Forecasting Salmon Returns to Coastal Area by Driftnet Test Fishery in Offshore Waters

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この文書を引用する場合は下記による：
石田行正・小倉未基・伊藤外夫．1989．沖合における流し網試験操業によるさけ・ます類の沿岸回帰量の予測・28ページ．（第36回INPFC定例年次会議提出文書．1989年10月．米国．シアトル）．水産庁．遠洋水産研究所．日本．〒424清水市折戸5-7-1．
沖合における流しぶり試験操業によるさけ・ます類の沿岸回帰量の予測

石田行正・小倉未基・伊藤外夫（遠洋水産研究所）

要約

1972年から1988年におけるさけ・ます調査船流しぶりの 결과より、2×5度海区別、魚種別、成長・成長魚別のCPUEと各種主要系群の沿岸回帰量あるいは沿岸漁獲量との相関関係から回帰量予測の可能性を検討した。


シロザケについては日本系の沿岸回帰量および東カムチャッカ系の沿岸漁獲量が6月の8050海区における成長魚のCPUE及び7月の8056海区における成長魚のCPUEとそれぞれ高い相関関係を示した。なお1989年の回帰量は1988年6月の8050海区における調査が実施されていなかったため推定できなかった。

カラフトマスについては東カムチャッカ系および西カムチャッカ系の沿岸漁獲量が7月のE6048海区におけるCPUEと高い相関関係を示した。

これらの結果にもとづき、回帰量予測に有効と考えられる海区における試験操業の必要性について指摘した。

はじめに

さけ・ます類の沿岸回帰量の予測は、再生産のための親魚を確保し、資源を有効に漁獲するために、重要な仕事である。これまで沿岸回帰量の予測は、回帰量とその年齢組成から求めた再生産関係、降海幼魚量、沖合での漁業の情報、水温など回帰量と相関を示す環境指標の利用などにより実施されてきた。また1部ではあるが、ブリストル湾のベンザケの回帰量の予測には日本のさけ・ます調査船の流しぶりCPUEが利用されている（Fried et al., 1987, Ito et al., 1988）。

本研究の目的は長年実施されてきた日本のさけ・ます調査船の流しぶりCPUEとさけ・ます類の主要系群の沿岸回帰量あるいは沿岸漁獲量との相関関係から回帰量予測の可能性を検討し、沖合におけるさけ・ます類調査の将来計画について考察した。
材料と方法

分析に用いた沖合資料は1972年から1988年に、日本のさけ・ます調査船が収集した流し網の操業資料及び魚体測定資料である。さけ・ます調査船は10種目合調査網、商業目合流し網および標識放流用の延繩を用いている。ここでは利用反数が比較的多く、かつ漁獲魚がその年に回帰する成魚および主に翌年に回帰と考えられる未成魚からなる商業目合流し網の資料を用いた。

一方、沿岸回帰量に関しては、各魚種について、資源量が大きく、過去の知見から、日本のさけ・ます調査船の調査海域に分布が確認されている主要系群について1972年から1988年までの沿岸回帰尾数あるいは沿岸漁獲尾数の資料を用いた（表1）。

分析では、まず6月および7月の2×5度海区別、魚種別、成魚・未成魚別のCPUE（反当たり尾数）の年変化を求めた。次ぎに各魚種、各系群について、各海区のt年の成魚のCPUEとt年の沿岸回帰尾数（漁獲尾数）との相関を、またt年の未成魚のCPUEとt+1年の沿岸回帰尾数（漁獲尾数）との相関を計算した。さらに10年以上のデータがあり、相関係数が0.6以上を示す海区の中で、平均CPUEが最も高く、また過去の知見から当該系群の分布が期待される海区についてCPUEと沿岸回帰尾数の散布図を作成し、回帰直線を求めた。また可能な場合には、この回帰直線を用いて1988年の未成魚のCPUEから1989年の沿岸回帰尾数（漁獲尾数）を推定した。

結　果

ベニザケ

アジア側の主要ベニザケ系群である西カムチャッカ系のt年の沿岸漁獲尾数とt年の沖合の成魚のCPUEとの相関を見ると、6月のE6548海区で高い相関係数（0.85）が示された（図1-a,b）。また西カムチャッカ系のt+1年の沿岸漁獲尾数とt年の沖合の未成魚のCPUEとの相関を見ると、6月のE7050海区で高い相関係数（0.90）が示された（図2-a,b）。さらに1988年の未成魚のCPUE（1.45反当たり尾数）から1989年の沿岸漁獲尾数は210万尾と推定された。

北米側の主要ベニザケ系群であるブリストル系のt年の沿岸回帰尾数とt年の沖合の成魚のCPUEとの相関係数はいくつかの海区で高い値を示し、これらの中から平均CPUEが2.80と最も高い6月の8050海区が選択された（図3-a,b）。またブリストル系のt+1年の沿岸回帰尾数とt年の沖合の未成魚のCPUEとの相関を見ると、7月のE7550海区で高い相関係数（0.64）が示された（図4-a,b）。さらに1988年の未成魚のCPUE（3.83反当たり尾数）から1989年の沿岸回帰尾数は3750万尾と推定された。

シロザケ

日本系のt年の沿岸回帰尾数とt年の沖合の成魚のCPUEとの相関を見ると、7月の8056海区で高い相関係数が示された（図5-a,b）。また日本系のt+1年の沿岸回帰尾数とt年の沖合の未成
魚の CPUE との相関を見ると、6月の 8050 海区で高い相関係数が示された（図 6-a, b）。

東カムチャッカ系の t 年の沿岸漁獲尾数と t 年の沖合の成魚の CPUE との相関を見ると、7月の 8056 海区で高い相関係数が示された（図 7-a, b）。また東カムチャッカ系の t+1年の沿岸漁獲尾数と t 年の沖合の未成熟魚の CPUE との相関を見ると、6月の 8050 海区で高い相関係数が示された（図 8-a, b）。

なお 1989年の回帰量は 1988年 6月の 8050 海区における調査が実施されていなかったため推定できなかった。

キラフトマス

東カムチャッカ系および西カムチャッカ系ともに t 年の沿岸漁獲尾数と t 年の沖合の CPUE との相関を見ると、7月の E 6048 海区で高い相関係数が示された（図 9, 10-a, b）。

考 察

対象とした各系群の沿岸回帰の時期は主に 7 月以降である（表 2）。それゆえ、6,7 月の沖合調査による成魚の CPUE から、その年の回帰量を推定し、実際の資源管理に役立てることができる。またペニザケとシロサケについては未成熟魚の CPUE から 1 年前に翌年の回帰量の推定が可能である。将来的には、当該海区での試験操業について、洋上のさけ・ます調査船から使用反数、魚種別漁獲尾数、さらにペニザケとシロサケについては生殖腺重量に基づく成魚・未成熟魚の割合等を電報で遠洋水研に連絡し、回帰量予測を迅速に行ない、7 月以降の沿岸漁期に十分活用することが可能であろう。

選択された各海区での CPUE と沿岸漁獲尾数または沿岸回帰尾数との相関係数は 0.643 ～0.904 とかなり高い。しかし、回帰量を推定するためには、より高い相関関係が望ましい。このような相関関係に影響する要因として、試験操業時期・位置・努力量の変動、さけ・ます類の各海区への来遊時期の変動、系群組成の変動、成熟・未成熟の判断基準としている生殖腺重量の変動、沖合の環境要因の変動などが考えられる。特に試験操業時期は年によりかなり変動している（表 3）。今後は少なくともこれらの海区について調査時期を 6 月中旬から 7 月中旬に設定し時期を一定にするとともに、各海区での調査努力を充実させることが必要である。

図 11 は今回の分析結果から回帰量予測に有効と考えられる海区とその調査時期を示している。これら海区の内、6月については 3 海区中 2 海区が、また 7月については 3 海区中 1 海区が米国 200 海里水域内である。本年は、3月の調査調整会議で合意した調査計画にもかかわらず、米国より米国 200 海里水域内での流し網の操作証が得られなかったため、試験操業を実施することができなかった。この点について、次年度の善処を米国代表に強く要請したい。
謝 辞

資料整理のための計算機使用に際し、助言いただいた遠洋水産研究所の魚住雄二氏および宮部尚純氏に感謝する。

文 献


Table I. Catch of salmon in the USSR coastal fisheries and number of salmon returning to Japan and Bristol Bay. (thousands of fish)

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Table 2. Fishing season of each stock in the coastal waters.

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<td>7 - 8</td>
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<td></td>
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<td>7 - 8</td>
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Table 3. The numbers of gillnet test fishing operation in the selected area.

Three figures in each year column correspond to the number of operation in early, mid and late of each month.

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Fig. 1-a. Correlation coefficient between CPUE of maturing sockeye salmon in 2x5° area in June of year t and catch of sockeye salmon in West Kamchatka in year t. Shaded area indicates $r \geq 0.6$ and dark area indicates the area selected.
Fig. 1-b. Relationship between CPUE of maturing sockeye salmon in E6548 in June of year $t$ and catch of sockeye salmon in West Kamchatka in year $t$. 

$Y = 1.182X - 0.306$

$r = 0.851$
Fig. 2-a. Correlation coefficient between CPUE of immature sockeye salmon in 2x5° area in June of year t and catch of sockeye salmon in West Kamchatka in year t+1. Shaded area indicates \( r \geq 0.6 \) and dark area indicates the area selected.
Fig. 2-b. Relationship between CPUE of immature sockeye salmon in E7050 in June of year t and catch of sockeye salmon in West Kamchatka in year t+1.
Fig. 3-a. Correlation coefficient between CPUE of maturing sockeye salmon in 2x5° area in June of year t and return of sockeye salmon to Bristol Bay in year t. Shaded area indicates $r \geq 0.6$ and dark area indicates the area selected.
Fig. 3-b. Relationship between CPUE of maturing sockeye salmon in 8050 in June of year t and return of sockeye salmon to Bristol Bay in year t.
Fig. 4-a. Correlation coefficient between CPUE of immature sockeye salmon in 2x5° area in July of year t and return of sockeye salmon to Bristol Bay in year t+1. Shaded area indicates $r \geq 0.6$ and dark area indicates the area selected.
Fig. 4-b. Relationship between CPUE of maturing sockeye salmon in E7550 in July of year $t$ and return of sockeye salmon to Bristol Bay in year $t+1$.  

$Y = 0.656X + 1.236$  
$r = 0.643$
Fig. 5-a. Correlation coefficient between CPUE of maturing chum salmon in 2x5° area in July of year t and return of chum salmon to Japan in year t. Shaded area indicates \( r \geq 0.6 \) and dark area indicates the area selected.
Fig. 5-b. Relationship between CPUE of maturing chum salmon in 1985 in July of year t and return of chum salmon to Japan in year t.
Fig. 6-a. Correlation coefficient between CPUE of immature chum salmon in 2x5° area in June of year $t$ and return of chum salmon to Japan in year $t+1$. Shaded area indicates $r \geq 0.6$ and dark area indicates the area selected.
Fig. 6-b. Relationship between CPUE of immature chum salmon in 8050 in June of year t and return of chum salmon to Japan in year t+1.
Fig. 7-a. Correlation coefficient between CPUE of maturing chum salmon in 2x5° area in July of year t and catch of chum salmon in East Kamchatka in year t. Shaded area indicates r>=0.6 and dark area indicates the area selected.
Fig. 7-b. Relationship between CPUE of maturing chum salmon in '8056 in July of year t and catch of chum salmon in East Kamchatka in year t.
Fig. 8-a. Correlation coefficient between CPUE of immature chum salmon in 2x5° area in June of year t and catch of chum salmon in East Kamchatka in year t+1. Shaded area indicates $r \geq 0.6$ and dark area indicates the area selected.
Fig. 8-b. Relationship between CPUE of immature chum salmon in 8050 in June of year t and catch of chum salmon in East Kamchatka in year t+1.
Fig. 9-a. Correlation coefficient between CPUE of maturing pink salmon in 2x5° area in July of year $t$ and catch of pink salmon in East Kamchatka in year $t$. Shaded area indicates $r \geq 0.6$ and dark area indicates the area selected.
Fig. 9-b. Relationship between CPUE of maturing pink salmon in E6048 in July of year t and catch of pink salmon in East Kamchatka in year t.
SPECIES=PINK SALMON
STOCK=WEST KAMCHATKA
MATURITY=MT
MONTH=7
GEAR=A

Fig.10-a. Correlation coefficient between CPUE of maturing pink salmon in 2x5° area in July of year t and catch of pink salmon in West Kamchatka in year t. Shaded area indicates $r \geq 0.6$ and dark area indicates the area selected.
Fig. 10-b. Relationship between CPUE of maturing pink salmon in E6048 in July of year t and catch of pink salmon in West Kamchatka in year t.
Fig. 11. Areas and month for forecasting salmon returns by drift net test fishery on the high seas.
FORECASTING SALMON RETURNS TO COASTAL AREA BY
DRIFTNET TEST FISHERY IN OFFSHORE WATERS

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THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
FORECASTING SALMON RETURNS TO COASTAL AREA BY DRIFTNET TEST FISHERY IN OFFSHORE WATERS

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ABSTRACT

The objectives of this study were to examine the possibility of forecasting salmon returns by correlating CPUE values of driftnet of salmon research vessels by month, by 2°x5° area, by species, and by maturing or immature fish, with the numbers of salmon returning to coastal areas or with the coastal catch from 1972 to 1988 for major stocks.

The coastal catch of sockeye salmon returning to the west Kamchatka area showed high coefficients of correlation with CPUE values of maturing fish in Area E6548 and with immature fish in Area E7050 in June. From CPUE values of immature fish in 1988 the coastal catch in 1989 was estimated to be 2.1 million fish. The numbers of sockeye salmon returning to Bristol Bay showed high coefficients of correlation with CPUE value of maturing fish in Area 8050 in June and with CPUE value of immature fish in Area 7550 in July. Numbers returning to the coastal area in 1989 were estimated to be 37.5 million fish from CPUE values of immature fish in 1988.

Numbers of chum salmon returning to Japan and coastal catch of chum salmon in the east Kamchatka showed high coefficients of correlation with CPUE values of immature fish in Area 8050 in June and with maturing fish in Area 8056 in July, respectively. The number of returns to the coastal area in 1989 was not estimated, because the survey was not conducted in Area 8050 in June 1988.

The coastal catch of pink salmon returning to east and west Kamchatka showed a high coefficient of correlation with CPUE values in Area E6048 in July.

Based on these results, we pointed out the necessity of test fishing in areas which are considered important to effectively forecast salmon returns to the coastal area.
Introduction

Forecasting salmon returns to the coastal areas is important to ensure spawners for reproduction and to effectively exploit the resources. Forecasting salmon returning to coastal areas has been conducted based on the following information, the numbers of return and age composition, numbers of juvenile fish migrating to the ocean, information from the fisheries in offshore waters, and environmental indices such as water temperature which shows the correlation with numbers of salmon returning. In addition, CPUE values obtained from driftnets of Japanese salmon research vessels have been partially used to forecast sockeye salmon returning to Bristol Bay (Fried et al. 1987, Ito et al. 1988).

The objectives of this study are to examine the possibility of forecasting salmon returns by correlating CPUE values obtained from driftnet operations of Japanese salmon research vessels which have been conducted for many years, with the numbers of salmon returning to coastal areas or with the coastal catch for major stocks. The future research plans for salmonid in offshore areas are also discussed.

Materials and method

Data on offshore used for this analysis were driftnet operation data and fish measurement data, obtained by the Japanese salmon research vessels from 1972 to 1988. Salmon research vessels used research gillnets which were composed of ten different mesh sizes, commercial-type driftnets and longline gear for tagging. Here we used data obtained by commercial-type driftnets because the number of tans used was appropriate and the fish caught mainly consisted of maturing fish which were returning that year and immature fish which were assumed to return the following year.

On the other hand, we used data from 1972 to 1988 on the number of salmon returning to coastal areas or of salmon caught in coastal areas for major stocks whose abundance was large and distribution in the survey area of the Japanese salmon research vessels was expected based on the information in the past (Table 1).

In the analysis, at first we examined the year to year fluctuations of CPUE values (number of fish caught per tan) of salmon in June and July by 2°x5° area, by species, and by maturing and immature fish. Subsequently, we calculated the correlation between CPUE value of maturing fish at each area in year t and number of fish returning to the coastal area (number of fish caught) in year t, and the correlation between CPUE values of immature fish in year t and the number of fish returning to coastal area (number of fish caught) in year t+1 for each species and each stock. Furthermore, from the areas having data of 10 years of more and showing a correlation coefficient of 0.6 or more, we selected the areas having the highest average CPUE and where concerned stock was expected to be distributed from the information in the past, and we made a scatter diagram using CPUE value and number of salmon returned to coastal area and estimated a regression line. In addition, when
it was possible, we estimated using this regression line, the number of salmon returning to coastal areas (number of fish caught) in 1989 from CPUE value of immature fish in 1988.

Results

Sockeye salmon

There was a high correlation coefficient (0.85) between the number of sockeye salmon caught in coastal area of the west Kamchatka in year t (the major sockeye salmon stock in the Asian side) and CPUE value of offshore maturing fish in Area E6548 in June in year t (Fig. 1a, b). The high correlation coefficient (0.90) between the catch in number of sockeye salmon of west Kamchatka in year t+1 and the CPUE value of offshore immature fish in year t was found in Area E7050 in June (Fig. 2a, b). Furthermore, the number of fish caught in coastal area in 1989 was estimated to be 2.1 million from CPUE value of immature fish in 1988. (1.45 fish per tan).

The correlation coefficient between the number of sockeye salmon returning to the coastal area of Bristol Bay (the major sockeye salmon stock in the North American side) in year t and CPUE value of offshore maturing fish in year t showed high values in several areas, and among them, Area 8050 in June was selected where the average CPUE value was the highest (Fig. 3a, b). A high correlation coefficient (0.64) was found in Area E7550 in July between the number of sockeye salmon returning to Bristol Bay in year t+1 and CPUE value of offshore immature fish in year t (Fig. 4a, b). Furthermore, the number of fish returning to coastal area in 1989 was estimated to be 37.5 million fish from CPUE value of immature fish in 1988 (3.83 fish per tan).

Chum salmon

A high correlation coefficient was observed in Area 8056 in July between the number of chum salmon returning to Japan in year t and CPUE value of offshore maturing fish in year t (Fig. 5a, b). In addition, a high correlation coefficient was shown in Area 8050 in June between the number of chum salmon returning to Japan in year t+1 and CPUE value of offshore immature fish in year t (Fig. 6a, b).

A high correlation coefficient was observed in Area 8056 in July between the number of chum salmon caught in east Kamchatka in year t and CPUE value of offshore maturing fish in year t (Fig. 7a, b). In addition, a high correlation coefficient was shown in Area 8050 in June between the number of chum salmon caught in east Kamchatka in year t+1 and CPUE values of offshore immature fish in year t (Fig. 8a, b).

Because no surveys were conducted in Area 8050 in June 1988, no estimate was made for chum salmon returns to coastal area in 1989.
Pink salmon

A high correlation coefficient was shown in Area E6048 in July between the number of pink salmon caught in both east and west Kamchatka in year t and CPUE value of offshore pink salmon in year t (Figs. 9 and 10a, b).

Discussion

The season for salmon returning to coastal areas was mainly in July and after (Table 2). Therefore, we can estimate number of salmon returning that year from CPUE value of maturing fish obtained from the offshore surveys in June and July and use for actual management of resources. In addition, it is possible to estimate the number of sockeye and chum salmon returning the following year from CPUE value of immature fish one year in advance. In the future, a salmon research vessel which is conducting test fishing on the high seas will be able to send by telegram to the Far Seas Fisheries Research Laboratory about such information as the number of tan used, the number of fish caught by species, and the proportion of maturing and immature fish based on gonad weights of sockeye and chum salmon, and the Far Seas Fisheries Research Laboratory will be able to forecast quickly the number of salmon returning. Such a forecast may be fully utilized for the fishing season in July and after.

The correlation coefficient between CPUE values in each selected area and number of fish caught in coastal areas or returning to coastal area was fairly high, between 0.643-0.904. However, it is desirable that the correlation should be higher to estimate the number of fish returning. Factors which affect such correlations are considered to be fluctuations of the test fishing season, location, fishing effort, time of the year when salmonid migrate to each area, stock composition, gonad weight which is a criterion used to determine maturity, and environmental factors on the high seas. In particular, the season of test fishing varies greatly by year (Table 3). From now on, it is necessary to increase survey efforts in each area as well as standardizing the survey season from at least mid-June to mid-July in each area.

The survey seasons for areas which are considered to be useful for forecasting the number of salmon returning are shown in Fig. 11. Of these, 2 out of 3 areas in June and 1 out of 3 areas in July are within the U.S. 200 miles zone. Notwithstanding, the research plan was agreed upon at the meeting of the Ad Hoc Salmon Research Coordinating Group which was held in March this year, no test fishing was conducted, because the U.S. did not allow any fishing operations with driftnets within the U.S. 200 miles zone. For this matter, we strongly request that U.S. representatives arrange the situation properly for the next test fishing season.

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References


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Tables 1 to 3 and Figs. 1 to 11 are in English in the Japanese document.