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A Consideration on the Long Years Trend of the Fisheries Fluctuation in Relation to Sea Conditions

Michitaka UDA
(Tokyo University of Fisheries, Tokyo, Japan)

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Michitaka UDA
(Tokyo University of Fisheries, Tokyo, Japan)

Since the fish populations (P) in nature repeat their growth and decay (accompanying with extension and contraction of their areas) under some invisible influences of natural environmental conditions the fisheries conditions and the resulting amount of catch (N) for each fish species (sardine, herring, tuna etc.) vary year by year cyclically (in periodic or some irregular ways) with near a century or twenty to thirty, fifty to sixty years intervals. (See Table 1 a, b) In general as for the periodic decaying (or growing) yield.

$$N=N_oe-\lambda t\sum\cos(\omega t-\mu)\cdots\cdots\cdots(1)$$

Table 1 a. Historical fluctuation of important fisheries in Japan

Years (A. C.)	Herring * (Hokkaidō)	Years (A. C.)	Sardine *	Years (A. C.)	Bluefin * Tuna
1447	Fishery began	Ca 1500	Fishery began	1377	Gotō-Net began
1596~1614	▲ Bad	~1600	developed	(1106 ?)	Miyagi 〃 〃
1661~1681	⊙ Favourable	1660	(Tyōsi ⊙)	1596~1614	⊙
1688~1703	▲ Min	1680~1730	⊙ Rich	1624~1643	⊙
(1716~1762)	⊙ Good	(1716~1724)	◎ Max	1644~1708	⊙ W N. Kyūsyū
1775~1791	▲ Min	1736~1789	▲ Bad	1700~1845	Kagosima ⊙
1814~1840	⊙ Rich	(1768~1780)	▲ Min	1784~1834	Tusima ⊙
1847~1857	▲ Min	1818~1859	⊙ Rich	1799	Aomori ◎
1858~1898	◎ Max	(1830)	◎ Max	1830~1853	Hokkaidō ⊙
1900~1912	▲ Min	1864	(Tyōsi ◎)	1847	Hitati began
1913~1920	⊙ Rich	1870~1890	▲ Bad	Rich Years	
1938	▲ Min	(1884~1888)	▲ Min	{ 1900~1911	Aomori ◎
1944~1945	⊙ Rich	(1917~1921)	Japan Sea ⊙	{ 1887~1907	◎ Hitati
1955~1957	▲ Min (?)	1929~1939	◎ Rich	{ 1897, 1905	◎ Noto
			Max	1908~1912	▲ Bad
		1941~	▲ Bad	1933~1940	◎ Max
		(1941~1947)	▲ Min	1941~1948	▲ Min
		Japan Sea		1955~1956	◎ Rich
SOURCE	* Hokkaidō Gyogyōsi (History of Hokkaidō Fisheries. 1957) and other Manuscripts.		* UDA. M. (1952) J. Tokyo Univ. of Fisheries 38 (3) ITo. S. (1956) YAMAGUTI. K. (1947) etc		* UDA. M. (1957) Teiti Z. Sasazawa (1956): Simokita Hantō Si, S. Nagata (1957) Teiti, T. YAMAGUTI (1947) T. YAMADERA & others

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Table 1 b. Recent fluctuation of the fisheries conditions in the JAPAN SEA.
(△ bad, ▲ very bad, ⊙ good, ◎ rich yields)

	Periods (Interval Years)	Sardine	Tuna	Squid	Herring
1	1868~1905	△	○		○
2	1906~1912	⊙	△		△
3	(1913~1917)	(⊙)		○	◎
4	1917~1921	○		△	(1913~1920)
5	1923~1931	△		○	
6	1932~1940	◎	◎		△
7	1941~1948	△	▲	⊙	○
8	1949~1955	⊙	⊙	◎	△
9	1956, 1957		◎	△	▲

The actual fluctation of fish population (or catch) proceeds on the base line of its natural fluctuation modified by some artificial fluctuation (e. g. fishing intensity or some bad effects of industrial wastes).

Following the pioneer works by F. I. BARANOV[1]. J. HJORT[2], M. GRAHAM[3], E. S. RUSSEL[4], W.E. RICKER[5], and M.B. SCHAEFER[6], M. TAUTI[7], J.C. MARR[8], et al, fish population dynamics should be established on the consideration of the fluctuating environmental conditions into the basic constants of the equations (e.g. natural increase $f(P)$, reproduction potential, rate of survival, rate of natural mortality, rate of fishing (k), rate of growth, rate of recruitment, availability, fishing effort (F) etc) to fit the actual fluctuation of fisheries. Following to SCHAEFER[6]

$$\frac{dP}{dt}=f(P)-kP\,F\cdots\cdots\cdots(2)$$

(where k, F, P. are all functions of environmental factors.)

In accompany with the movement of predominant warm currents and cold currents the regional zones of favourable catch and unfavourable catch shift and undulate from north to south or from south to north meridionally (y-direction) along the coast and from offing to nearshore or from nearshore to offing laterally (x-direction). As the function of the movements in each directions x, y with velocities c_1, c_2 resp.

$$N=\Phi\,(x-c_1 t,\ y-c_2 t)\cdots\cdots(3)$$

The migration-route of fish shoals approaches to the coast in rich years and next further away from the coast in poor years (e. g. sardine, yellow-tail etc).

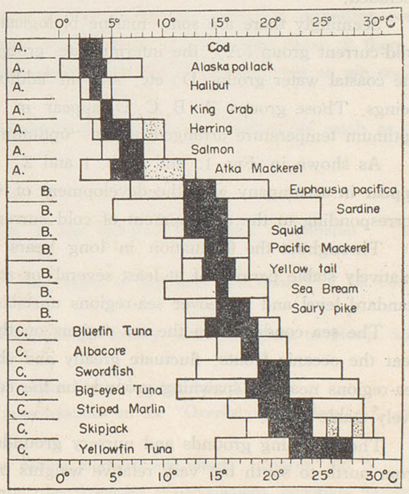

Fig. 1 Optimum water temperature spectra of important fishes in Japan.

Table 2. Phase lag of the mode (maximum) of catch curves and their optimum temperature.

	Fish species	Period I (Years)	Period II (Years)	Optimum Water Temp
A	Herring	1944~1945	——	3°~8°C
A	Atka Mackerel	1944~1948	(1951~1953)	2°~6°(~13°C Youngs)
B	Squid	1941~1943	1951 (1952)	12°~16°C (10°~18°)
B	Sardine	1933~1939	1947~1950	12°~16°C
B	Yellowtail	1942~1943	1951~1952	14°~16°C
B	Pacific Mackerel	1939	1954(1951~52, JAPAN SEA)	13°~18°C
B	Pacific Saury	1932~1940	1955	15°~18°C
B	Horse Mackerel	1940~1941	1954~1957	15°~18°C
C	Bluefin Tuna	1936~1941	1956, 1957	(12°)~14°~19°~(21°C)
C	Albacore	1935~1940	1954~1957	18°~21°C
C	Skipjack	1936~1938	1955~1957	20°~24°C
D	Anchovy	——	1955	17°~19°~(21°C)

The fishing gears fitted to each fishing locality changes from set-net near the coast, in the intermediate waters to purse-seine net, drift gill-net, and to long lines in the offing etc.

We can find those groups of important fish species which show some positive or negative variations respectively and some indicator species for each group (euphausia, copepods, sagitta, needled-puffer, tiny horse mackerel, some kinds of jelly fishes etc.) included.

Seemingly there are some marine biological sequences in the seas and oceans i. e. cold-current group (A), the intermediate group (B), the warm current group (C), and the coastal water group (D) etc. and in addition to them their representative indicator beings. Those groups A, B, C, D appear in succession, corresponding to the order of optimum temperature arranged as the "optimum-temperature spectra" in recent years.

As shown in Fig. 1. and Tab. 1 and 2, the growth and flourishment of C group appear in accompany with the development of warm current contrary to those of A group corresponding to the development of cold current.

Throughout the fluctuation in long years we can distinguish unstable periods and relatively stable periods of at least several or at most ten-several years, referred to some standard level and moreover sea-regions unstable and relatively stable.

The sea conditions in the sea regions on the course of feeding migration, especially near the oceanic fronts, fluctuate greatly and show unstable (rich or poor) catch and in sea-regions near the spawning grounds on the course of spawning migration show comparatively stable catch.

The spawning grounds and nursery grounds move not only from south to north or from north to south but vary relative weights of abundance in the distributed grounds as we see in the cases of sardine, herring etc. The uprupt change in the secular variation are brought by the uprupt growth or decay of warm and cold currents (e. g. in the years of 1923, 1941, 1951). Except the artificicial cause (over-fishing, water pollution etc.)

the ultimate cause of the fisheries fluctuation may be found in the variation of reproduction potential, survival, recruits and availability etc. following to the variation of environmental conditions.

The fisheries fluctuation of some important pelagic fishes (sardine, tunas, salmon etc.) seems to occur in some world-wide scale which may corresponds to the global geophysical variation (climatic changes or the fluctuation of oceanic currents, polar-ice, precipitation and evaporation over the oceans or zonal regions). Even in the case of bottom fishes (haddock, cod etc.) the effects of environments, especially the wind conditions in the larval stage are very serious (HACHEY[8], CARRUTHERS[9]).

Dominant year-classes of the important fish populations (e. g. sardine, herring, bluefin tuna etc.) prevail during several, ten to about twenty years and the appearance of large sized (old aged) fish population without the youngs (small sized) foretell us the warning of the approaching end of fisheries.

The increase of youngs and adults year by year may fortell the growing fishery.

The feeders swarmed on the boundaries of water masses, upwelling, thermocline and thermoanticline, eddies such as loopsacks of warm or cold water masses corresponding to the particular sea-conditions (meander or collision of currents etc.) attract the predators and consequently constitute fisheries grounds. The reversal relations between sardine and anchovy or others may suggest us some law of balance or law of alternative predominance in the seas.

Concerning sardine, mackerel, herring, pacific saury or other fish populations we can find the fluctuation of the spawning grounds in the course of spawning migration-route and the corresponding environmental fluctuation may be the fundamental cause ot them.

Special phase for each prosperity of fish populations can be pointed out as we see in Table 1. Table 2.

In conclusion we should define the abundance and maximum sustainable catch as the function of the environmental factors.

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