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シイラの漁業生物学的研究

Fishery Biology of the Common Dolphin, *Coryphaena hippurus* L., inhabiting the Pacific Ocean

児　島　俊　平

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October　1966

目　　次

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Although *Coryphaena hippurus*, the dolphin, is cosmopolitan in tropical and subtropical waters, comparatively little study has been done on the fish, excepting the general work on the Atlantic dolphin by Gibbs and Collete (1959). And especially, the biology of the fish in the Pacific and the Indian Oceans has been left unknown likewise the ecology of the fish.

The dolphin migrates into Japanese waters from early summer to autumn.

The mean annual catch of the fish in recent five years (1957–1961) amounts to 10,000–15,000 metric tons, two thirds of which are caught in coastal waters of the western region in the Japan Sea, composing one of the important commercial fishes for coastal fisheries in this region (Table 1). From the ecological stand point, it may be noteworthy that the dolphin shows interesting habit to gather around flotsams. Taking abvantage of the habit, *Shiirazuke* fishery is extensively carried on especially in the western region of the Japan sea.

The purpose of the present paper is to describe from the stand point of the fishery bioiogy the characteristics of the fish concerning with the ecology and the fishing condition as well as the stocks.

Distribution and Migrationg

In the Pacific Ocean, the dolphin lives all the year round in the waters within Latitude 30° of the both hemisphere and performs seasonal migration into the waters of higher latitudes as shown schematically in Fig. 8. In the northern hemisphere, the fish begins to increase in their population density in the waters of latitude 0–10° N. from November to December with ripening of gonad, then the fish begins to spawn from January to February. The same phenomena are observed from March to April at about latitude 20° N., and from May to June at lat. 30 °N. Some schools of the fish migrate even into the waters higher than lat. 40° N. during the periods when the temperature of sea water rises to the highest in the year, and it may be considered that the isotherm of 20°C in surface layer indicates the migrating limit of the fish (Fig. 6).

The fish begins to move southwards with the drop of the water temperature. The dense schools of the fish appear from Septemver to October at lat. 30° N. and from October to November at lat. 20° N. These schools are almost composed of small immature fish. The seasonal migration in the southern hemisphere shows a reverse tendency as in the northern hemisphere according to the reverse transition of seasons in each hemisphere. It seems that there are two races of dolphins living separately in each hemisphere.

As for the northern limit of migration, the schools migrating northwards through along the Japan Sea side of Japan extend to the Soya Straight(lat. 45°30′N). But, the migrations of the fish along Pacific coast and in the coastal waters of the continent extend only to lat. 42° N. The fish migrates neither into coastal waters in the Yellow Sea nor into Pô Sea.

According to the results of tagging experiment in the western region of the Japan sea, the fish schools migrate northwards in summer and reversely in autumn (Fig. 4, Table 2, 3). All fishes recaptured by 27.2% in recapture rate were caught under *Tsukegi*.

Judging from the data by doiphin purse seines, tuna long lines and angling, the fish seems to swim in upper layer of the sea, shallower than 10 m layer at deepest. They always try to escape horizontaly and never to dive downwards. The swimming layer of dolphin must not extend to deeper than 20–30 m, though the layer naturally change with growth of the fish.

Reproduction and Growth

According to the body length compositions of the dolphins migrating into Japanese waters, schools in early season(June) are composed mainly of larger fishes, more than 70 cm in fork length, and those on and after August mainly composed of smaller fishes, about 50 cm (Fig. 18). Comparing size compositions of the dolphins in the waters of lower latitude with those in the waters of high latitude, the formers are larger than the latter in general. (Fig. 7, Table 4). The relationship of body weight (W) to body length (L, in fork length) in dolphins is represented by following formula:

$$W = 0.039 L^{2.688} \qquad (\text{cm}, \text{g})$$

According to the result of age estimation using Bertalanffy's equation, the dolphin is considered to reach about 38 cm, in length in the first year, about 68 cm in the second, 90 cm in the third, 108 cm in the fourth, 122 cm in the fifth, and the biological maximum size is estimated to be about 175 cm (Fig. 20, 21).

There exists a definite difference between the shapes of heads in matured individuals of both sexes, but it is difficult to distinguish both sexes by external appearence befoee they reach 40 cm in length.

Gonads of the fish develop as follows; Existence of gonads become to be visible to the naked eye when the fish grow up about 20 cm in length. It becomes possible to distinguish both sexes with the naked eye when the fish reachs 40—50 cm.

It is supposed that a part of 1-age dolphins participate in spawning, for fully developed ovaries become to be found in the fishes larger than 55 cm in fork length (Table 6).

As for sex ratio of the dolphin, females outnumber males in earlier fishing season and with the approach of the spawning season the number of both sexes become to make no great difference (Table 5). Judging from the results of the studies with the larval net, the dolphins in the neighbouring waters to Japan are considered to spawn from May to September in the waters of the temperature at the ranges from 23 to 30°C, and the chlorinity 18.5—19.5 ‰.

Feeding Habits

Feeding habits of the dolphin change with growth of the fish as follows: Juvenile dolphins up to 4 cm in total length mainly feed on copepods such as *Calanus*, *Scolecithrix*, *Oncaea*, etc. and thereafter they begin to feed on other juvenile fishes such as saury, yellow tail, *Girella punctata*, file fishes, etc., (Table 9). Young fishes after 18 cm in fork length feed maily on pelagic juvenile of fishes such as anchovy, red mullet, flying fish, etc. (Fig. 22). Adult fishes more than 50 cm in fork length feed mainly on pelagic fishes. Although organisms which compose food items of dolphins are multifarious, they are equally restricted to surface swimmers (Table 10). As supposed from the swimming layer of the fish, feeding places of dolphins are limited to extremely upper layer of the sea. Examining the relationship between the compositions of food items in stomachs of dolphin and the faunistic compositions in the sea surface, the following fact was found:Dolphins become to feed on juvenile fishes, which ordinary are the secondary food organisms for adult dolphins, when the primary food organisms --adult of pelagic fishes —are wanting. So we can estimate the state of population of pelagic fishes to a certain extent through examining stomach contents of dolphins. Larval fishes which make food items for dolphin are limited to those species which have a nature to school or a nature to accompany flotsams(Fig.30).

Shiira-zuke Fishery

In *Shiira-zuke* fishery, bamboo rafts called *Tsukegi* as shown in Fig.32 are set afloat in the fishing ground. When dolphins gathered under *Tsukegi*, fishermen catch them with a purse seine net. The usual process of purse seine operation are shown in Fig.33 and Fig. 34.

Besides dolphin, 24 species of fishes belonging to 12 families were gotten under *Tsukegi* (Table 16). Of the total catch, 93–96% were occupied by dolphins, 1.5–3% by file fishes and 0.1–0.5% by Caranx (Table 14).

It is shown in Fig. 36 how many dolprins gathered daily under single *Tsukegi*. Maximum individual number of dolphins observed under *Tsukegi* was 1,100, while the same under a mass of drifting sea-weeds was 1,670. In general the fish prefers drifting substances to *Tsukegi* which are anchored (Fig.38).

The spacial distribution of fishes around *Tsukegei* by species is as a basic patpern like as shown in Fig. 39. Dolphins usually swim about the places 10–15 m to the current-werd from *Tsukegi* and are seen seldom in the other places. Each of other species of fishes seems to show a peculiar distribution too, vertically according to the body size and horizontally according to the feeding habit of them

(Table 17.)

Significance of *Tsukegi* to Dolphins

The reasons for which the dolphins is attracted under *Tsukegi* were studied from three view points, that is, the shade, the sound and the food. The orientation to the optical stimulation must be one of the reasons for which dolphins gather under *Tsukegi*, but at the same time it is difficult to explain enoughly the phenomenon that thousands of the fish often gather under single *Tsukegi* anchored, only by the optical orientation. *Tsukegi* sounds a noise different from the usual noises in the sea, and it is possible to detect the noise about 1 km far. It is considered that only through the auditory stimulation thousands of dolphins can gather towards *Tsukegi* from a distant (Fig. 43). It must not be the reason but the result of the orientation to drifting sea-weeds that dolphins feed on the organisms accompanying drifting sea-weeds. It seems that, however, the abundance of food organisms around the flotsam have influence on the staying time of dolphins under them. This must be the reason why dolphins gather under old *Tsukegi* better than under new ones (Table 18, Fig. 40).

Considering synthetically, it is difficult to attribute the behavior of dolphins gathering under *Tsukegi* to a single element, however, it is sure that the optical stimulation and the auditory stimulation play an important role here. It is doubt that food environment play any role in attracting dolphins towards *Tsukegi*. But considering on the ecology, especially on the feeding habits from juvenile and young stages of the fish, dolphins must be benefited consequently by accompanying *Tsukegi*.

Fishing Conditions

In adjacent waters to Japan, the dolphin begins to be cauget when the surface water temperature has risen to 18°C. The optical tempereture for dolphin fisheries is 23–30°C, just same as in the waters of lower latitude (Fig. 45). It seems that 31‰ is lower limit of salinity for the dolphin, so migrations into coastal regions of the yellow Sea and the Pô Sea have not yet been known. While the degree of salinity has a relation to the turbidity and the transparency of the sea, and the turbidity has the most important effect upon the fishing conditions of the fish.

Meteorological elements also have a great influence upon the fishing condition of the dolphin. The catch becomes greater with improvement of weather after passing of depression, and in the opposite case the catch decreases in quantity. The wind toward the land brings a good catch, while the wind toward the offing results in a poor catch (Table 20), and this seems to be caused by the increasement of turbidity following the movement of water mass by the drifting current.

As for biological elements, the abundance of food organisms affects the fishing conditions of the dolphin. Comparing the fishing conditions with the mean stomach content weights of schools for recent three years, the greater the fromer is, the better the latter is (Fig. 50). It is probable that dolphins gather better and stay longer under *Tsukegi* when the food organisms are abundant.

State of Stock

Considering from a view point of fishing gears and fishing methods of dolphins in the first place, 93% of the total catch in Japan are yielded by three kinds of gears; the angling, the long line and the purse seine net (Table 13). Moreover in the

Pacific Ocean, dolphins are only byproducts of tuna-and bonito-anglings and-long lines. This fact has an important significance concerning the maintenance of stocks(Fig. 31). On the contrary in Japan Sea, the fish is caught efficiently by the purse seine -- *Shiirazuke* fishery. But the schools migrating into Japan sea are no more than a small part of the stocks migrating into tne adjacent waters of Japan. Moreover, the fishing ground of *Shiira-zuke* fishery is naturally limited in the shallow waters on continental shelf.

Such being the case, it is considered that the fishery of the dolphin is, at the present, not so powerful as to exert a harmful influence upon the maintenance of stocks.

Concerning with the ecology of the fish, the school of spawning fishes migrate seldom into the waters of high latitude, but they spawn, for the most part, in the waters of low. latitude. Furthermore, the fish becomes to participate in the breeding at full one year old.

Putting the above mentioned facts together, it is not considered that the fisheries of the dolphin give any blow to the repoduction of the fish.

The growth rate in young stages of the fish being considerably great, the fish soon becomes to occupy a position of the final consumer of the food chain among the oceanic fauna. This may be advantageous to the fish in the struggle for existense as well as in the maintenance of the stocks.

緒　　　言

研究の意義・目的

シイラ *Coryphaena hippurus* LINNÉ はシイラ科 Coryphaenidae に属する亜熱帯性の回遊魚であり，わが国ではオホーツク海が来遊の北限である。本邦近海にみられるシイラ属には，この他にエビスシイラ *Coryphaena equiisetis* L. があるが，前者に較べ極めて数が少なく，産業的にも重要度が低い。それゆえ，本研究はもつぱらシイラを対象としておこなつた。

農林省統計調査部の農林水産統計表*によれば，1957～61年の5か年間のわが国におけるシイラの総漁獲量は毎年1万～1.5万トンの間にある。これは魚類総漁獲量の僅かに0.25%に過ぎないが，シイラは夏季の短期間に漁獲されるものであるから，7月から10月だけについてみると，その漁獲高は同期の総漁獲量の0.65%を占め，その2/3は長崎県から福井県にいたる対馬暖流域の沿岸漁場で漁獲されている。このような漁場における夏季のシイラの漁獲高は夏季の総漁獲量の5%におよび，夏季における魚種別漁獲高順位は年により第2～6位を占め，ことに，沿岸漁業において占める比重は大きいものがある。

最近，沿岸漁業の全国的な不振に伴ない，その振興策が色々と論議されている。しかし，沿岸性魚類資源の利用の可能性がゆきづまつた状態にある現状においては，シイラのようにある程度の余裕が予想される資源を充分に活用することこそ必要であろう。

シイラは海面に浮遊する流木や流れ藻などの近くに集まる習性がある。この習性を利用して，海面に漬木を敷設し集まつたシイラを旋網または釣で捕獲するシイラ漬漁法が古くから広くおこなわれてきた。漁法が特異なために本種の生態は多くの人々の関心を引き，多くの経験が語られているけれども，シイラに関する科学的知識は必ずしも充分とはいえない。ことに，漬木に集まる原因については殆んどわかつていない。そこで，漁業生物学的な立場から，本種のもつ生態・漁況・資源に関する特性を明らかにして，シイラ漁業の発展と安定化とに資することがこの研究の目的である。すなわち，第1章では日本近海や太平洋・印度洋における分布・回遊を明らかにし，第2章では産卵や成長に関する生活史を追求し，第3章では食性について検討を加えた。第4章ではシイラ漬漁法の特異性を述べ，第5章では本種と漬木および流木・流れ藻などとの関係を考究し，第6章では漁況とそれに影響をおよぼす各種要因との関係について述べた。

最後に全体の総括として，第7章で現在および将来における資源の変動状況について生物学的な立場から総合的な考察を加え，もつて本種漁業の現況を明らかにすることに努めた。

シイラについての過去の研究

シイラ *Coryphaena hippurus* L. は LÜTKEN (1880) によつてエビスシイラ

* 「漁業養殖業漁獲統計表」を習慣に従い「農林水産統計表」と略称する。

Coryphaena equiisetis L.と分離し記載されて以来，JORDAN・EVERMANN (1896) などによつて形態学的研究がなされ，最近ではGIBBS・COLLETTE (1959) の大西洋産のものについて形質的特徴と相対成長の研究がある。日本近海産のものについては内田（1935）が初めて記載しており，内橋（1953）の脳形態の研究がある。

地理的分布については，大西洋における採集記録の北端としてVLADYKOV・MCKENZIE (1953) はカナダ南東部Nova Scotia半島の Halifax港と Bedford Basin を記録し，南端としてBARNARD (1927) がアフリカ南端のCape Seas，Table Bay，False Bay，でそれぞれ標本を得たことを報告している。概略的な分布については，大西洋についてGIBBS・COLLETTE (1959)の，太平洋について児島（1964）の記述がある。

生態学的研究については，GIBBS・COLLETTE (1959)が大西洋の，内田 (1924) が日本海西区の産卵期をそれぞれ推測し，発生については水戸（1960）の研究がある。稚魚については，LÜTKEN (1880)，内田 (1924)，FOWLER (1928)，中村 (1934)，千田 (1954) の記載があるが，近年稚魚の時・空間的分布が次第に明らかにされ，内田・道津 (1958) が対馬暖流域の，服部（1964）が黒潮流域の出現状態についてそれぞれ報告している。食性については断片的な記載であるが，SUYEHIRO (1942)，SCHUCK (1951)，TESTER・NAKAMURA (1957)，GIBBS・COLLETTE (1959)，横田・その他 (1961)，児島（1961）などの報告がある。

漁況に関する研究は，日本海産のものについて児島（1955・1956・1960・1963・1964）と岡地（1958）の報告があるにすぎない。

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