | | 2 | | | | |
| Ommastrephidae | | | | 1 | | | | | |
| *Ommastrephes bartramii* | | | | | | | 1 | | |
| *Ocythoe tuberculata* | | | | | 1 | | | | |
| Unidentified cephalopoda | 1 | | | 24 | | 12 | 8 | | 6 |
| *Isistius brasiliensis* | | | | | | | 1 | | |
| Paralepididae | | | | 3 | | | 2 | | |
| *Alepisaurus* sp. | | | | | 1 | 2 | | | |
| *Scomberesox saurus* | | | | | | | | | 1 |
| *Trachurus* spp. | 4 | 6 | | 56 | | 9 | 1 | | 9 |
| Bramidae | | | | 1 | | | 1 | | |
| Scombridae | | | | | | | | 2 | |
| *Allothunnus fallai* | 8 | | | | 3 | | 1 | 1 | |
| Centrolophidae | | | | 1 | | | 1 | | |
| Unidentified fishes | 5 | | | 7 | 1 | 6 | 5 | | 5 |
| Miscellaneous | | | | | 5 | 4 | 1 | | 2 |

## Discussion

The diet composition differed significantly, not only between the Peru Current South and Subantarctic subregions in the 1986/87 survey (except for subregion NE), but also among some subantarctic subregions. Discounting the year parameter, the frequency of occurrence of euphausiids seemed to increase from the Peru Current South to the central subantarctic area (1985/86 survey). In contrast, the relative importance of squids was greater in the Peru Current South region and the eastern part of the Subantarctic region. These regional differences may reflect food availability, including the patchy distribution of prey (cf. Kawamura, 1974).

Mori (1967) reported on the diets of young *Allothunnus fallai* obtained from tuna and marlin stomachs. The most dominant items were planktonic crustaceans followed by planktonic gastropods. Wolfe and Webb (1975) reported that stomach contents of adult *A. fallai* taken from Tasmania consisted mainly (96% by volume) of a euphausiid, *Nyctyphanes australis*, with a small fraction of squids, fishes, algae and amphipods. Krill were found in one stomach of *A. fallai*, also taken from Tasmania, and 38 small anchovies were recorded from an adult *A. fallai* obtained from California (reported along with other anecdotal accounts of *A. fallai* feeding by Olsen [1962] and Fitch and Craig [1964]). These reports, along with the gill raker development described by Nakamura and Mori (1966), support the view that *A. fallai* is a planktivore. Nevertheless, micronektonic animals, such as young squids, are also important food items, especially in the Southeast Pacific Ocean, including the Peru Current.

Generally, scombrid fishes prey on a variety of species, including crustaceans, squids and fishes (Collette and Nauen, 1983). Magnusson and Heitz (1971) found a negative relationship between gill raker gap and percentage of crustaceans in the diet of scombrids. Nakamura and Mori (1966) noted well-developed secondary gill rakers in *A. fallai*, the number of gill rakers (70–80) on the first gill arch of this species being much higher than in any other scombrids (Collett and Nauen, 1983). These studies suggest that the gill apparatus of *A. fallai* is suitable for feeding upon small crustaceans, although the gill raker gaps have not been measured.

Webb and Wolfe (1974) postulated that *A. fallai* occupied a niche unutilized by other tuna species. Three scombrid species are known to occur in oceanic subantarctic waters; i.e., *Thunnus maccoyii*, *T. alalunga* and *Gasterochisma melampus*. The two former species are commercially caught by long-line and/or trolling gear and the latter is experimentally fished using long-line. The very rare catches of *A. fallai* by the Japanese long-line fishery in the Southern Ocean suggests that the feeding habits of slender tuna differ from those of other tuna species (Warashina and Hisada, 1972). The food of tunas generally consists of micronekton measuring from about 1 to 10 cm (Sund et al., 1981). Two major groups in terms of micronektonic biomass that are little consumed by tunas are euphausiids and mesopelagic fishes (myctophids and gonostomatids), with the exception of *Vinciguerria* and certain euphausiids preyed upon by skipjack tuna, *Katsuwonus pelamis* (Sund et al., 1981). In addition, copepods may be another group represented by a large biomass in subantarctic waters (Kawamura, 1974, 1980; Vinogradov et al., 1990). The substantial contribution of this fauna to the diet of *A. fallai* thus lends support to the hypothesis of Webb and Wolfe (1974).

The Peruvian jack mackerel, *Trachurus murphyi*, is also a plankton feeder distributed in subtropical and subantarctic waters between New Zealand and South America, with annual commercial catches of 1.3–3.7 million tons during the 1980's (Elizarov et al., 1993). The principal prey of *T. murphyi* included calanoid copepods (*Neocalanus tonsus* being the most important), euphausiids, amphipods, and small fishes, chiefly young myctophids (Vinogradov et al., 1990). Thus, *T. murphyi* trophically overlaps *A. fallai*.

Vinogradov et al. (1990) discussed the characteristics of plankton biomass in subtropical, subantarctic and Antarctic waters in relation to the seasonal migration of *T. murphyi*. They considered the high biomass of small plankton with small seasonal changes to be more suitable for young fish than adult jack mackerel. On the other hand, large concentrations of calanoid copepods, chaetognaths and euphausiids occur in the austral spring and summer in subantarctic epipelagic waters, such seasonal fluctuations of planktonic abundance following that of primary production, i.e., the surface and integrated values of chlorophyll-a and $^{14}C$ uptake are highest in summer and lowest in winter in the South Pacific (El-Sayed, 1970).

*A. fallai*, like Peruvian jack mackerel and baleen whales, undergo seasonal migration between subtropical and subantarctic waters. It seems curious that there is no apparent ecological counterpart for *A. fallai* among scombrids in the northern hemisphere, considering the bipolar distribution of the feeding grounds of sei whales (Kawamura, 1974, 1980) and pelagic jack mackerels (*T. murphyi* and its North Pacific sister species, *T. symmetricus*, which mainly feeds on euphausiids [Brodeur et al., 1987]).

The Southern Ocean and North Pacific copepods, *Neocalanus tonsus* and *N. plumchrus*, respectively, are closely related to each other in terms of morphology, ecology and lipid content (Ohman et al., 1989), both species being important food of sei whales (Kawamura, 1974, 1980). *N. plumchrus* is also an important dietary item for some salmonids, *Oncorhynchus gorbuscha*, *O. nerka* and *O. keta* (Ito, 1964). Since these salmons are dominant in epipelagic waters of the Subarctic Domain (Brodeur et al., 1987; Ware and McFarlane, 1989), they may play similar role in the subarctic pelagic ecosystem to *A. fallai* in the subantarctic ecosystem.

Of all tunas, *A. fallai* are known to spawn in the coldest waters (Sund et al., 1981), with the probable exception of *Gasterochisma melampus*, which supposedly spawn at latitudes of about 35°S (Yano et al., unpubl. data). On the basis of stomach content analysis and gonad condition, *A. fallai* appears to have adapted its life-history to the seasonally-fluctuating biomass of epipelagic subantarctic zooplankton (i.e., the seasonal vertical migration of *Neocalanus tonsus* as described by Ohman et al. [1989] and Vinogradov et al. [1990]).

The shift in spawning grounds may be a result of such an adaptation. However, the seasonal migration of slender tuna is remarkable not only for the distance covered, but also with regards to the energy budgets of the pelagic ecosystems involved. The faunas of subtropical (central), subantarctic and transitional waters are distinct from each other and considered to be separate ecosystems (McGowan, 1974; Vinogradov et al., 1990). *Allothunnus fallai* is a highly migratory fish, which transports energy from transitional-subantarctic ecosystems to subtropical waters, where they are preyed upon by large sharks, swordfish and billfishes.

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## 南太平洋外洋生態系におけるアロツナスの役割

谷津明彦

1985–1987 年に南太平洋（20–54°S, 74–150°W）から表層流し網により得られた 2257 尾のアロツナス（尾叉長 463–896 mm）の生殖腺の状態と胃内容物を調査した．10–11 月の亜熱帯域と 31°S 以北のペルー海流域は産卵場，11–2 月の亜南極域と 38°S 以南のペルー海流域は索餌場と考えられた．索餌場でアロツナスは主にオキアミ類，イカ類，カイアシ類，ハダカイワシ科の小型魚および端脚類を摂餌していた．餌料中の優占種はオキアミ類の *Euphausia vallentini*, *E. lucens*, *Thysanoessa gregaria* およびカイアシ類の *Neocalanus tonsus* であった．アカスルメイカは南東太平洋で優占したが，ニュウドウイカ属の数種は南太平洋中部で普通に見られた．端脚類では *Primno macropa* と *Themisto gaudichaudii* が普通に見られたが，これらの重要性は重量比では相当低かった．アロツナスの成魚はアオザメ，ヨシキリザメ，メカジキおよびクロカジキにより亜熱帯域で捕食されていた．アロツナスは高度回遊魚であり，亜南極外洋表層域の季節的に変動するプランクトンのバイオマスに適応した種と考えられた．

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