Current, catch and weight composition of yellowfin tuna with FADs off Okinawa Island, Japan

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Abstract

Yellowfin tuna (*Thunnus albacares*) is a main target for the fisheries at Fish Aggregating Devices (FADs) off the south of Okinawa Island. Catch and weight composition of the tuna were monitored at a fisheries cooperative market from 1989 to 1998. Some distinct weight groups (considered to represent cohorts) appeared in the catch and the weight of these groups increased monthly presumably as individual tuna grew. Although small, light weight fish were caught year-round, the 2 kg-weight group that was recruited in May grew to about 15 kg by May of the next year. There was a significant seasonal cycle in the monthly catch. The catch of heavier weight groups decreased in winter indicating the tuna moved out of this FAD area. There was also a large fluctuation in the annual catch. The number of 15 kg-weight group in May and the annual catch of that year were significantly correlated.
At one of huge FADs (nirai), fifteen nautical miles southeast of Okinawa Island (depth about 1 300 m), a current meter (Aanderaa RCM-7) recorded current and water temperature from June 1995 to March 1996. The current meter was attached to the FAD at 4 m depth. When typhoons attacked Okinawa, the water temperature drastically dropped. Typically, average current speed was 29 cm/s and eastward current was most frequent. Being affected by tide, the current was averaged over twenty-five hours. Current speed was correlated with the yellowfin catch in 120 daily sets at the FAD; the weaker the current speed, the greater the catch. Although not significant, the catch was greater with northeastward current than with southwestward current.

Weight composition analysis

Yellowfin tuna (*Thunnus albacares*) is a main target for the FAD fisheries in Okinawa. However, very little is known about its migrating pattern or aggregating behaviour with FADs. Particularly, those behaviours may change with size or age of the fish.
Although spawning occurs year-round (Suzuki, 1991), yellowfin in Okinawan waters have distinct size groups. The data of weight of the fish is far easier to obtain than the data of the length. So, we gathered the weight data to better understand the migration, the aggregation behaviour with FADs and the growth of yellowfin.

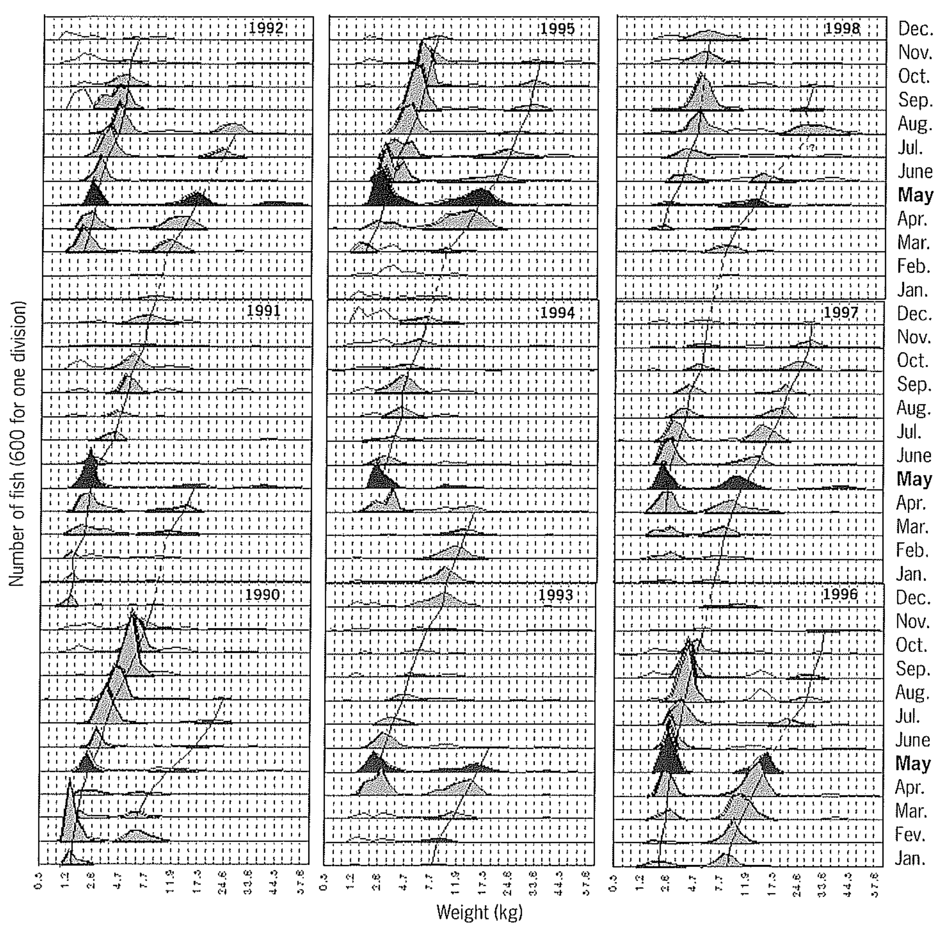
Material and methods

At Itoman Fisheries Cooperative (FC), southern Okinawa Island, catch records of FAD fisheries have been stored in a computer. Large yellowfin are auctioned individually while smaller ones are sorted into similar size groups, then auctioned. The weight of the groups and the number of the fish in each group were recorded. The weight of the group was divided by the number of the fish to obtain an average weight of the fish in the group. The weight data of 237,264 yellowfin caught from 1989 to 1998 was used. The length from 30 cm to 150 cm was divided into 32 strata with intervals of four centimetres. Then the weight was stratified so that each boundary weight corresponds to the boundary length. The number of the fish in every stratum was counted monthly to determine the weight composition.

Results

In the weight composition from January 1990 to December 1998, some weight groups (considered to represent cohorts) appeared in the catch and the weight of these groups increased monthly presumably as individual tuna grew (fig. 1).

Figure 1
Weight composition of yellowfin. One division of Y axis indicates the number of fish caught in that month (600 max). Hatched modes are G-May-2 kg and G-May-15 kg. The modes in May are hatched in black.

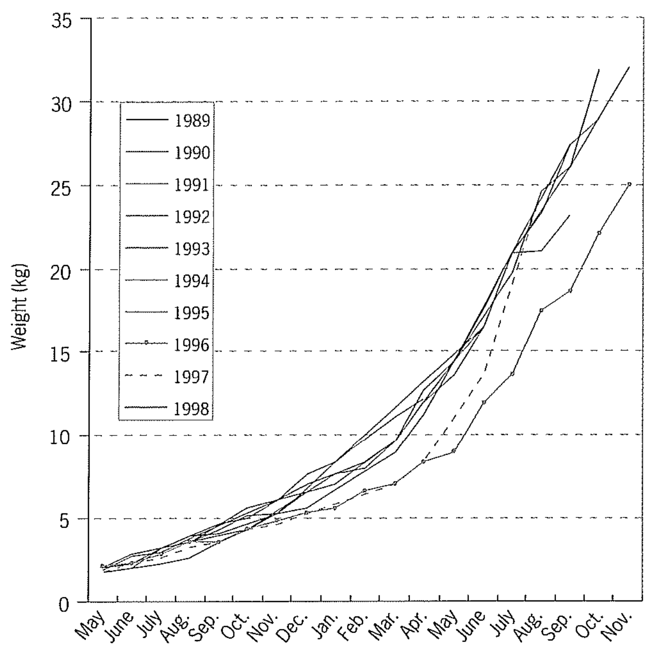


Discussion

The modes of weight groups that were about 2 kg in May are clearly identified in all years and they continued to be clear until October or November (hereafter, these groups are called G-May-2kg). In winter, the catch of the weight groups, especially heavier weight groups, decreased. This indicates that those tuna moved out of this FAD area. In May of some of the years, the modes of about 15 kg-weight groups (hereafter G-May-15 kg) are clear. Presumed from growth rate, these groups are the same cohorts of G-May-2 kg. Although light weight groups are caught year-round, G-May-2 kg (=G-May-15 kg) are considered to be main cohorts in Okinawan waters.

Starting from about 2 kg in May, the clear modes of the weight groups in every year demonstrate the growth pattern (fig. 2). From 1989 to 1995, the growth patterns are similar, while in 1996 and 1997, the patterns indicate slower growth rates.

Figure 2
Growth of yellowfin tuna of G-May-2 kg and G-May-15 kg.
Dark lines: from 1989 to 1995.
Bright lines: 1996 and 1997.



Comparative growth curves are plotted in figure 3 from: (1) a study in the Central and Western Equatorial Pacific (CWEP) (Lehodey & Leroy, 1999); (2) a study in the Philippines (Yamanaka, 1990); (3) this study (an average from 1989 to 1995) to best fit the monthly weight from 2 kg to 5 kilogrammes. The growth rates among these places might be different. However, if we assume the yellowfin around Okinawa grow as fast as the other two growth curves, then the birth month of G-May-2 kg is back calculated to be November of previous year for CWEP growth curve, and August for the Philippines'growth curve.

Figure 3
Growth curves of yellowfin tuna: the Central and Western Equatorial Pacific (CWEP, bright thin line); the Philippines (bright thick line); and Okinawa (black line with dots).

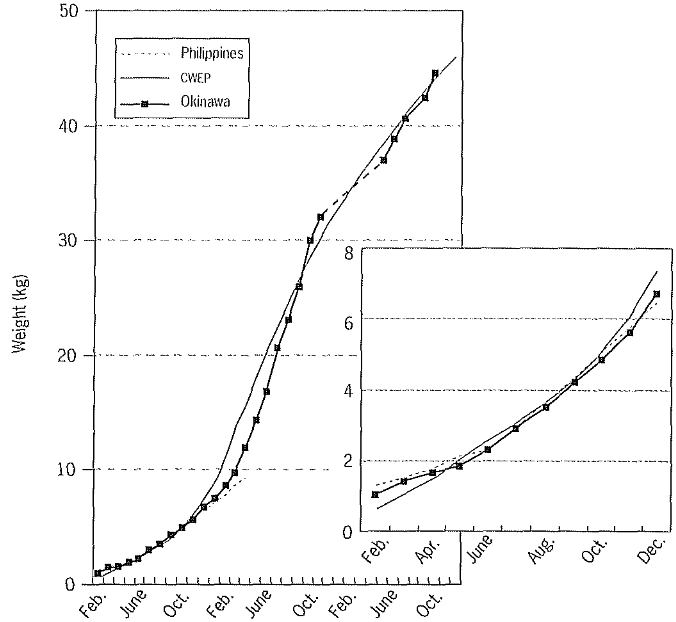
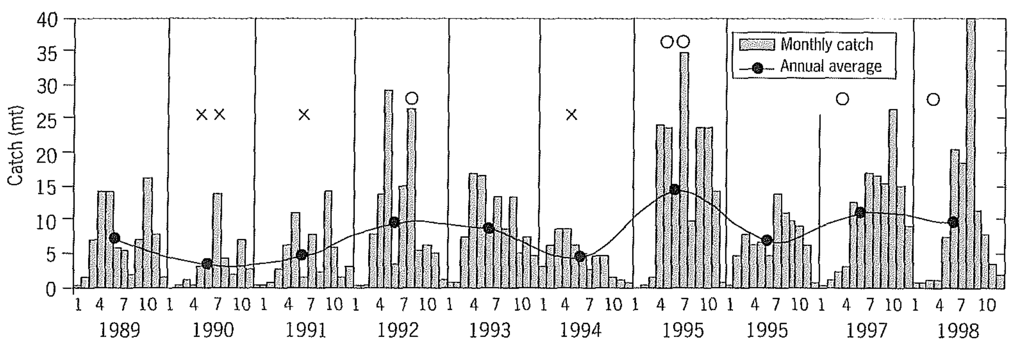


Figure 4
Monthly catch of yellowfin tuna at Itoman.
Hatched bars: monthly catch. Curved line with dots: annual average catch.
xx: very small catch.
x: small catch.
o: large catch.
oo: very large catch.

Because the prices of larger yellowfin are far higher than smaller ones, the fishermen usually target larger yellowfin. The catch of yellowfin tuna (>10 kg) fluctuated seasonally and annually (fig. 4). Catches were very small in 1990, small in 1991 and 1994, large in 1992, 1997 and 1998, very large in 1995. Figure 5 shows the yield (instead of the number of the fish) composition using the same weight strata.



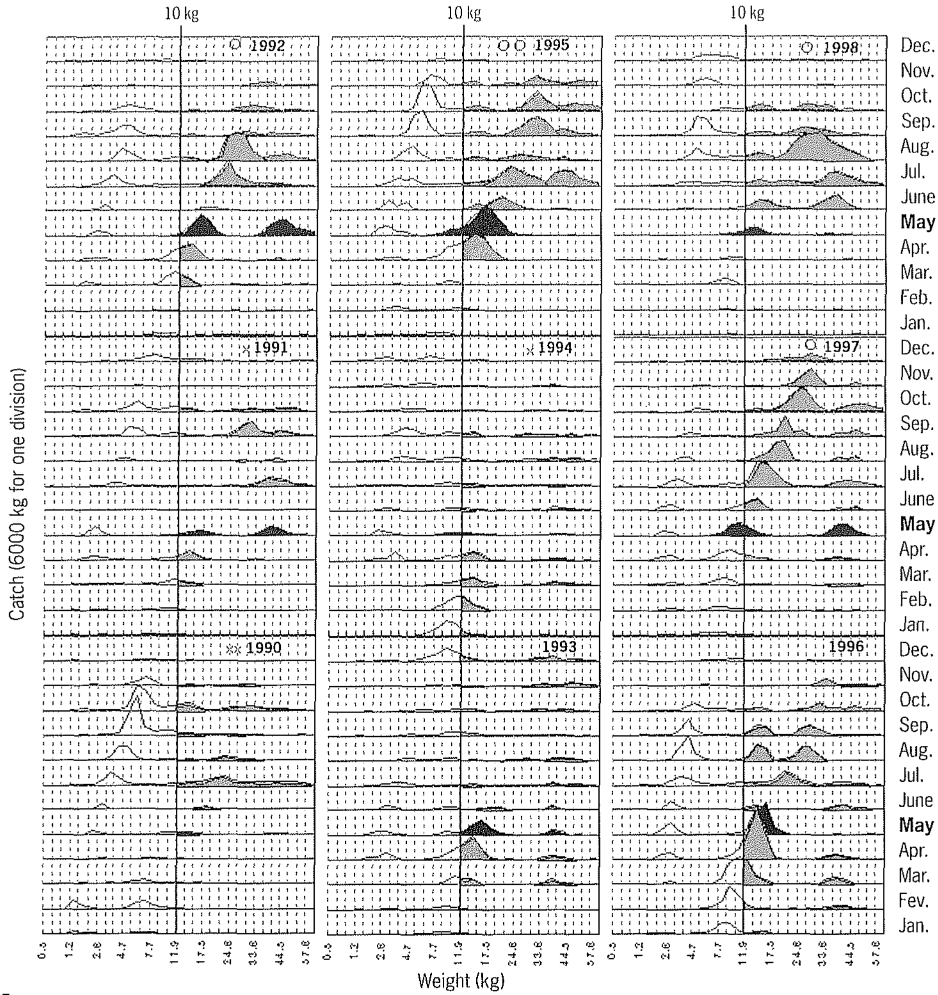


Figure 5
Weight composition of yellowfin tuna expressed by yield (kg) instead of the number of the fish. One division of Y axis indicates the yield in that month (6 000 kg max). Hatched modes are weight groups more than 10 kg. The modes in May are hatched in black.

In the good-catch year (1992, 1995, 1997 and 1998), the catches of G-May-15 kg were large through fishing season (April to October). The number of G-May-15 kg in May and the annual catch of that year are significantly correlated ($p<0.01$). This correlation is significant not only for the catch of Itoman FC but also the catch of whole southern Okinawa's FCs (fig. 6). This suggests that we can predict the annual catch if we obtain the weight composition at early stage of the fishing season.

The number of G-May-15 kg in May and the number of G-May-2 kg in May in previous year are not significantly correlated ($p>0.05$). Although they are presumed the same cohorts, the magnitude of migrating schools to Okinawa is probably affected by environmental factors (such as current and/or water temperature) rather than the stock abundance of the cohorts.

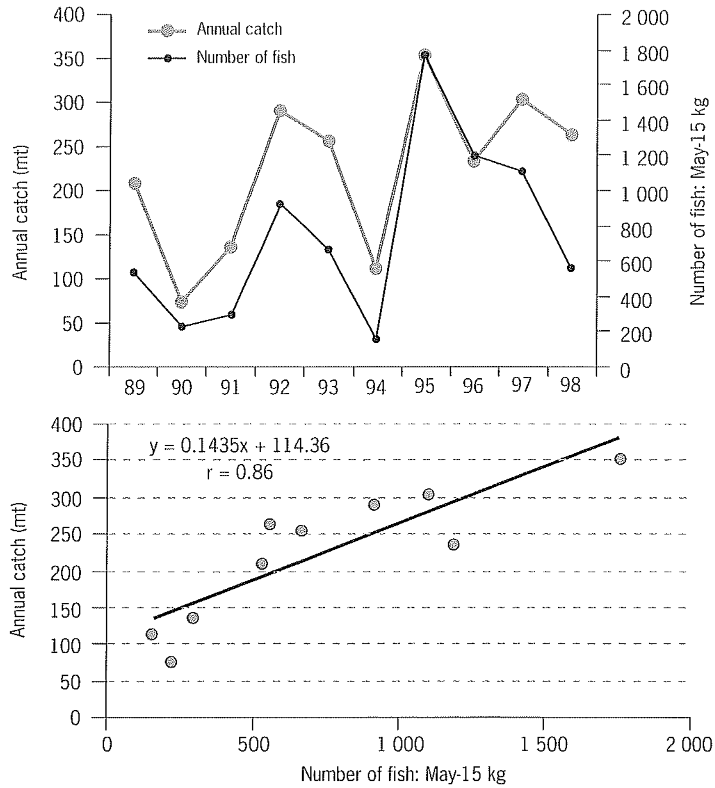


Figure 6
The relation between the number of G-May-15 kg in May and the annual catch of that year.
Upper: yearly transition.
Lower: the relation.
The two factors are significantly correlated ($p<0.01$).

Current and Catch

According to many FAD fishermen, the catch is strongly affected by current or water temperature. However, there have been very few studies on the relation between the catch of FAD fishing and environmental factors.

We have ten huge FADs (nirai) in 1999 that provide suitable platforms for installing current meters. We have measured the current and the water temperature at nirai since 1995, while monitoring the catch around the FADs.

Material and methods

From 15 June to 23 October 1995 and from 27 November 1995 to 12March 1996, at nirai 1, fifteen nautical miles south-east of Okinawa Island (depth about 1 300 m), a current meter (Aanderaa RCM-7) recorded current and water temperature. The current meter was attached to the FAD at 4 m depth. Figure 7 shows the location of nirai 1.

The current speed and direction were compared with the daily yellow-fin catch that was caught by fishermen using nirai 1 and FADs in the vicinity.

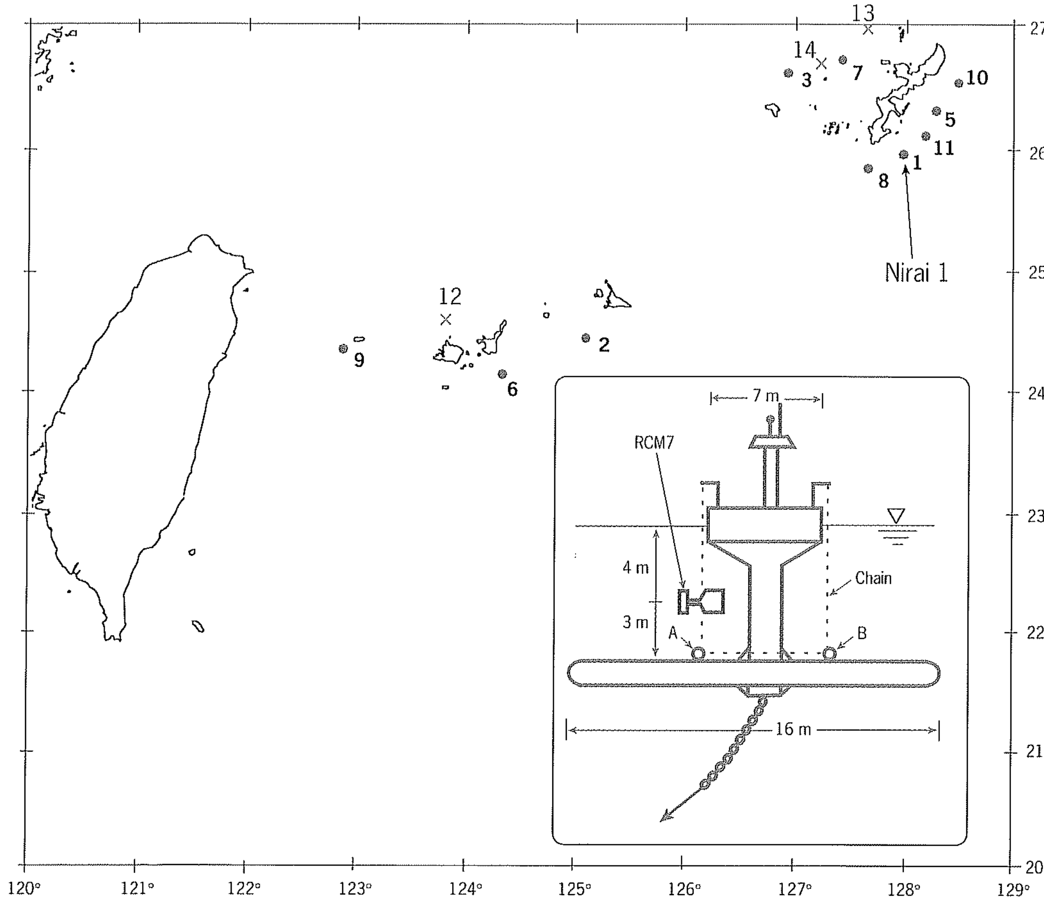


Figure 7
The location and
the configuration of nirai 1.
The current meter was
installed to the nirai
with chains at 4 m depth.

Results

When typhoons attack Okinawa, the surface water temperature drops by the effect of surface water mixing. Figure 8 shows the water temperature at nirai 1. When Typhoon 3 approached to Okinawa Island on 22 July, the temperature drastically dropped about from 30 to 26 degrees centigrade.

Figure 9 shows the current vectors, northward current composition and eastward current composition. Typically, average current speed was 29 cm/s and eastward current was most frequent.

Figure 10 shows the current from 15 June to 25 June 1995. The current was affected by tide, and the current direction turned clockwise in about one day. So, the current was averaged over 25 h, then compared with yellowfin daily catch.

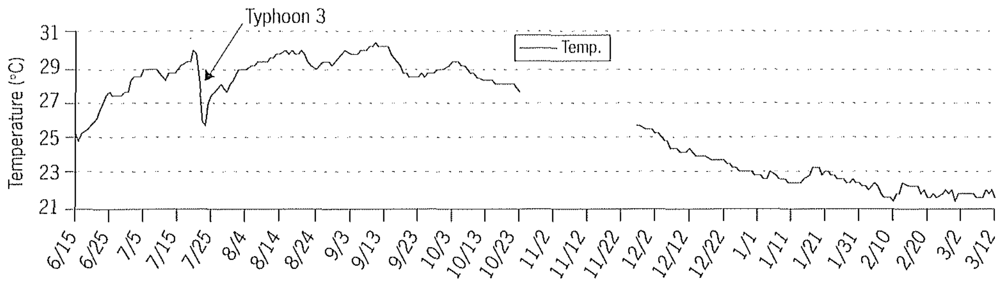


Figure 8 - The temperature at nirai 1 from 15 June 1995 to 12 March 1996. The temperature drastically dropped when Typhoon 3 approached to Okinawa.

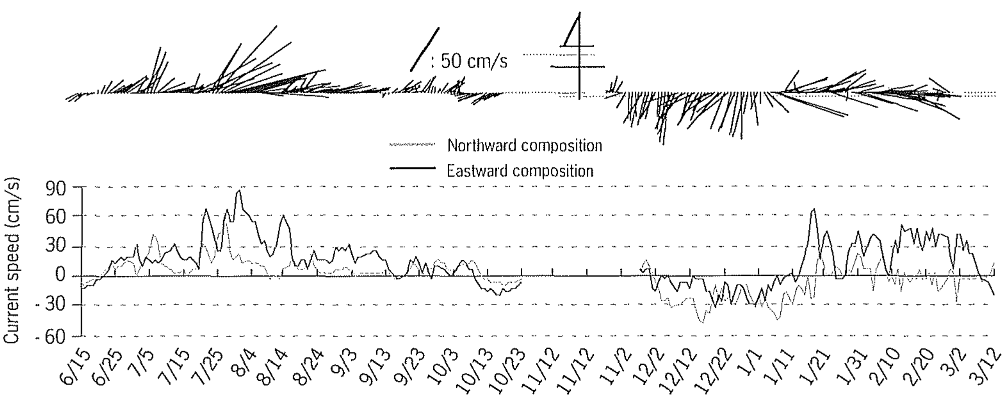


Figure 9 - The current at nirai 1. Upper: expressed with stick diagram. The direction of the sticks indicates the current direction. The length of the sticks indicates the current speed. Lower: northward (bright line) and eastward (dark line) current composition.

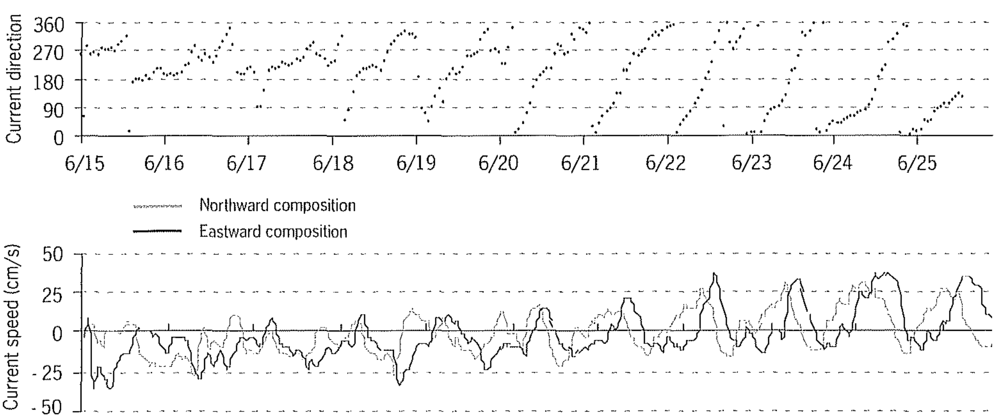


Figure 10 - The current at nirai from 15 June to 25 June 1995. Upper: current direction. The direction turned clockwise in about a day. *Lower: The northward (bright line) and eastward (dark line) current composition.*

Figure 11 shows the relation between the current speed and the catches. The catches are for two yellowfin tuna weight groups: (1) larger than about 10 kg, and (2) smaller than about 10 kilogrammes. The current speed was stratified to five strata: 0-10; 10-20; 20-30; 30-40; and over 40 centimetres per second. The catches are average catches in the corresponding current speed strata. The current speed was correlated with the yellowfin catch in 120 daily sets, the weaker the current speed, the greater the catch.

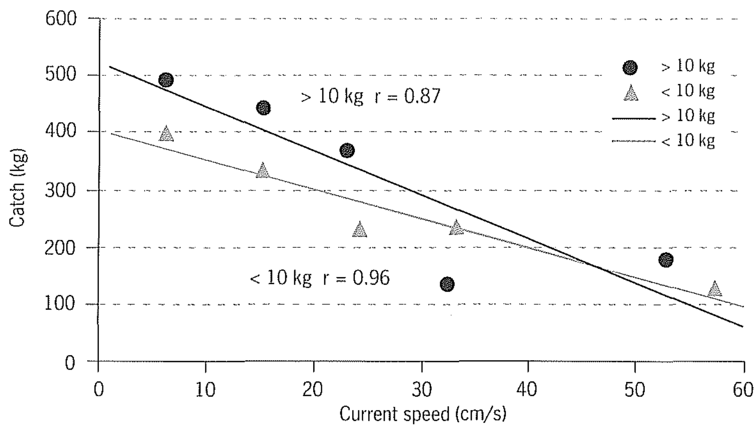


Figure 11
The relationships between the current speed and yellowfin tuna catch. The dark line and dark dots indicate yellowfin larger than 10 kg. The bright line and bright dots indicate yellowfin smaller than 10 kg. Both of the groups show negative correlation, the weaker the current speed, the greater the catch.

Figure 12 shows the relation between the current direction and the average catches. The current direction was divided into eight groups: N, NE, E, SE, S, SW, W, and NW. Although not significant, the catch was greater with northeastward current than with southwestward current.

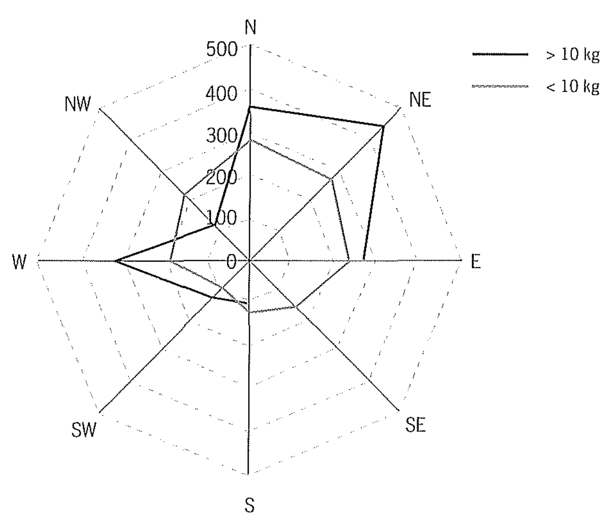


Figure 12
The relation between the current direction and yellowfin tuna catch. The dark line: yellowfin larger than 10 kg. The bright line: yellowfin smaller than 10 kg. The farther the lines from the center, the greater the catches.

Discussion

One of the reasons for the negative correlation between the current speed and the catch seems that the yellowfin lost much energy to associate with the FAD against the strong current, assuming without adequate food sources.

Many FAD fishermen in Okinawa say that the catch is good when the current direction is toward the islands. We have not clearly confirmed this yet. However, we have continued measuring the current at nirai 1 or other nirai, and would add better understanding of the relation between the current and the catch.

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