Possible effect of surface wind force on the sex-specific mortality of young fur seals in the eastern Pacific*

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Introduction

The estimate of natural mortality rate is an important parameter to evaluate the population level of the northern fur seals. In the following two cases, the mortality rates are directly estimated through the age composition of catch. The age composition of randomized kill for living bulls as well as of naturally dead bulls on land presents the best estimate of the mortality rate of territorial bulls (JOHNSON, 1968). The female compositions collected pelagically at random are available for estimating the mortality rate of adult females when the degree of commercial exploitation for females has been negligible (ICHIHARA, 1972) or not so biased (CHAPMAN, 1964).

In the early life of seals of both sexes, however, it is hard to estimate the annual natural mortality rate through the catch composition, because the harvest of young seals on land and at sea does not represent the age structure of population. Although the tagging for seals of ages 1 and 2 and the subsequent tag recovery on land help to estimate the survival rate in each year class, the final results are not obtained yet. In the application of this improved tagging method, the survival rate of young females must be infered from that of young males, since the massive commercial kill for females has not made recently on the breeding islands. Several papers concerning the stock assessment of the northern fur seals state that the survival rate from birth to age 3 differs between sexes and that it is higher in females than in males. Such divergent mortalities have been interpreted as a sex-specific character of seals but not proved yet by other informations.

It is reasonable to consider that the natural mortality of seals is higher in the first ocean life after seals go down to sea from the breeding islands. Arranging the past records on stranded seals on beaches and the weather data on sea, I propose a view in this paper which the divergence of mortality between sexes is possibly affected by the frequency of stormy weather attacking sea.

Information sources

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From 1959 through 1971, 35 dead seals which were stranded on the beaches of Hokkaido and of the northern part of Honshu in Japan were reported. In the west coast of North America, a total of 228 young seals was stranded from 1958 through 1967. All of reported seals bore the metal tags on fore-flippers, and hence the tag number indicates the age of seals and the island of origin where the seal was born. Reports on seals from the coast of North America were presented in 1967 by the courtesy of late Mr. GORDON C. PIKE and Mr. I. B. MACASKIE, Biological Station at Nanaimo, Fisheries and Marine Service, Department of Environment (formerly Fisheries Research Board of Canada). My thanks are due to their kind helps.

Speeds of wind on sea was rearranged on the basic data in Marine Climatic Atlas of the World published by U. S. Navy which shows the monthly mean wind forces in 4 locations in the west coast of North America; Gulf of Alaska, northern British Columbia, California and lower California. This Atlas summarizes data on surface winds for the past ten years from 1949 to 1958.

The surface water temperature in the eastern Pacific was obtained from Fishing Information published by National Oceanic and Atomospheric Administration in La Jolla, U. S. A. which reports the monthly surface isotherm in the Pacific Ocean.

Off the west coast of North America, major seals comprise the Pribilof herd and the segregation by sex in the wintering waters is clear than in the western Pacific. Therefore, informations from the eastern Pacific area are utilized primarily in this paper and those from the western Pacific are applied supplementally.

Segregative distribution by sex of young seals in the eastern Pacific

According to Canadian and U. S. A. annual reports on fur seal investigations, a total of 2,516 seals younger than age 3 was collected by the pelagic research in the eastern Pacific from 1958 through 1967. The pelagic catch comprising 1,009 males and 1,507 females was carried out from Bering Sea to Carifornia. When the location of catch is rearranged by area, 6 areas are established from North to South; Bering Sea, Gulf of Alaska, British Columbia, Washington, Oregon and California. Throughout all areas, 38.1% of the total catch is accounted for by seals of age 1, 22.6% by age 2 and 39.3% by age 3 respectively. The major seals are collected in Gulf of Alaska, off the coast of British Columbia and Washington. The seasons of collection are different among areas; from June through October in Bering Sea, March through August in Alaskan waters, January through June in far southern waters than British Columbia. When the sex ratio by age of seals is plotted for each area in Fig. 1, the clear segregation by sex appeares in the eastern Pacific. Except for the composition in Bering Sea where the catch was centered around the breeding season of seals, the male sex ratio declines from the northern to the southern areas although females are dominant in the total pelagic catch including all ages for each area. In every age of seals from age 1 to age 3, a boundary of 50% sex ratio is found in the waters off the northern

British Columbia and hence females are dominant in the southern waters.

The mean temperature of water surface is 9.4°C in the boundary area, off British Columbia, from November through June. Since no information is available for the water temperature during 1958–1967, the mean temperature is obtained from the surface isotherm during 1969–1971. Probably a limiting factor determining the segregation by sex is the temperature of the water mass.

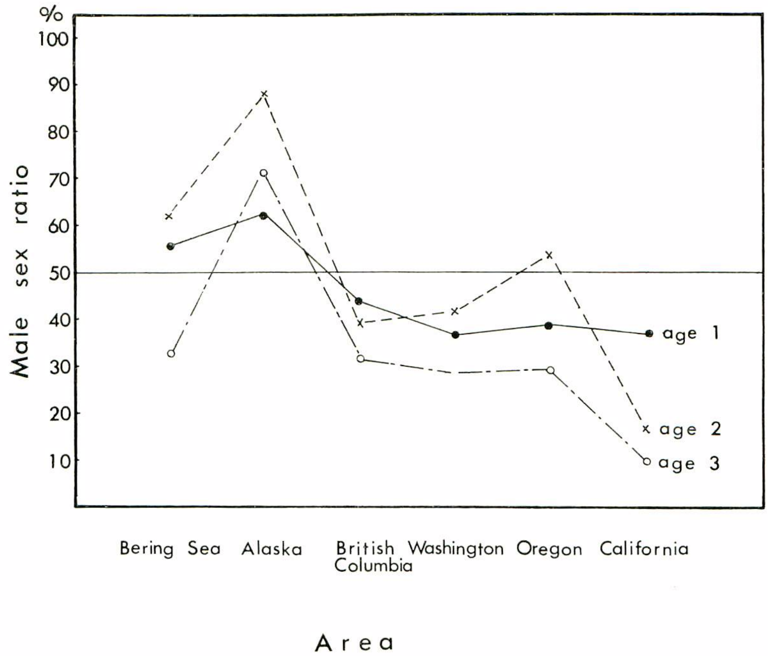

Fig. 1. Male sex ratio of fur seals by age taken in 6 areas of the eastern Pacific.

Records of stranded seals

Seals stranded on the beaches in the northern Japan are summarized by age and by month in Table 1. The majority of stranded seals, 82.9% of the total record, comprises ages 0 and 1, and it appeares from November through April with the peak occurrence in January and February. Seals of ages 0 and 1 live the first ocean life from the breeding islands in the winter and spring season. The occurrence of seals of ages 2 and 3 decreases gradually, indicating 11.4% and 5.7% of the total record respectively. The metal tags attached on the fore-flippers of these dead seals suggest that 28 stranded seals, 80.0% of the total, are from the Robben origin, 5 seals from the Commander origin and 2 seals from the Kuril origin. No seal from the Pribilof origin has been reported. The sex of stranded seals is not determined by biologists.

On the other hand, 228 seals of ages 0 and 1 were stranded on the west coast

Table 1. Occurrence of stranded seals in the coast of the northern Japan, by month and by age, from 1959 to 1971.

Month	Age				Total
	0	1	2	3	
November	2		1		3
December	5				5
January		8	1		9
February		9			9
March		3		1	4
April		1			1
May					
June			1		1
July			1	1	2
August					
September		1			1
October					
Total	7	22	4	2	35

of North America from 1958 through 1967. According to the basic data sent from Biological Station at Nanaimo, it is interpreted that most of seals was dead at the time of stranding. These records are summarized by area and by month in Table 2. Of 8 seals of known sex, 5 seals are males and 3 seals are females. As in the case of the Japanese coast, the major seals, 97.4% of the total, are stranded in North America from November through April with the peak occurrence in January. Although all stranded seals have not been always reported, number of stranded seals in the

Table 2. Occurrence of one year old seals stranded in the coast of the eastern Pacific, by month and by area, from 1958 to 1967.

Month	Area					Total
	Alaska	British Columbia	Washington	Oregon	California	
November	1					1
December	2	1		1		4
January	19	74	14	5		112
February	5	4	21	8	1	39
March	1	8	31	16		56
April	2	1	3	2	2	10
May		1	1		1	3
June		1				1
July	1					1
August						
September		1				1
October						
Total	31	91	70	32	4	228

coast of British Columbia are the largest among 5 areas; Alaska, British Columbia, Washington, Oregon and California. Only 4 seals are reported from the coast of California. The month of peak occurrence differs by area and it is March in Washington and Oregon.

A total of 122 stranded seals is observed in the northern area composed of Alaska and British Columbia, while 106 seals are reported in the southern area comprising Washington, Oregon and California. The male sex ratio of stranded seals is probably higher in the northern area, when the segregation of seals at sea is taken into consideration. The sex determination unfortunately is not made in the major case but 4 males and 2 females are stranded in the northern area.

Surface wind force

Regardless of ages of seals, the mortality in the ocean life are caused by the following four factors; disease or trauma, natural enemy, environment and the complex of the former three. With regard to killer whales (*Orcinus Orca*) as a natural enemy, RICE (1968) points out no documented finds of fur seals in killer whale stomachs. The large white shark (*Carcharodon carcharias*) and other species of shark probably prey on pups of seals. KEYES (1965) suggests that the principal cause of mortality in seals at sea are predation, starvation, weather, parasitism, food poisoning and infectious disease. Among diseases, he refers to effect of the ascarid infection on the seal mortality, indicating no examples of autopsy.

After seals of age 0 go down to sea from the breeding island, they solitarily inhabit the wintering waters and make no herd at sea. Compared with elder seals acclimatized to the ocean life, these seals possibly spend the winter season in waters near the coast and do not dive so deep.

Most of reports on stranded seals in the coast of the northern Japan suggests that dead seals are observed in the next day of the stormy weather. In the violent weather, such young seals are rolled by high waves and fall into emaciation. It can be readily imagined that subsequently these seals face death through starvation. If the stormy weather continues, the mortality of young seals will be elevated but we have no other evidence to explain the relationship between the mortality of young seals and environmental sea conditions.

Although there is no climatological information available on the visiting frequency of heavy storms at sea, the mean wind force is an index which shows the rough condition of the sea surface. A linear relation of the surface wind force to the height of wave is presented by CORNISH (1934) as follows.

$$H\,(m) = 0.48W\,(m/s)$$

Where H is the height of wave in meter and W is the wind speed in meter per second.

The coefficient of this formula depends on the blowing duration of prevailing wind as well as on the distance from the coast and so on. According to the above formula, the height of wave is 4.9 meter under the blowing wind speed of 20 knots an hour.

On the basic data of Marine Climatic Atlas of the World, the monthly mean wind force on the sea surface is plotted in Fig. 2 for 4 areas in the eastern Pacific. The original data expressed with Beaufort force is converted to the speed in knot. To facilitate the explanation, the yearly life cycle of adult seals on both sea and land is described also in Fig. 2. In the Alaskan waters and off the northern British Columbia, the wind forces decline from the highest in January to the lowest in July.

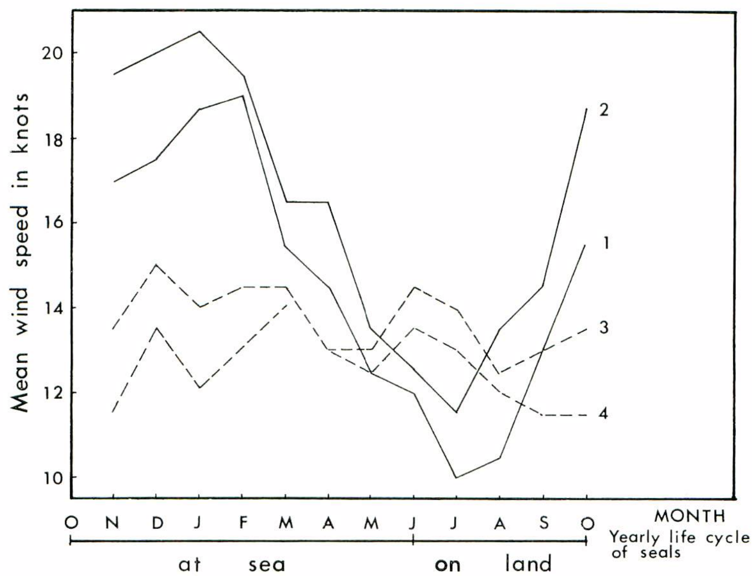

Fig. 2. Mean wind force on sea surface by month and by area in the eastern Pacific.
1; Gulf of Alaska 2; off the northern British Columbia
3; off California 4; off lower California

On the other hand, the wind speeds do not fluctuate greatly with the range of 11–15 knots an hour, off California and lower California. When the Alaskan and the British Columbia waters is expressed as the northern area and two California waters as the southern waters, the wind forces in June and July are weaker in the former than in the latter.

Table 3 shows the monthly ratio of the wind force in the northern area against that in the southern area. The ratio in January is 1.51, the maximal value throughout a year. In the period from November through April in which the major stranded seals appear along the west coast of North America, the mean ratio is 1.33. This comparison suggests that the mortality of seals caused by violent conditions of sea is higher in the northern area than in the southern area.

Conclusion

It is difficult to evalute the relative importance of mortality from young seals at sea, for lack of evident informations available. Among principal causes of mortality in seals which spends the first ocean life, disease and traumas are not a sex-specific factor, even if these are induced from the metal tagging carried out in the pup stage on land. The predation pressure by natural enemies is impartially imposed on seals regardless of sex when the predators show uniform distribution at sea. The informations on predators for seals are uncertain.

Table 3. Surface wind speed in knots by month and by area in the eastern Pacific during 1949–1958. The northern area comprises Alaska and northern British Columbia waters. The southern area involves California and lower California waters.

Month	Area		A/B
	northern(A)	southern(B)	
November	18.3	12.5	1.46
December	18.8	14.3	1.31
January	19.6	13.0	1.51
February	19.3	13.8	1.40
March	16.0	14.3	1.12
April	15.5	13.0	1.19
May	13.0	12.8	1.02
June	12.3	14.0	0.88
July	10.8	13.5	0.80
August	12.0	12.3	0.98
September	13.8	12.3	1.12
October	17.1	12.5	1.37

In the eastern Pacific where the major habitants are seals from the Pribilof origin, the state of segregation by sex and the monthly occurrence of seals stranded on beaches was examined by area in this paper. When the border is drawn off British Columbia, males are more abundant and stranded seals of unknown sex are observed in larger numbers in the northern area than in the southern area. The weather statistics from November through April shows that the stormy weather attacks sea more frequently in the northern area than in the southern area. These evidence suggests that through the violent weather males wintering in the northern area suffer death in the higher rate than females in the southern area. The effect of weather condition on mortality is considered to be great for seals of the first ocean life. Consequently, the mortality caused by marine environment is different between sexes.

This findings show a possibility which the detailed data on the stormy weather along the coast is an indicator estimating the ratio of the survival in females against that in males. In the future, therefore, the comparison should be tried between the weather condition and the survival ratio by estimated from the other sources, from year to year. Through necropsy, confirmation of the mortality cause for stranded seals is necessary.

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東部太平洋における若令オットセイの性別死亡率に海面風力が影響する可能性（要旨）

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商業的捕獲の対象前の若令オットセイの死亡率は加入量の大小に直接関係するため資源評価の要素として重要なものである。しかし，それを年令別に推定する手段に欠けていたために，雄については生まれてから3才までの死亡率を一括して推定し，雌については商業捕獲が実施されていないために雄の推定死亡率に定数を乗ずる方法で処理してきた。いくつかの資源評価のモデルを考慮する時，生まれた時は同数でありながら若令の雄の死亡率は雌のそれを上回る結果となっており，その原因は不明である。この論文では東部太平洋アメリカおよびカナダ沿岸に自然死後打ち上げられた若令オットセイの時期別地域別分布と海上調査の結果入手された若令オットセイの性別棲み分け分布とを対応させ，打ちあげられる量の多い海域が時期的に風波の烈しい海域と一致する点を見出した。このことから若令雄オットセイの自然死亡率が高い原因のひとつが波浪にともなう斃死である可能性を指摘した。また，他の死亡原因を検討してみても死亡率の性別差を見出すことが困難である点を指摘してある。そのほか日本沿岸に打ち上げられた若令標識オットセイの時期別分布も併記した。