



Serial No. 5341

ICNAF Res. Doc. 79/II/15

SPECIAL MEETING OF STACRES - FEBRUARY 1979

A Preliminary Review of Silver Hake (*Merluccius bilinearis*)
Stock Distribution and Differentiation on the Scotian Shelf

by

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Introduction

The Silver hake (*Merluccius bilinearis*) fishery in ICNAF division 4VWX began in 1958. It is a relatively new fishery when compared to the US hake fishery in neighbouring ICNAF subarea 5. This latter fishery has been in progress for over 40 years (Fritz, 1962). The 4VWX hake fishery has had a variable history (Figure 1). The USSR has been the major harvesting nation, taking over 98% of the catch, from 1961 to 1975. In 1976 and 1977 quota allocations reduced the USSR catch proportion to 83% and 89% respectively. Detailed histories of the fishery and species biology for hake of the Scotian Shelf can be found in Halliday (1973), Doubleday and Halliday (1976), Noskov (1976), and Doubleday and Hunt (1976 and 1977).

Although in 1976 and 1977 some restrictions were placed on the fishery in terms of quotas, 1977 was the first year for restrictions by both gear and area. The most commonly used codend mesh size during 1977 was 60 mm compared to 40 to 44 mm used in previous years (Anon, 1976a). This area restriction should not severely affect the commercial hake fishery for, as Halliday (1973) pointed out, the "highest [historical] catch rates were ... along the continental slope in depths greater than 100 fathoms" - the very area which is outside the legislated small mesh gear line* (Figure 2) (Anon, 1976b). Even though historical catch distribution indicates the small mesh gear line should not be a major factor, the Soviet Union (Konstantinov & Noskov, 1978) felt this to be the major cause of the reduced catch of 1977. A more probable indirect cause of the reduction in catch was the abnormally high squid abundance which was found over the entire shelf. This resulted in the squid quota being filled before that of the hake and thus the hake fishery was curtailed before the quota was filled.

With the extended jurisdiction of many coastal states to 200 miles, much more interest is being placed on fish population management. The major purpose of analysing commercial fishery catch statistics is to attempt to predict the total allowable catch (TAC) for a stock of fish in the forthcoming fishing season. The more accurate the sampling, data collection and analysis becomes, the more dependable the estimated TAC. A pre requisite to stock assessments is identification of stock boundaries and distribution in order to permit accurate data collection and sampling.

* In effect from April 15 to November 15 of each year.

Silver Hake Spacial Distribution and the Unit Stock Problem

The Silver hake stock of the ICNAF division 4VWX has been assumed a unit stock since the first assessment (Halliday 1973). Since that time, more data have become available to study this assumption.

Figure 3 shows 12 maps (one per month) each indicating the areas of commercial Silver hake concentrations in division 4VWX from 1961-1968. These observations were summarized from a Soviet commercial fishing atlas (Anon, 1971). More detail data is recorded in Table 1. A basic assumption made here is that the commercial fishing fleet follows the movements of major Silver hake concentrations. A summary chart (Figure 4) shows the annual anti-clockwise movement of the hake (commercial Soviet fleet) on the Scotian Shelf with approximate dates of occurrence for each section.

From American (Bowman, 1972; Anderson, 1974) and Canadian (Scott, 1976) groundfish inventory cruises the Silver hake distribution in ICNAF subarea 5 and neighbouring division 4X can be studied. Scott (1976) as well as earlier Soviet studies (Sauskan, 1964; Sarnits and Sauskan, 1966) suggested hake distribution was generally related to a temperature range of 6 to 8 °C in the winter and 9 to 12 °C in the summer and followed a seasonal movement (Fritz, 1959; Edwards, 1966) from the shallows in summer to deeper water in winter. This is similar to other species of *Merluccius* spp. (Alverson and Larkins, 1969; Hart, 1948) which move to shallower water during the spring to spawn in summer and early fall. The U.S. groundfish inventory cruises (Bowman, 1972) indicate the Silver hake occupy a wide variety of depths in all seasons. During the winter hake were found mainly on the slopes of the Continental shelf, while they appear to concentrate in the deeper slope waters during early spring. Overwintering concentrations have been reported (Sarnits and Sauskan, 1966) from the Fundian Channel between 4X and Georges Bank. In summer some hake concentrations can be found in shallow areas (often less than 100 m depth). In the fall the hake are widely distributed with fish being found in most depth strata. During this time they are probably moving back to their winter-spring concentrations in deeper waters. Anderson (1974) using groundfish cruise data and morphometric data from Conover et al. (1961) divided the Silver hake stocks from ICNAF subareas 5 and 6 into: 1) Gulf of Maine, 2) Georges Bank, and 3) Southern New England - Middle Atlantic. Using the Soviet fishing atlas (Anon, 1971) to study the movements of commercial hake concentrations on Georges Bank and ICNAF division 4X areas (Figure 5) it would appear another circular pattern exists here with some intermixing with the Southern New England area. Konstantinov and Noskov (1969) reported that the hake populations from Sable Island Bank, Georges Bank and the Middle Atlantic had been distinguished as separate stocks by serum and erythrocyte antigen studies. Taking all the above data into consideration (both seasonal distribution patterns and the studies on population differentiation) it can be assumed that the Sable Island Bank population (ICNAF division 4VW and northern 4X) is separate from the Georges Bank population (ICNAF subarea 5Ze and southern 4X) although some mixing will probably occur. This mixing would probably occur in the fall-winter-spring periods when the hake are off the spawning grounds in deeper slope water. Silver hake catches in ICNAF subarea 5 have generally been greater than catches in division 4VWX. This is probably due to the warmer waters and rich feeding grounds of Georges Bank. Occasional reports of Silver hake catches in ICNAF subarea 3 (ICNAF, Statistical Bulletins) are probably due to warm water movements from division 4VWX occurring during summer months.

Figure 6 shows egg and larval concentrations of Scotian Shelf Silver hake. Soviet ichthyoplankton data from September-October 1977 (Noskov et al., 1978) and August 1974 (Noskov, unpublished) shows both Silver hake egg and larval concentrations on Sable Island Bank and Emerald Bank with lesser concentrations on Southern Browns Bank. Canadian egg and larval concentrations in August 1976 (Kohler, personal communication) shows similar distribution patterns.

These plankton cruises indicate two major areas of spawning concentration, the first, Sable Island Bank, is the area of an anti-clockwise gyre of the Soviet commercial fleet (1961-1968) (Figure 4). The second, Browns Bank, may in fact be the fringe of the Georges Bank concentration of Soviet fishing (Figure 5). It would appear that there are two separate spawning areas and thus probably two populations in ICNAF division 4VWX.

Silver Hake Temporal Distribution of catch and Effort

Annual catch, effort, and catch per unit of effort (CPUE) of the Soviet Silver hake fishery on the Scotian Shelf has varied widely during the last two decades (1958-1977). Figure 1 shows the wide range of annual fluctuations in Silver hake catch for ICNAF division 4VWX - the total catch (all nations) in tonnes is above the corresponding year on the graph and the Soviet portion of the catch is in brackets. The annual variation of the CPUE (Figure 7) has followed a trend somewhat similar to that of the total catch (Figure 1). An interesting feature of the CPUE (Figure 7) is the nearly constant nature of the total (all species) CPUE even though the Silver hake has varied between 0.1 and 2.6 tonnes per hour. This indicates that whenever Silver hake was not available to the Soviet fleet - it has been able to make up any shortfall with other species. This option is no longer available as species specific quota's and bycatch limitations have been introduced to assist in managing various stocks.

The seasonal (monthly) distribution of effort for ICNAF division 4W (the majority of 4VWX catch) indicates the spring and summer (April to September) are the major time of fishing effort in both the early (1966-1970) and the more recent (1971-1975) Silver hake fishery (Figure 8). The monthly total catch (Figure 9) follows nearly the same pattern as effort. The catch (Figure 9) is expressed as the percentage of the total annual catch. The seasonal trend for CPUE (Figure 8) shows a slightly different trend as the highest catch rates occur in the winter and early spring when effort is relatively low and the Silver hake are concentrated on the continental slope.

Silver Hake Distribution with Regards the Small Mesh Gear Line

Taking both spacial and temporal distribution of Silver hake into account it would appear the majority of effort (Figure 8) occurs in the summer months, when according to the maps of Figure 3 the Soviet fleet is concentrated on the continental slope regions. An ICNAF working group (Anon, 1977) reported that 80% of the annual catch was taken at depths of 110-350 m in division 4W. According to historic data and because the small mesh gear line (Anon, 1976b) approximates the 100 m contour line there should not be any great limitations on the catch potential of the Silver hake fleets. The International Observer Program data in 1977 indicated the CPUE seaward of the small mesh gear line was greater than that on the landward side, however in 1978 the reverse was observed. Looking at the historic picture it would appear that the data collected in 1978 was the exception rather than the rule and that until further data is available the small mesh gear line appears to be as accurately placed as historic data will allow.

Acknowledgements

Dr. A.C. Kohler of St. Andrews Biological Station kindly allowed the use of three unpublished distribution maps for silver hake egg and larval data from August 1976.

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Table 1. Monthly catch and effort statistics for Soviet fishing fleet - subscript refers to subscript of Figure 3. Different subscripts often refer to different classes of vessel. All catch values are expressed in tonnes.

Month	Year-subscript	Days Fished	Daily Catch	Catch per hour (all Species)	Percent Silver hake	
January	63	3	18.4	1.5	80	
February	63-1	20	27.0	-	45	
	63-2	107	33.0	2.6	75	
March	64-1	5	-	-	30	
	64-2	11	-	-	80	
	63	113	37.6	3.1	35	
April	64-1	20	14.7	1.7	15	
	64-2	7	37.9	2.7	65	
	62	38	31.4	3.0	70	
May	63-1	38	28.1	2.2	25	
	63-2	91	39.2	2.9	80	
	62	51	47.8	4.1	55	
	63	398	41.8	3.4	75	
	64	420	44.1	3.7	65	
	65-1	3	-	-	30	
	65-2	304	7.4	1.0	75	
	67-1	58	39.3	2.9	15	
	67-2	25	39.1	2.8	10	
	67-3	3	28.3	2.2	35	
June	68-1	41	30.0	2.2	25	
	68-2	7	26.0	2.4	60	
	68.3	8	20.6	2.7	5	
	63	36	47.4	4.7	75	
	64-1	14	-	-	20	
	64-2	50	34.9	2.6	50	
	65	38	40.6	2.9	60	
	66-1	14	20.9	1.4	20	
	66-2	38	28.0	1.8	30	
	63	671	34.8	3.4	85	
July	64	325	43.4	3.7	75	
	65-1	482	47.4	3.4	30	
	65-2	44	47.1	3.9	80	
	65-3	11	52.2	3.6	20	
	66-1	10	-	-	45	
	66-2	17	23.9	2.0	50	
	August	63-1	162	25.1	2.5	75
		63-2	45	43.7	4.2	80
64-1		38	5.6	0.4	30	
64-2		277	52.0	3.7	50	
64-3		126	45.5	3.9	80	
64-4		36	57.9	4.4	80	
65-1		4	34.2	2.2	20	
65-2		249	51.2	3.6	20	
65-3		17	49.5	4.1	30	
65-4		72	51.8	3.5	30	
66	4	30.8	1.9	10		
68	5	24.2	2.1	10		

Table 1. (cont'd)

Month	Year-subscript	Days Fished	Daily Catch	Catch per hour (all Species)	Percent Silver hake
September	62	12	6.6	0.9	30
	63-1	36	35.4	3.1	80
	63-2	49	42.5	3.8	75
	63-3	33	34.4	3.0	70
	63-4	100	40.8	3.3	70
	64-1	47	48.2	3.4	70
	64-2	16	51.0	3.9	60
	65-1	7	33.7	2.2	20
	65-2	112	48.2	3.2	10
	65-3	52	44.4	3.6	20
October	63-1	4	24.7	2.2	95
	63-2	44	30.8	2.3	10
	63-3	18	21.5	1.5	45
	64-1	33	21.4	1.8	10
	64-2	4	-	-	60
	64-3	1	25.5	2.2	20
	64-4	10	43.7	3.4	45
	65-1	19	22.1	1.5	10
	65-2	107	38.0	2.4	15
	65-3	31	35.8	2.7	5
November	66	1	14.0	1.8	2
	68	91	37.9	2.7	30
	62	204	33.5	2.0	45
	63-1	2	18.1	1.9	10
	63-2	1	17.0	1.2	50
	63-3	18	27.2	2.5	10
	63-4	12	21.3	1.7	65
	63-5	5	20.5	1.7	25
	64-1	4	12.8	1.3	75
	64-2	237	-	-	30
December	64-3	18	17.6	1.4	55
	64-4	9	23.5	2.1	30
	64-5	15	22.2	2.2	10
	65-1	8	32.0	2.0	20
	65-2	1	15.2	0.9	20
	65-3	111	38.2	2.4	15
	68	446	39.1	2.5	5
	62	284	26.4	1.9	50
	63	131	-	-	55
	64	31	-	-	30
December	65-1	19	25.8	1.8	25
	65-2	4	21.5	2.2	45
	65-3	42	37.2	2.4	10
	68	351	41.1	2.7	5

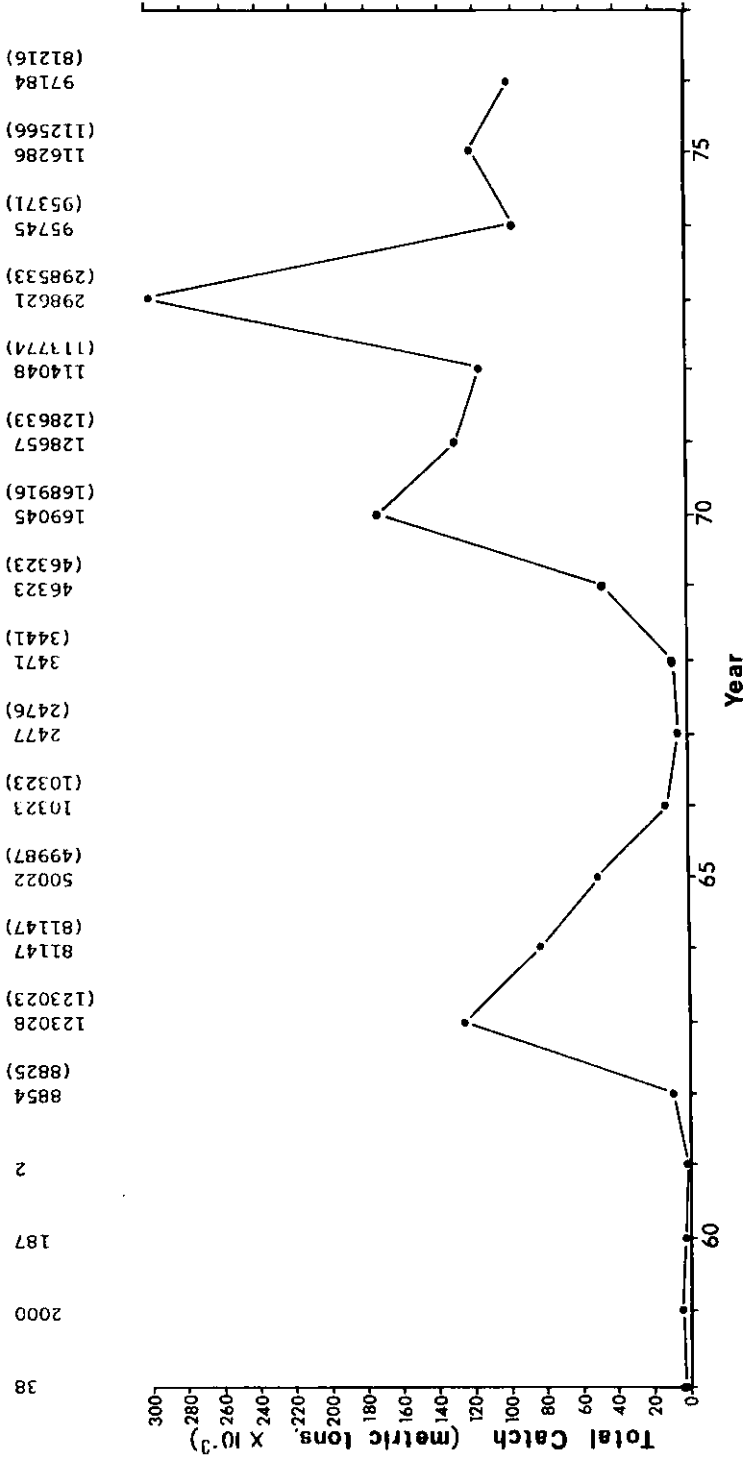


Fig. 1. The catch of silver hake by all countries in ICNAF Division 4VWX (data taken from Statistical Bulletin Vol. 8-26). The annual catch is given above the graph - the USSR catch is given in brackets.

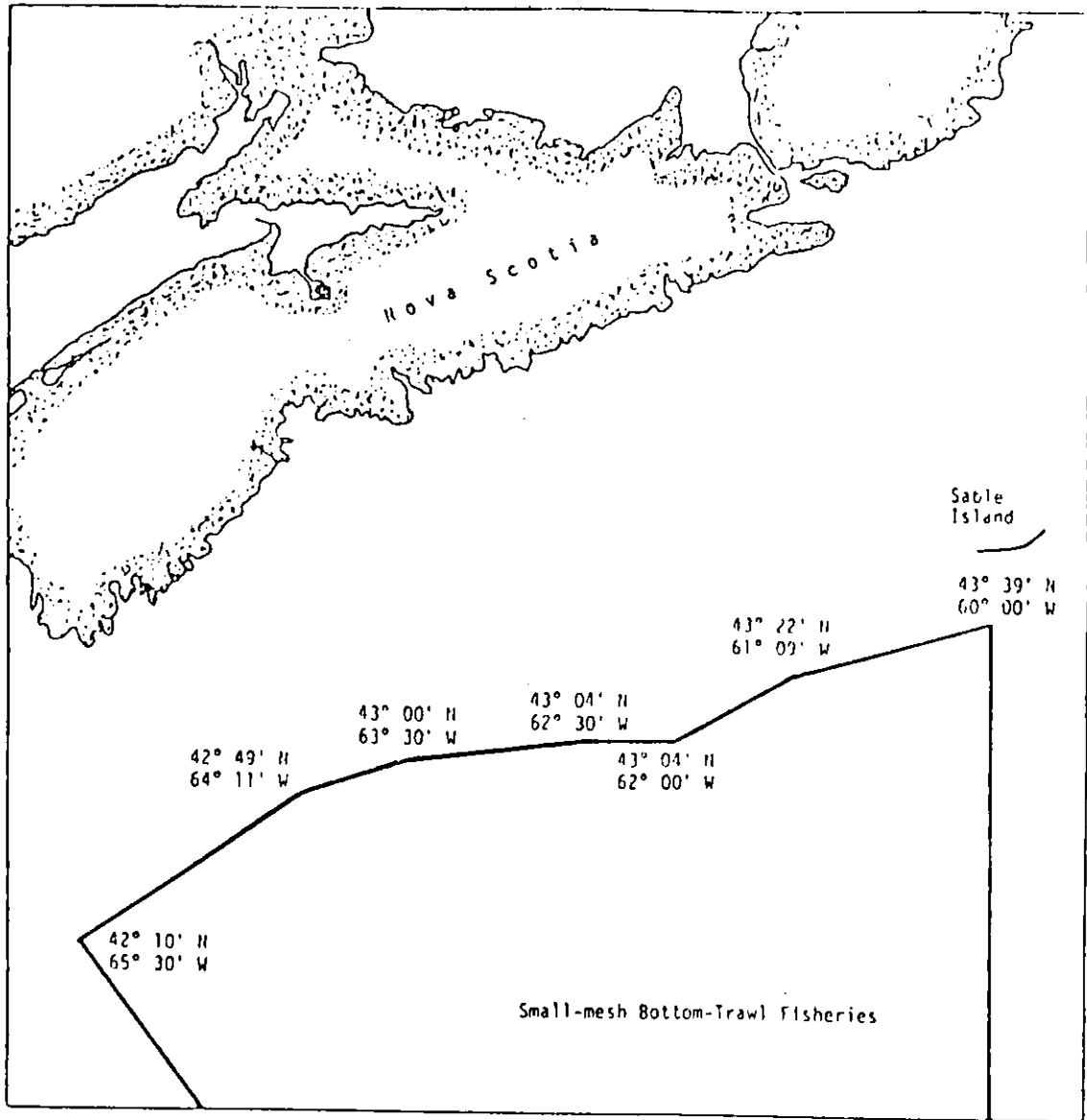


Fig. 2. Small mesh gear line for the regulation of the Scotian Shelf silver hake fishery.

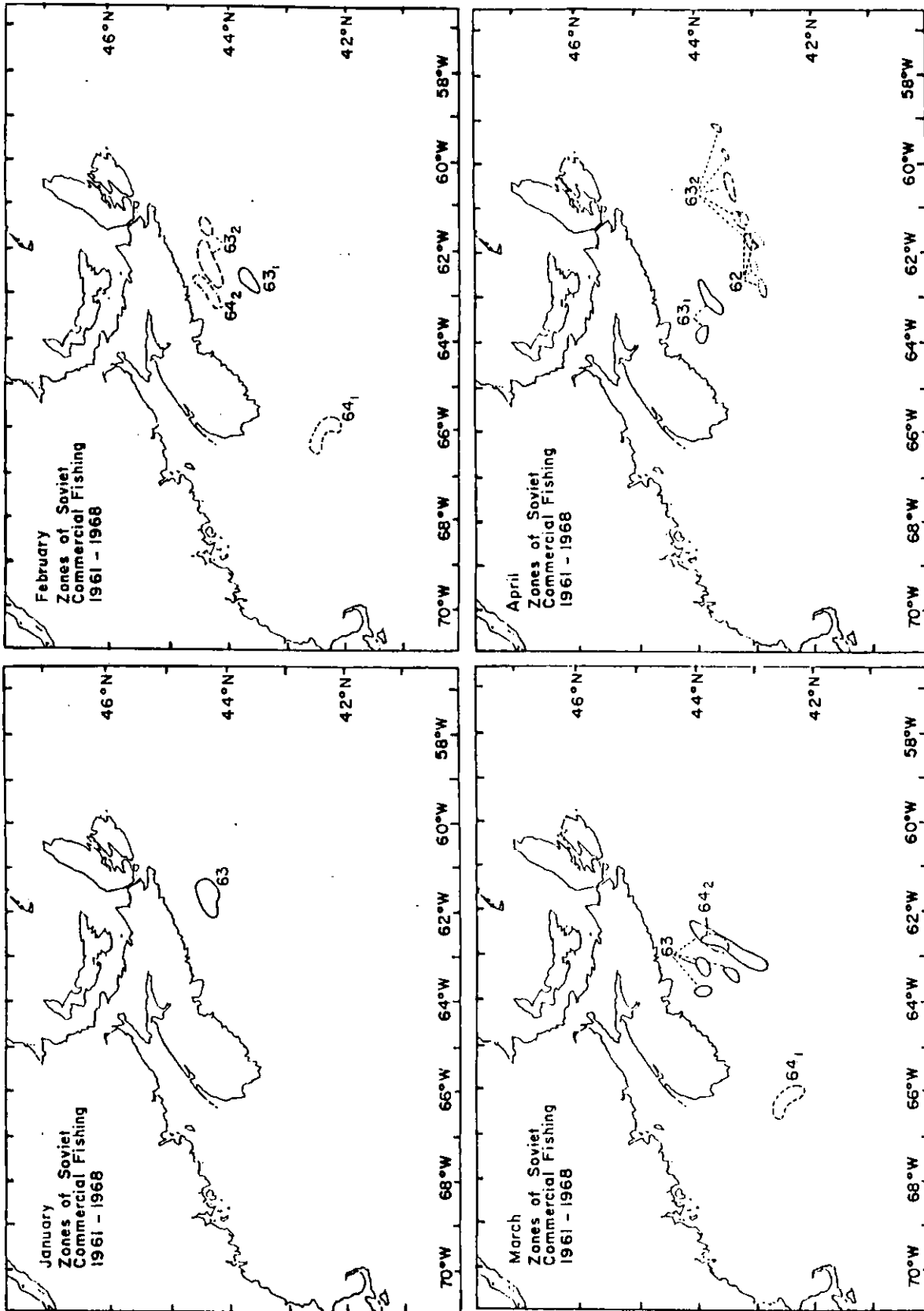


Fig. 3. Zones of Soviet commercial fishing activity between 1961 and 1968. The number beside each zone indicates the year and a subscript indicates the subscriptions of Table 1 where more detailed data is recorded.

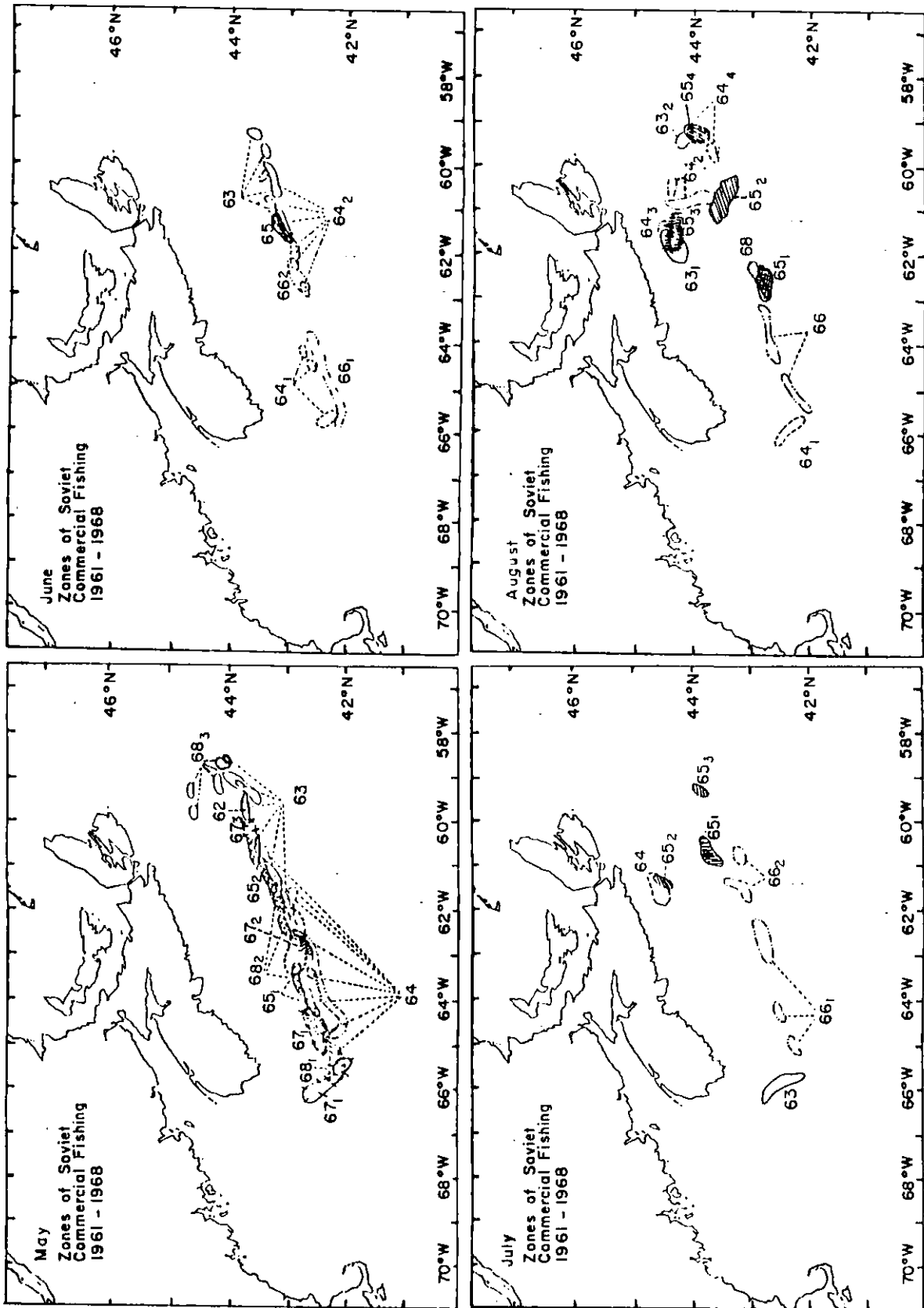


Fig. 3. (cont'd)

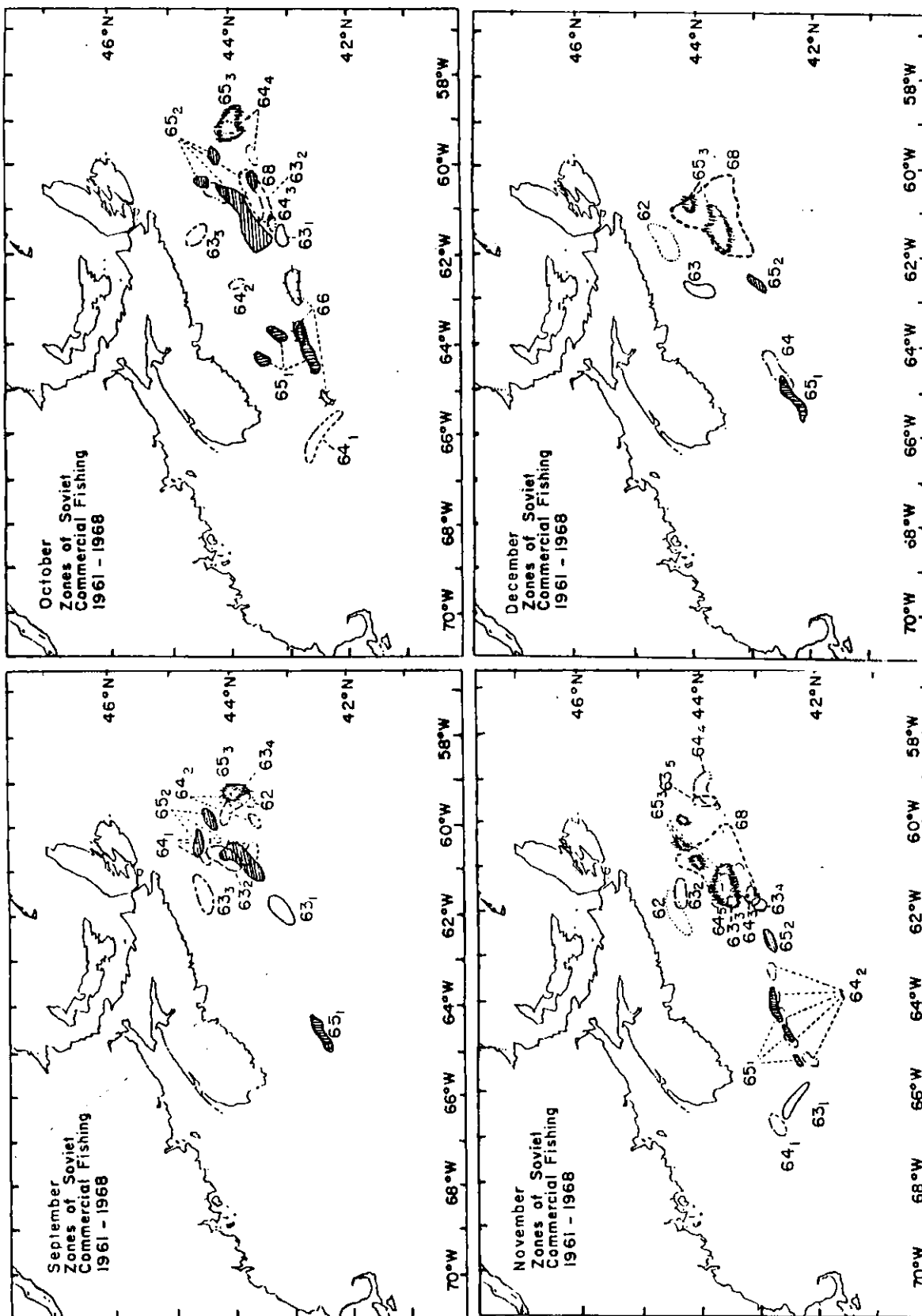


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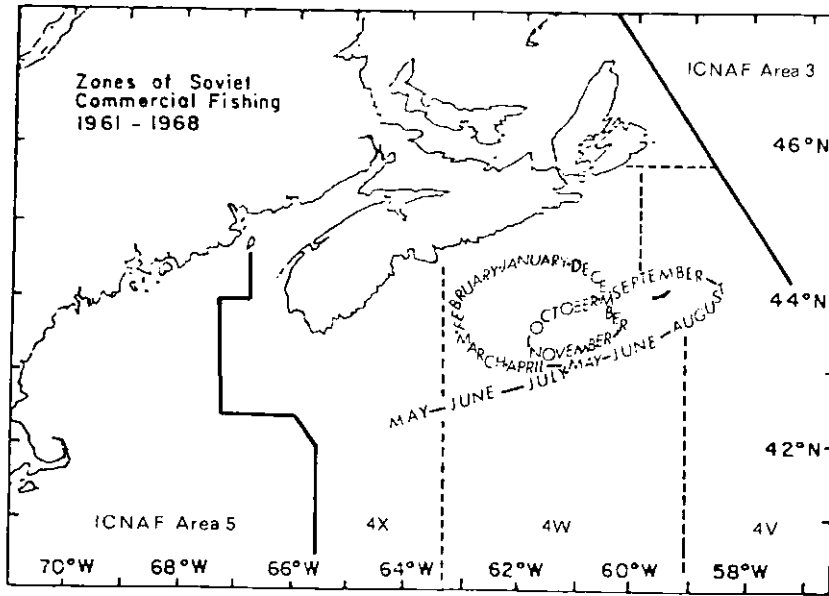


Fig. 4. Summary of the annual movements (Fig. 3) of the Soviet commercial fleet from 1961-1968 in ICNAF Subarea 4.

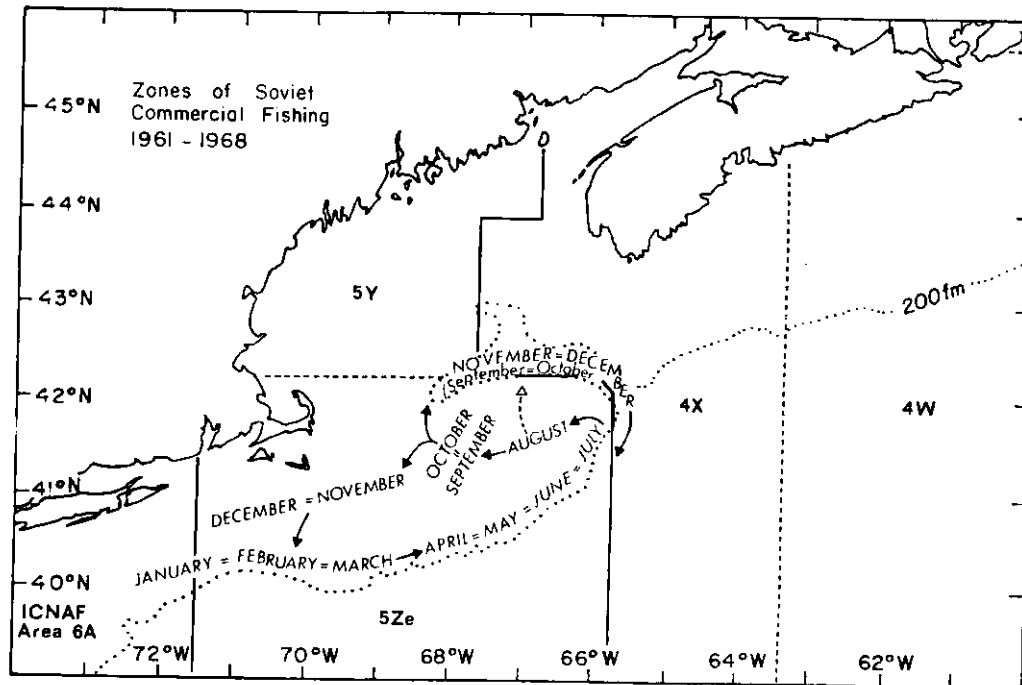


Fig. 5. Summary of the annual movements of the Soviet commercial fleet from 1961-1968, in ICNAF subarea 5.

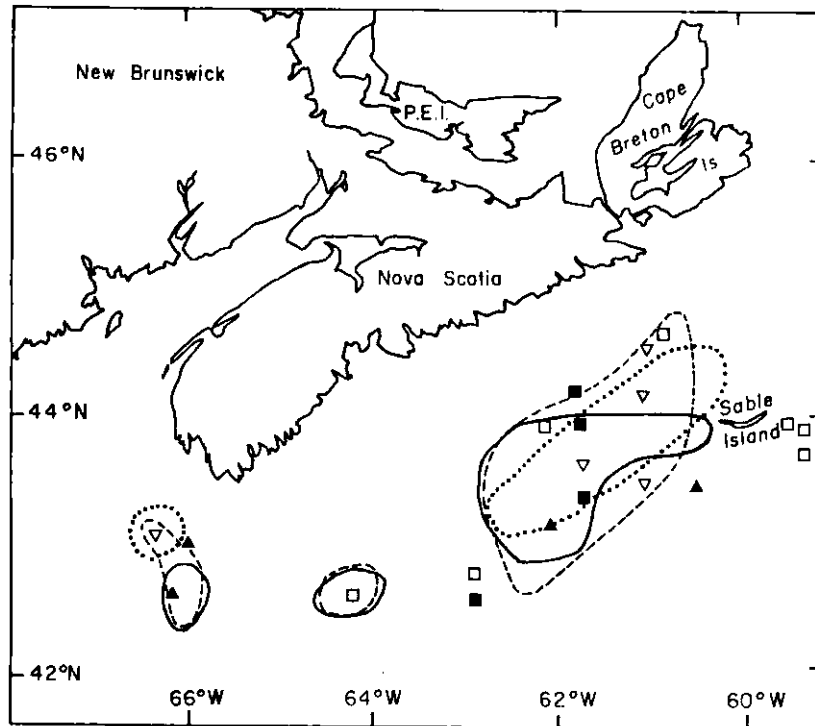


Fig. 6. Egg and larval distributions of silver hake on the Scotian Shelf.
 a) Open squares: silver hake eggs (over 50 per tow) (Noskov et al., 1978).
 Closed squares: silver hake larvae (over 50 per tow).
 b) Open triangles: silver hake eggs (over 50 per tow) (Noskov, unpublished).
 Closed triangles: silver hake larvae (over 50 per tow).
 c) Areas enclosed by solid line, broken line, and dotted line represent zones of high silver hake egg and larval concentrations as studied by meter net, isaac-kid net, and bongo nets respectively (Kohler, personal communication).

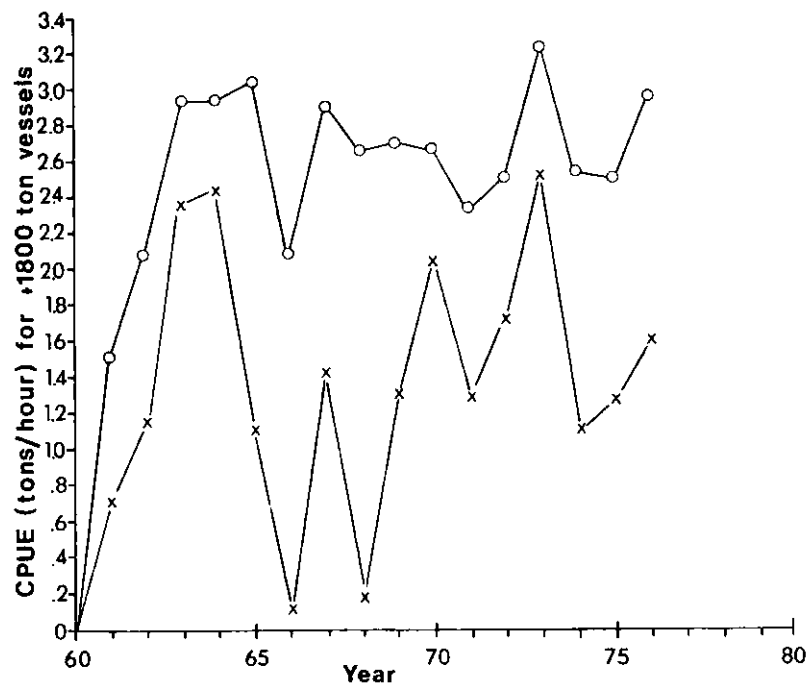


Fig. 7. Catch per unit of effort (CPUE) for +1800 ton trawlers. The total (finfish + squid) CPUE in mt/hr is indicated by the open circles - the silver hake CPUE (mt/hr) is represented by cross.

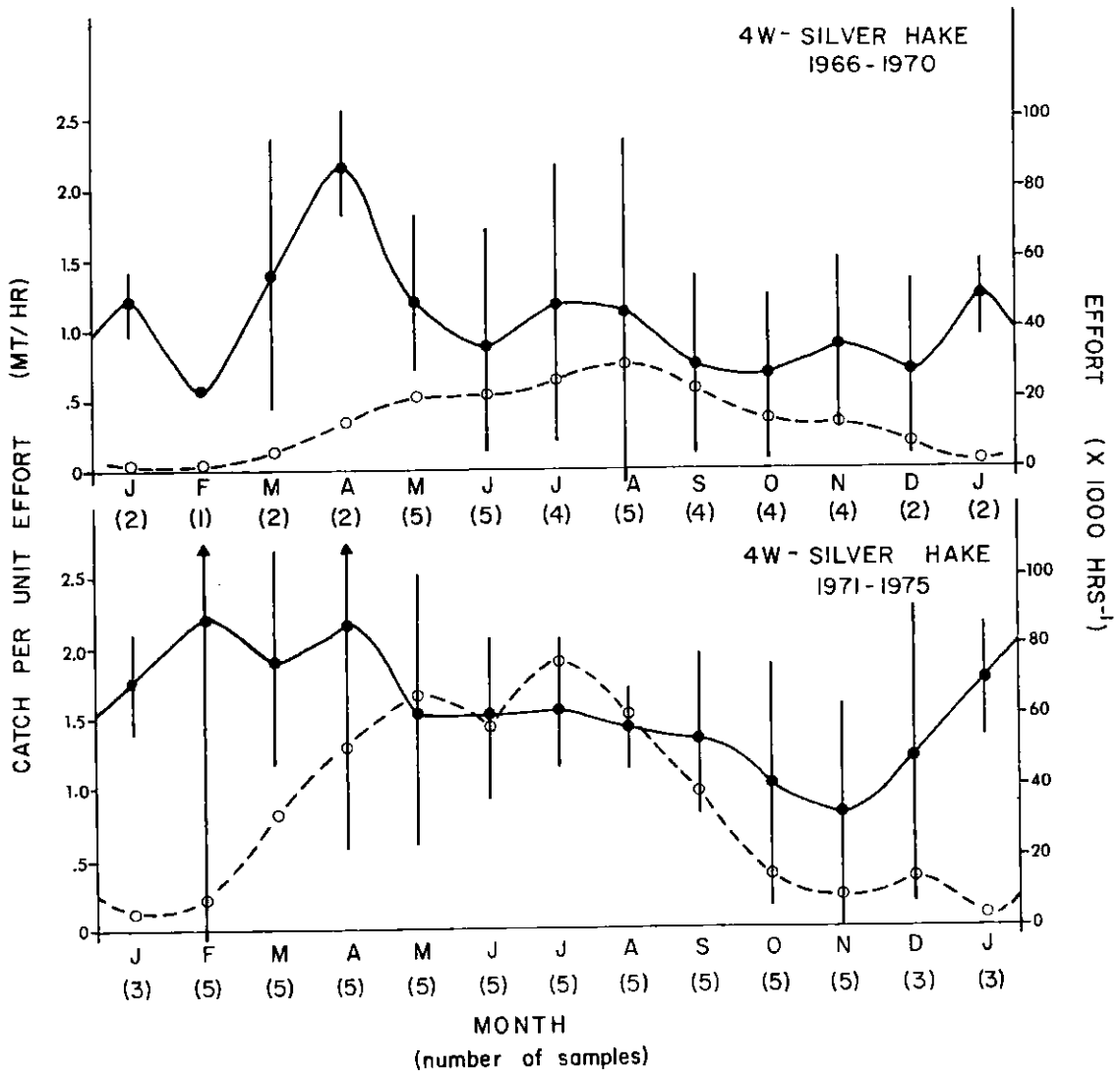


Fig. 8. Catch per unit of effort (CPUE) represented by the solid line and the effort (broken line) shown as a monthly mean of 5 years data from ICNAF Div. 4W. The numbers under the month represent the number of samples (years) for which data were available.

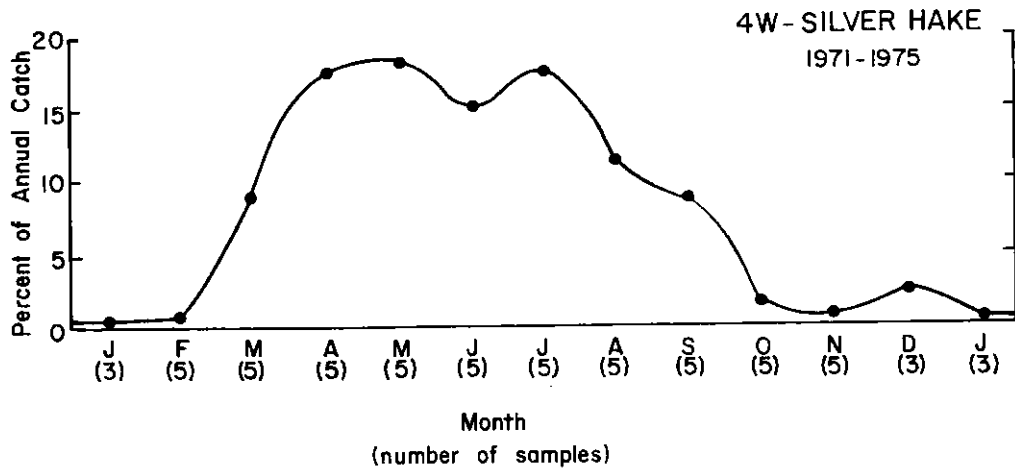


Fig. 9. The mean monthly catch of silver hake in ICNAF Div. 4W represented as a percentage of the annual catch. The numbers under the month represent the number of samples (years) for which data were available.

