Cyclic, Correlated Occurrence of World-wide Anomalous Oceanographic Phenomena and Fisheries Conditions

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Abstract: Anomalous oceanographic phenomena such as cold and warm years appear to occur cyclically in the world oceans through the effects of atmospheric circulation (corresponding to changing pressure systems) and through atmospheric insolation correlated with the solar activity. A second major effect is through deep water circulation.

Inspecting data hitherto published papers the author presents tables showing the contrasted warm and cold years in the Pacific and Atlantic, anomalous Kuroshio patterns, California Current, and Peru Current (El Niño).

Concerning sea temperature, the reciprocal relations of anomalous years as well as the longterm trends (rise or fall) in the east and west portions of the Pacific and the Atlantic Oceans have been roughly established, though they are somewhat obscure in the Atlantic. The mechanism related to the pressure pattern in winter was illustrated.

Notwithstanding the scarcity of data from the southern latitudes, the temperature variations along the Pacific coasts of North and South America nearly follow the same trends.

Most of the years of cold oceanic temperatures are correlated with periods of minimum sun-spot activity; warm oceanic water years are correlated with periods of maximum sun-spot activity. Both short and long period cycles are discussed.

The anomalous Kuroshio patterns and El Niño might be linked through the fluctuation of trades-index and westerlies-index or through pressure gradients between the atmospheric High and Low (or Trough) caused by the dislocation and development of pressure systems. Rich and poor years of tunas, salmons, herring catches etc. are correlated with the above environmental changes including their longterm trends.

Introduction

Anomalous oceanographic conditions such as cold and warm years appear to occur cyclically in the world oceans, firstly through the effects of atmospheric circulation (corresponding to changing pressure systems) and through atmospheric insolation correlated with the solar activity. A second major effect is through deep water circulation.

I. Changing pattern of the polar front in the North Pacific

The distribution of those water types such as Subarctic, Polar Frontal and Subtropic, which were proved by the discriminant TS-diagrams and vertical distribution curves of temperature, salinity, dissolved oxygen and density *in situ* during the past years has shown the intruding shift from west to east in succession with the cycle of several years. (UDA, 1960).

Isolines of dynamical anomaly showing geostrophic flow, water temperature, salinity and transparency for each year during 1955–1959 were superimposed in one map which illustrates the above stated pattern of pulsation. Concerning the non-persistent flow in the upper few hundred meters in the Subarctic region, two warm intrusions from the south originates in the summer period. These weak surface currents, the South Aleutian Current and the North Kurile Warm Current, developed rapidly starting about May and then decay in the following September and October. The South Aleutian Current presents at about 45°–50°N and between about 180°- and 170°W, then it shifts somewhat to west during the course of the summer. (Fig. 1).

The North Kurile Warm Current occurs east of the North Kurile Islands and off Kamchatka between about 160°E and 165°E.

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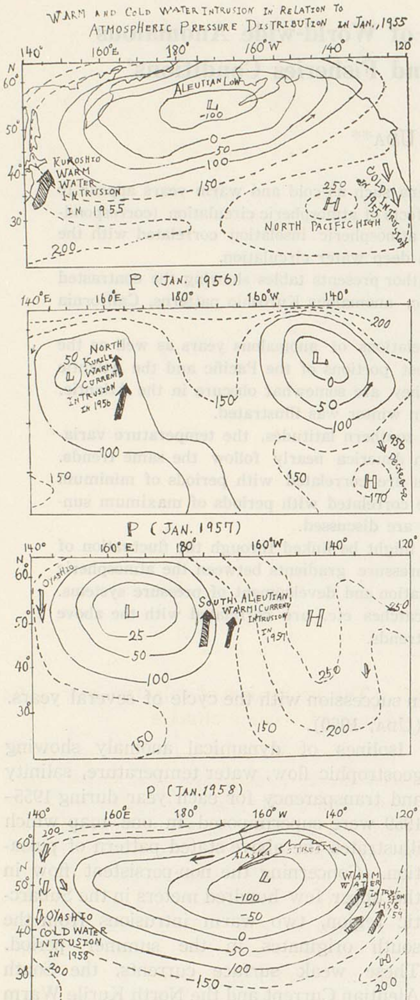

Fig. 1.

Some of the relatively saline water of these currents cools sufficiently to subside and contribute to form the meso-thermal water as it moves to north into the Subarctic region.

The currents also transitional in nature, affect the overall circulation of the Subarctic to some extent. A part of the Aleutian Current mixes with the Alaska Stream Extension and enters in the Bering Sea through passages on the Aleutian Islands Chain. The water entering in the Okhotsk Sea is composed of the water originally from the East Kamchatka Current and thus is modified by both warm currents.

While these currents recur to some extent every year, the degree of their intensity appears to vary markedly with years.

Summer surface water temperature in the western and central Bering Seas was found during the period of 1954–1959 to be warmest in 1957 due to the predominant intrusion of the South Aleutian Warm Current in that year.

The eastern intrusion in the Subarctic Region is present between about 150°W. and the North American coast.

The western intrusion occurs off the north-east coast of Japan about Lg. 145°E.

The North American Intrusion, which has been intensively studied by Canadian (Tully, Dodimead, Tabata, 1960) and United States oceanographers (Reid, J. L. Jr. et al 1958 etc.) showed by years the 1958 was the strongest, 1957 and 1959 stronger and 1955–56 weakest.

By contrast, general strength of the north-ward intrusion off the Japanese coast varied during the summers of 1955–1958 inclusive, in the following manner: 1955 strongest, 1956, 1957, and 1958 weakest. In addition the weakening of this intrusion appeared to be accompained by simultaneous development of a countering southward movement of colder water. This feature arises because of variation in strength of the southword flowing Oyashio Current and its undercurrent (Subarctic Intermediate Current).

A fact readily noticeable is the phase difference of the occurrences of the various intrusions. There appears to be a lag of 3–4 years between these extremes of intrusions in the western and eastern. The lag between the intrusion in the western and central portions is about 2–3 years.

Thus, the heads of the waters, south of Hokkaido (in 1955), south of Kamchatka (in 1956), South of Central Aleutian (in 1957) and off British Columbia and northwest off the United States (in 1958)– and less in 1959– and strongest during the years 1955–1959 successively, suggests to us the migration of pulsating Polar Front in easterly direction with trans-Pacific period of 3–4 years. This pulsation corresponds to the changing pattern of pressure system in winter as shown in Fig. 1. and Fig. 2.

II. Reciprocal relation of cyclic change of sea temperatures on both sides of the Pacific Ocean

Temperature rise and fall along the Japanese side occurs almost conversely to that along the American side (east) during the fifty years from 1911 to 1960. The intermediate pattern between those extremes on the east and west coasts indicates the displacement of warmer or cooler waters in succession in middle latitudes from west to east (refer to RODEWALD, 1955-1960, UDA, 1960) and presumably from east to west in the lower latitudes (RODEWALD, 1955–1960, and J. BJERKNES, 1961) during the cycle of years.

The anomaly chart of water temperature for each year during 1910–1941 and 1952–1960 indicates transpacific travelling pattern from west to east in the north to 30°N and on the contrary from east to west in the lower zone probably.

The water temperature along the Japanese side and in the American side in the North Pacific changes conversely in the long term trend. (Table 1).

Table 1. Reciprocal relation of water temperature along the Japanese side and in the American side in the North Pacific during the years 1911～'41.
(A: 35°–40°N. 140°–155°E., H: 35°–40°N., 130°–120°W)

Year	Year Mean Temp. in A.	Year Mean Temp. in H	Temp. Dif.
1911	22.3°C	15.5°C	6.8°C
12	22.9	16.5	6.4
13	*22.3*	**18.6**	*3.7*
14	**23.2**	17.3	5.9
15	**23.5**	16.0	7.5
16	23.0	15.0	8.0
17	*21.0*	*14.5*	6.5
18	23.5	14.8	8.7
19	22.4	14.4	8.0
20	**24.7**	**16.0**	8.7
21	24.3	*15.2*	**9.1**
22	23.4	15.8	7.6
23	*22.9*	**16.1**	*6.8*
24	23.9	*15.1*	8.8
25	**24.5**	15.5	**9.0**
26	*21.0*	**16.1**	*4.9*
27	(23.9)	15.4	8.5
28	(23.6)	14.9	7.7
29	(24.5)	**16.5**	8.0
30	(25.0)	**16.6**	8.4
31	23.5	15.7	7.8
32	*23.2*	*14.9*	8.3
33	**24.8**	15.3	**9.5**
34	*21.3*	**16.2**	*5.1*
35	22.9	*15.0*	7.9
36	22.9	15.9	7.0
37	**24.7**	15.9	8.8
38	23.9	16.1	7.8
39	23.9	16.1	7.8
40	22.9	16.7	6.2
41	*21.1*	**17.8**	*3.3*

III. The mechanism of pulsation and cyclic change of oceanic climate

The atmospheric pressure differences between the core pressure of Siberian High, North American High, Aleutian Low and North Pacific High, in winter increased year by year since 1955 to 1959, causing the accelerated geostrophic flow, and the intensified gyres with heat transport of water masses from west to east. Successive intrusions were followed in course of such transfer (Fig. 2). (Refer also to Fig. 1).

In the year of Aleutian Low and the North Pacific High shifted to southwest, the water temperature along the American side rises and that along the Japanese side falls.

In winter higher pressure on the continent and lower pressure on the sea and ocean arouse stronger monsoon between Siberian High and Aleutian Low in the western sea region carried colder water to the south and brought cooler climate and transported more abundant warm waters by westerly or south-

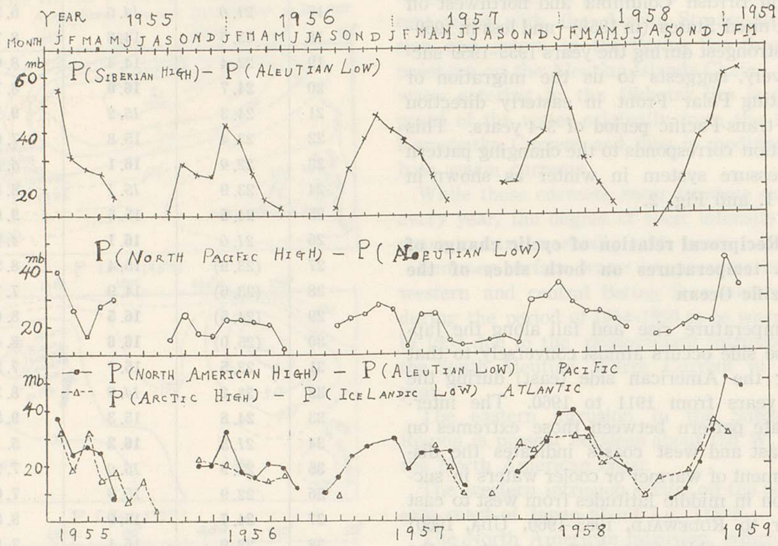

Fig. 2. Difference of Core pressure corresponding to the Center of Action.

westerly drift due to prevailing winds between the North Pacific High and Aleutian Low into the eastern portion of the ocean.

The abnormal changes of El Niño, California Current Systems, the Peru Current, as well as the anomalous Kuroshio might be correlated with the changes of pressure systems and wind systems in the Pacific.

IV. Anomalous oceanographic phenomena caused by the effect through deep water circulation and upwelling.

Anomalous Kuroshio meander had been correlated with the upwelled cold water mass by the present author and other researchers in Japan, although still there left diverse theories on the mechanisms of upwelling itself. (Refer to UDA 1949, MASUZAWA, FUKUOKA, NAN'NITI, SAITO, MORIYASU, and YOSHIDA, S. etc.)

It seems quite probable that such a phenomenon might be caused by the effect through the changing intensity of deep circulation such as the Pacific Intermediate Current.

The Intermediate water of low salinity originated from Subarctic Region sinks at the Polar Front obliquely, represent also a good indicator of the prevalence of the Subarctic Current. Figs.* (were neglected) show the distributions of the values, and the depth of the salinity minimum in different years, 1955, 1958. To maintain the broad extended areas of salinity minimum, intermediate layer advection current is necessitated. Vertical mixing only without advection can not explain its stationary existence.

Meridional sections across the Polar Frontal Zone indicates the second maximum of dissolved oxygen which suggests that the advectional descent of Subarctic water, lying along the salinity minimum core axis of the Intermediate water (Fig. 3).

The major routes of Salinity Minimum water in the North Pacific are shown in Fig.* which enters strongly in the Southern Sea basin of Japan extending from 34° to 20°N with the depth of 800 m or shallower (upwelling near the coast of Ryukyu and Japan Proper) southwesterly and presents at last in the Equatorial Pacific region.

On the contrary to the southwards extension of the Intermediate Water, the deep

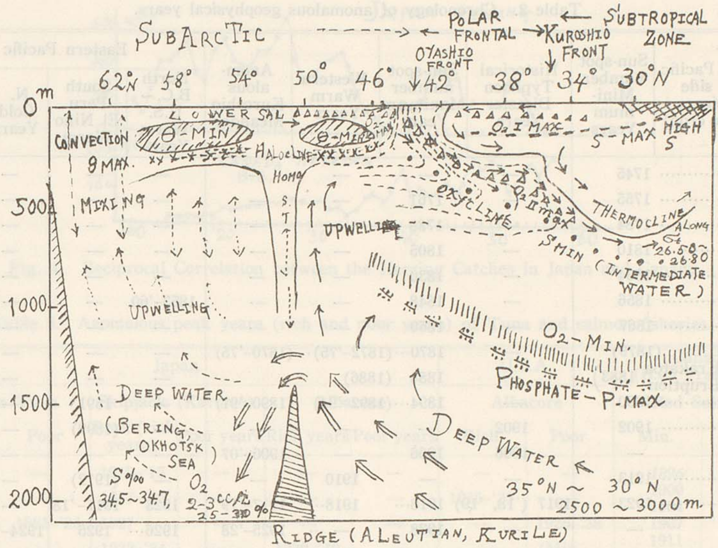

Fig. 3. Schematic Circulation in the North Pacific at Meridional Section.

current seems to extend northward as shown in Fig. 3.

The schematic pattern of deep circulation in the meridional section is shown in Fig. 3. The inflow of the Pacific Deep water in the Okhotsk Sea and Bering Sea in the bottom layer over the Aleutian and Kurile Ridges, showing the higher salinity of 34.0-34.7‰ and richer dissolved oxygen which shows the pattern of conspicuous upwelling in general, especially near the ridge, coming the Subarctic region north to the Polar Front from the deeper layer below the 3000 m. depth, similar to the case in the Antarctic Ocean (UDA, 1961).

The productivity of whale and salmon fishing grounds may depend on such upwelling and partly in addition to the turbulent mixing and convection in the upper layer.

Table* (was neglected) suggests us the influencial depth of convectional mixing in the northern Subarctic water from winter to spring and summer within the 200-300 m. depths from sea surface in winter almost completely, and gradually to the lower depths with delayed phase lag.

In the upper layer waters of lower salinity in the subarctic Okhotsk and Bering Seas flow out through the Middle Kurile and Aleutian Islands, with contrast to the waters in the deeper layer flowing northward in those basins tending to upwelling in addition to entrainments, which are basically important and different from the oceanographic structures in the North Atlantic Ocean.

V. Correlated fluctuation of world-wide oceanographic phenomena

Inspecting hitherto published papers the author presents chronological tables showing the contrasted warm and cold years in the Pacific and Atlantic, anomalous Kuroshio patterns, California Current and Peru Current. (El Niño) (Table 2).

The pressure difference between the North American High and the Icelandic Low in the Atlantic varies similar to that in the Pacific, which suggests to us the concurrent changes of High and Low in the Northern Hemisphere (Fig. 2).

Concerning sea temperature, the reciprocal relations of anomalous years as well as the long term trends (rise or fall) in the east and west portions of the Pacific and the

Table 2. Chronology of anomalous geophysical years.

Western Pacific Japan side Cold Years (Bad rice crop)	Sun-spot number Minimum Years	Historical Typhoon Disaster Years	Sun-spot number Maximum Years	Western Warm Years	Anomalous Kuroshio Meander	Eastern Pacific: North B.C. ~ U.S. Warm Years	Eastern Pacific: South Peru El Niño Warm	Eastern Pacific: N. Cold Years	Eastern Pacific: S. Cold Years
1745 ············	1745	—	—	—	—	—	—	—	—
1755 ············	1755	—	1761	—	—	—	—	—	—
1783 ············	1784	—	1788	—	—	—	—	—	—
1809 ············	1810	—	1805	—	—	—	—	—	—
1833 ············	1834	—	1830	—	—	—	—	—	—
1854 ············	1856	—	1848	—	—	1853–'60	—	—	—
1866 ············	1867	—	1860	—	—	—	—	—	—
1869	(1879)	—	1870···	(1872–'75)···	(1870–'75)	—	—	—	—
1884	(Krakatoa Eruption 1883)	—	1884	(1886)		—	—	—	—
1891 ············	1890	—	1894···	(1892–'94)	(1890–'91)	—	1891	—	—
1902 ············	1902	1902	—	—	—	—	(1899)	—	—
(1905)	—	1906	1906	— ···	1906–'07	—	—	—	—
1913 ············	1913	—	—	1910	—	—	(1912)	—	—
1923 ············	1923	1917 ('18, '19)	1918···	1918···	1917–'19	1923	1917–'18	—	—
1926	—	—	1928	— ···	1925–'28	1926···	1925	1924–'25	—
1931	—	—	—	1930	—	1931···	1930	—	—
1934 ············	1934	1934	—	1933···	(1934)	1934	—	1933	—
1935	—	—	1937···	1937, 38···	1936–'40	—	—	1935	—
1941	—	—	—	1942···	—	1941···	1941	—	1942
1944 ············	1944	1943	—	—	—	—	—	—	—
1945	—	1945, 47	1948	1950···	(1947)	—	(1947)	—	—
1953 ············	1954	1954	—	1955···	1955–'56	—	1953	1948–'56	1950–'55
1958	—	1958, '59	1958	— ···	1959–'61	1958–'59···	1957–'58	—	—
? ············	(1964)	—	—	—	—	—	—	—	—

Atlantic Oceans have been roughly established, though they are somewhat obscure in the Atlantic (Tables 1, 2).

Notwithstanding the scarcity of data from the southern latitudes, the temperature variations along the Pacific coasts of North and South America nearly follow the same trends.

Most of the years of the cold oceanic temperatures are correlated with the periods of minimum sun-spot activity; warm oceanic water years are correlated with periods of maximum sun-spot activity. Both short and long cycles of them might be corresponded to the oceanic changes.

The anomalous Kuroshio patterns and El Niño might be linked through the fluctuation of trades-index or through pressure gradients between the atmospheric High and Low (or Trough) caused by the dislocation and development of pressure systems.

The climatic changes like the occurrence of severe typhoons are also correlated with the anomalous years of oceanic conditions, as we see in Table 2.

VI. Cyclic fluctuation of the fisheries in response to the variation of the oceanic climate

Rich and poor years of tunas, salmons, herring and sardine catches are correlated with the environmental changes including their secular trends (Refer to Fig. 4 and Table 3).

(1) Fluctuation of the tuna fisheries.

(i) Skipjack-tuna fisheries

Peak landings of skipjack from Japanese waters have occurred at irregular inter-

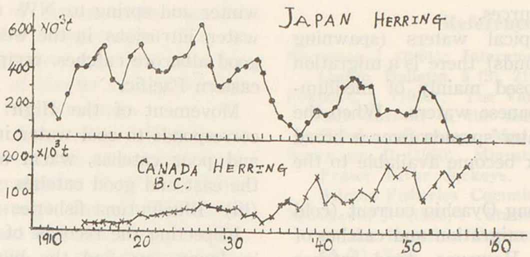

Fig. 4. Reciprocal Correlation between the Herring Catches in Japan and Canada

Table 3. Anomalous peak years (rich and poor years) of Tuna and salmon fisheries.

Japan						U.S.A.		Canada (B.C. Fraser R.)	
Bluefin Tuna		Skipjack (Katuwo)		Albacore		Albacore		Red Salmon	
Rich,	Poor	Peak (rich years)	Poor years	Rich years	Poor years	Rich	Poor	Min.	Max.
1891,	—	1912–'15	—	—	—	—		*1896*	—
1902–'19,	—	1917–'20	—	—	—	1915–'25	—	1900 1904	**1901** 1905
—,	1921–'26	1927	—	—	—	—	1926–'38	1907	1909
1930–'40,	—	1933–'34	—	1930–'40	—	—	(Min. 1933)	1911 1916	**1913** 1917
(1939–'40), Peak	—	1936–'38	—	(peak 1936–'38)	—	—	—	*1918* *1923*	1921 1925
—		1942	—	—	—	—	—	*1928* 1931	1930 **1934**
—,	1941–'48	—	1944–'50	—	1941–'49	1941–'50	—	1935	1938
1950–'58,	—	1956–'58	—	1950–'57	—	—	1953	*1939* *1943*	**1942** 1946
—		—	—	—	1958–'60	1956～	—	*1947* 1952 1956	1951 1954 **1958**

vals: 1912–1915, 1917–1920, 1927, 1933–1934, 1936–38, 1942, 1956–58.

The years of 1944–1950, representing continued poor catches of skipjack, correspond to the prevalent cold current.

Since the year 1956 conditions have improved remarkably, following the uprise of warm current strength and the northerly shift of sardine fisheries areas.

Compiling the above, we can conclude that in the period of prevalent warm current we have abundant catches (rich years) from the densely concentrated schools of skipjack and by active feeding on bait fishes.

Conversely in the period of prevalent cold current the less abundance of northerly migratihg schools in addition to the poor feeding on bait ended in the failure of fisheries.

Or in other words, a study of oceanographic conditions showed that good catches were made during the years with warm water temperatures, while poor catches were made during years with cooler water temperatures.

These differences in temperatures are primarily related to the relative strengths of the warm Kuroshio and the cool Oyashio. It was postulated that recruitment of skipjack is favored by the enriched zones associated with upwelling in the Equatorial Counter Current and subsurface layer near the equator.

Accordingly, fisheries-biological and oceanographical surveys in the equatorial and tropical waters are urgent in order to solve the mechanism hidden in the mystery of the changing tuna resources.

From these tropical waters (spawning areas or home grounds) there is a migration of skipjack (composed mainly of medium-sized fish) into Japanese waters. When the warm Kuroshio water spreads over a broad area, more skipjack become available to the Japanese Fishery.

Conversely a strong Oyashio current (cold water) hinders the migration and catches of skipjack are low. However, good catches may also be made when both the Kuroshio and Oyashio are stronger.

Under the latter conditions skipjack are concentrated along the boundary between the warm and cold water (Polar Front) in summer and fall seasons.

It is postulated that the yield of skipjack from Japanese waters varies inversely with that from American waters.

(ii) Albacore-tuna fisheries

During the years 1930–1940 the albacore fishery in Japan was prosperous, having peak rich years in 1936–1938. After 1941 bad years occurred. Then, in the years of 1950–1957 the rich fishing period returned again. Among the peak years of 1951, 1952 and 1957, the greatest peak everknown in 1952 was notable.

Albacore fishery off the west coast of USA started in 1910 and after passing rich years in 1915–1925 fell almost into extinction during the years of 1926–1938 (the lowest in 1933). After about 1941 the albacore fishery entered a richer period, and the largest catch occurred in 1950. After that year albacore again disappeared and the decline of the yield came to the bottom in the year 1953. However, since 1956 off the States of Oregon and Washington, the albacore has tended to increase and its fishery has improved. Especially in the years of 1958 and 1959 big catches occurred corresponding to the northerly shift of their fishing localities at the time of the warm water intrusion.

It is postulated that the variations of albacore catch between these two areas (western and eastern pacific) occur in a reciprocal manner as was the case of skipjack.

Movement of the North Pacific High in winter and spring to NW results in warm water intrusions in the western Pacific and good albacore catches, reciprocal to that in eastern Pacific.

Movement of the High to the Southeast corresponds to cool water intrusion in west and poor catches, warm water intrusion in the east and good catches.

(iii) Bluefin-tuna fisheries

Inspecting the records of bluefin fisheries in Japan, we find the big catches in 1891 and 1939–'40. During the period 1941–'48 bluefin almost disappeared from Japanese coast. However since 1950 young tunas appeared again in the adjacent waters of Japan. The yield was improved year by year with an increase of size (age group). The bluefin fisheries along the coast of Japan Sea side were poor in 1921–'26 (cooler period), rich in 1928-1936 (warmer period), poor in 1944–1953 (cooler period), and comparatively rich in 1954–1960 (warmer period).

Thus, bluefin catches off the coasts of Japan have also shown periodic fluctuations, with a decline in catch associated with the periods of cold water intrusion, an increase in catch with periods of warming.

The cause of these fluctuations may be correlated to dominant brood strength during periods of rising temperatures. When cool waters intrude southwards into the spawning grounds, one or more year classes are seriously affected. However, these cooler waters are comparatively rich in nutrients and, with a reversal in temperature towards warming, fovorable temperature conditions for their migration northward into the Japanese waters. Thus we have a cyclic situation-a reduction of year class strength and the fishery during periods of cool surface waters-followed by and increase in brood strength during the subsequent period of warming.

The tuna inhabiting water becomes more fertile during the southward intrusion of cold water, which in turn might have an effect upon the strength of year classes. The progressive northward distribution of tunney will continue for several years together with the shifting of a favourable environment. Changes will occur with the fluctuation of warm currents.

The abundance of young tunny coincides with a rise in water temperature. The occurrence of the extremely big-sized tuna foresigns the decline of bluefin fishery through the experience in the past years.

(2) Fluctuation of the salmon fisheries

Relation between maxima of sun-spot variation the peak migration of the Fraser River sockye salmon through the Johnson Strait has been established by P. Gilhousen (1960).

Refering to Table 3, the present author remarked that the peak years of the salmon catch on the American side (the abnormal cool years on the Japan side) e.g. in 1901, 1905, 1913, 1923, 1926, 1931, 1934, 1941, 1958.

In the sun-spot maximum year 1958, concerning Fraser River Sockye, the delay of the arrival of the escapement on the spawning ground disturbed the normal spawning population to its reproductive environment and may have seriously jeopardized its reproductive potential. Oceanographic variations in offshore and inshore waters largely control the ultimate rate of survival and approach of migration of salmons. (Tully 1960).

(3) Fluctuation of the herring fisheries

Reciprocal relation between the landing in Japan and that in Canada (BC) was established. (Fig. 4)

Conclusion

Finally we can conclude that the environmental conditions of sea and atmosphere affect on the reproduction potential and consequently changes the relative population strength as well as the distribution or concentration of those fishes. In the future we will be able to predict the oceanographic environmental conditions of them by considering the meteorological conditions of the world and the persistent effects of solar activity.

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