Pacific salmon abundance and biomass as estimated by trawl survey in the Gulf of Alaska in February-March 2019

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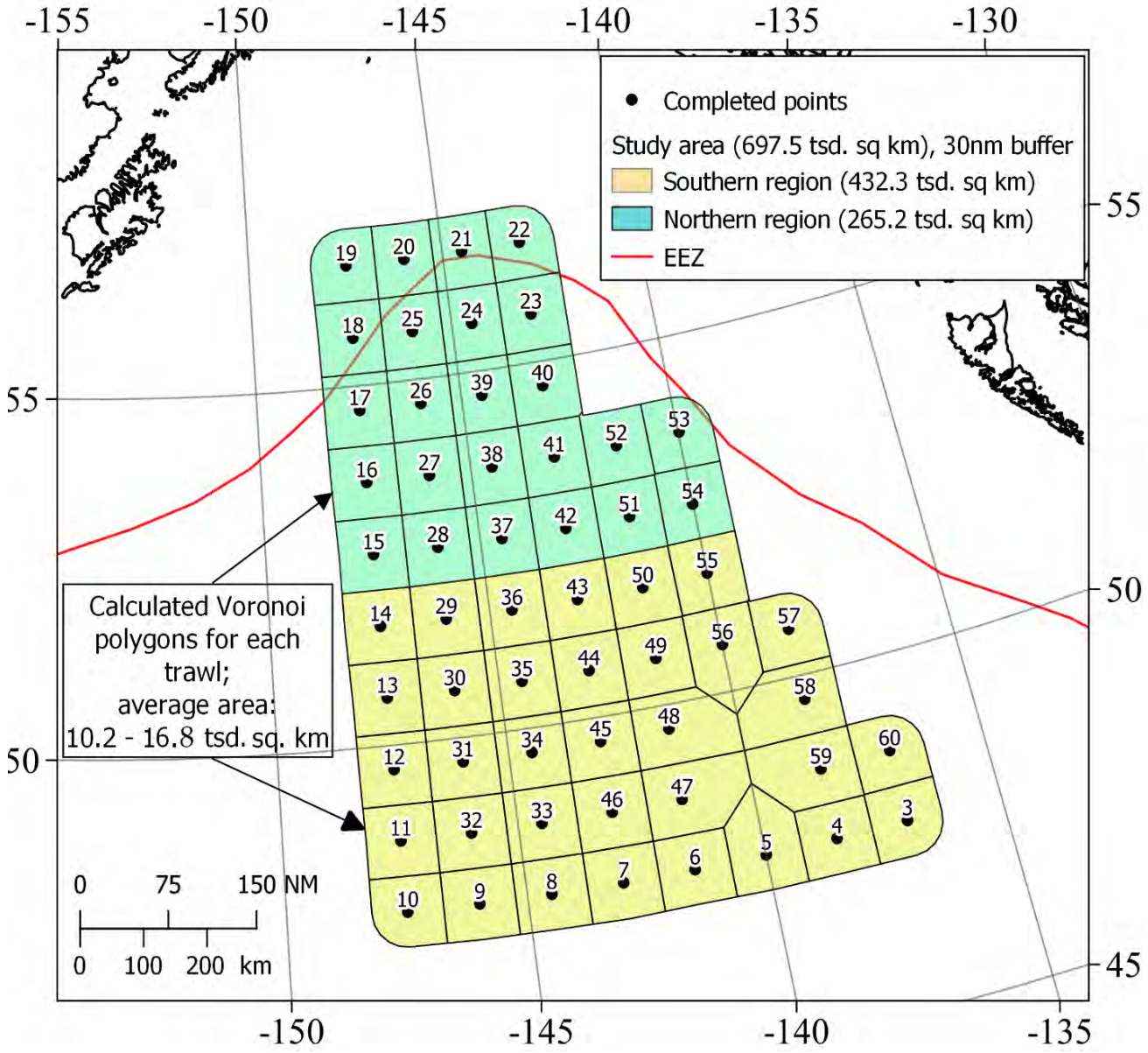
The Gulf of Alaska survey area and integrated survey stations, 21.02-15.03.2019

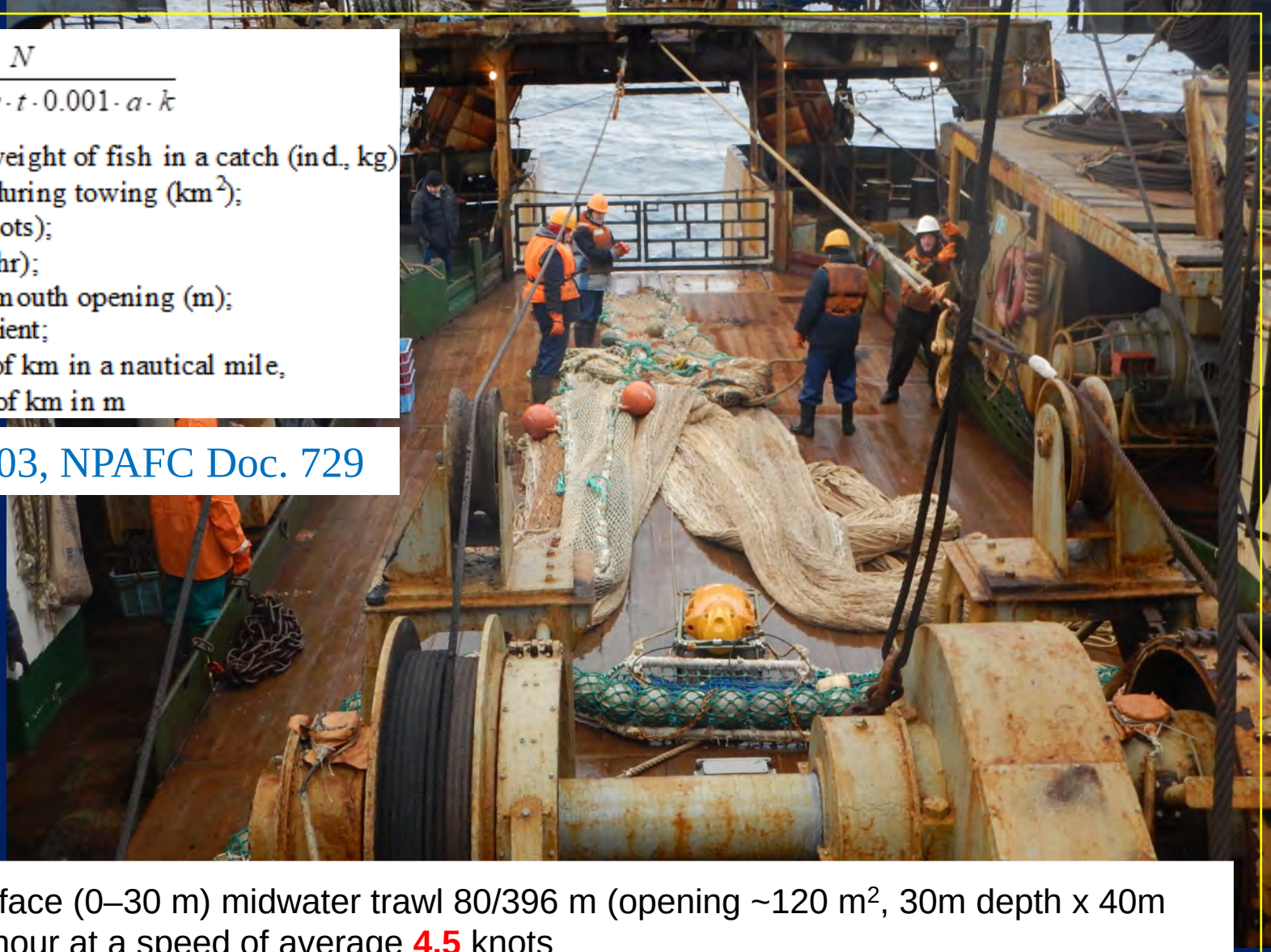


Red line shows the boundary of Canadian and U.S. exclusive economy zones (EEZs).

$$\frac{N}{A}\cdot\frac{1}{k}=\frac{N}{1.852\cdot v\cdot t\cdot 0.001\cdot a\cdot k}$$

N - number or M - weight of fish in a catch (ind., kg)
A - an area trawled during towing (km^2);
v - towing speed (knots);
t - towing duration (hr);
a - horizontal trawl mouth opening (m);
k - catchability coefficient;
1.852 - the number of km in a nautical mile,
0.001 - the number of km in m

Volvenko 2003, NPAFC Doc. 729



Used gear: surface (0–30 m) midwater trawl 80/396 m (opening ~120 m^2, 30m depth x 40m width) for one hour at a speed of average **4.5** knots

The trawl catchability coefficient for maturing and immature Pacific salmon aged n.1+ or older, as well for quickly growing pink and coho salmon spending one year at sea, is **0.3**;

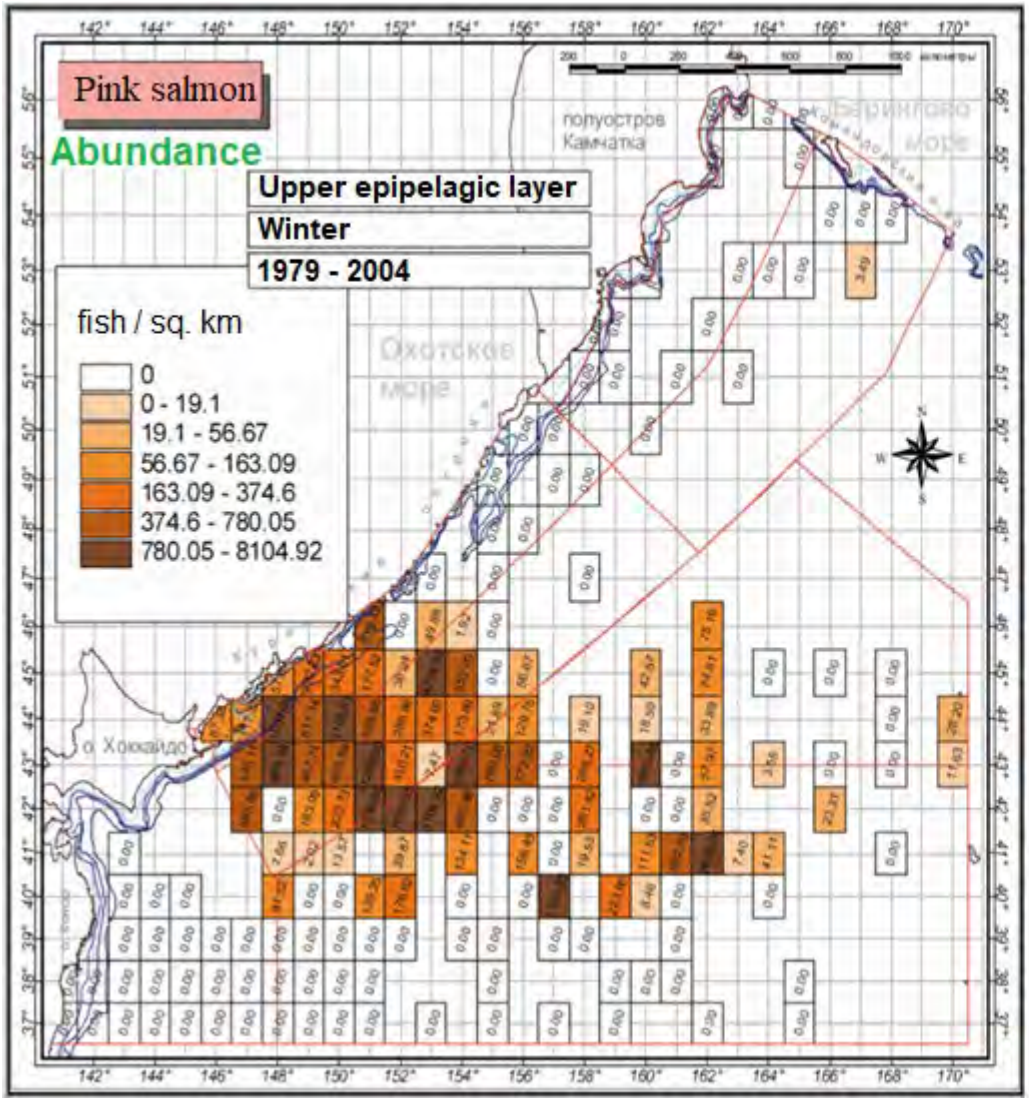
- for other juvenile salmon of first marine year is **0.4**.

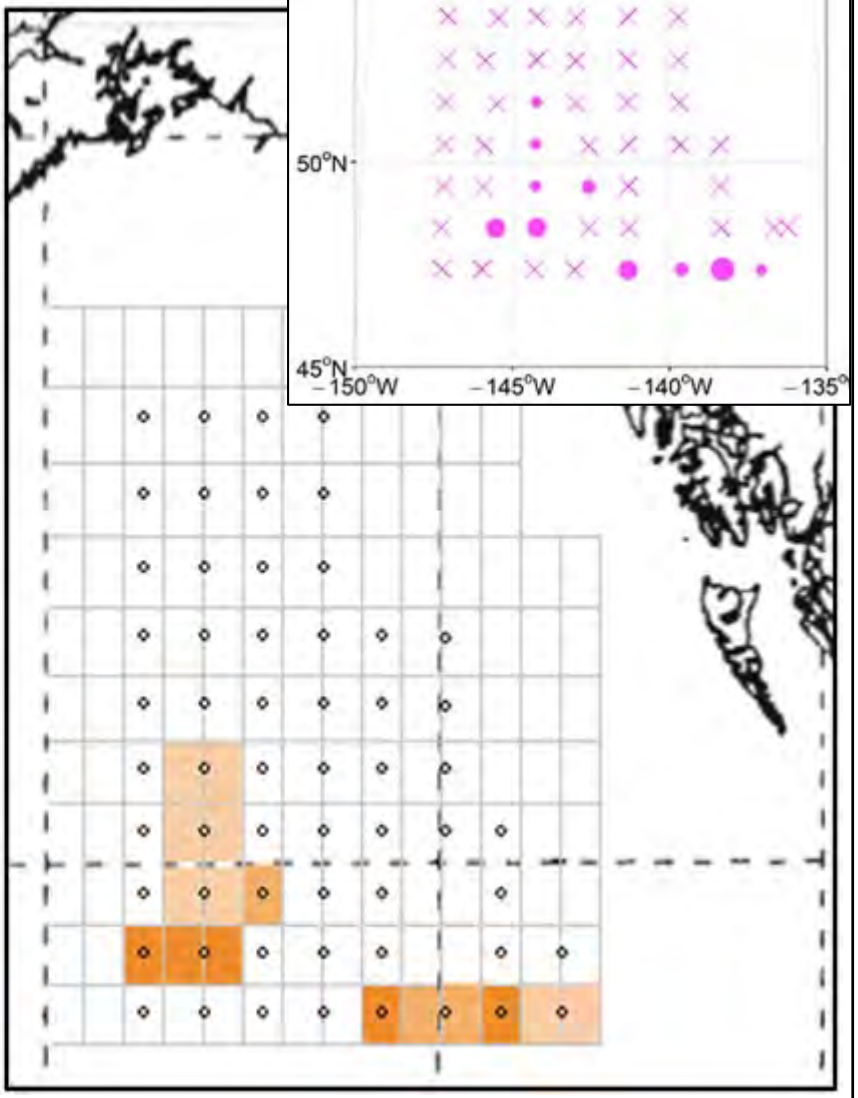
Frequency of occurrence in trawl catches, estimated numbers and biomass of **Pacific salmon species** in the upper epipelagic layer throughout the investigated area in the Gulf of Alaska in winter 2019

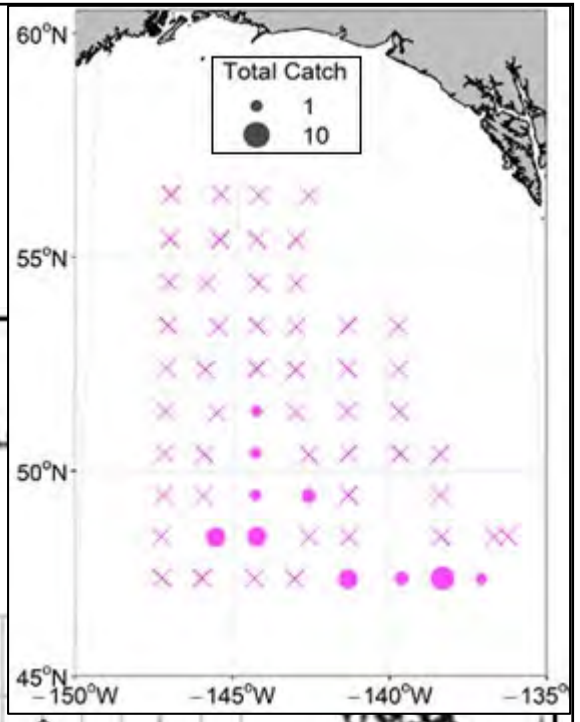
Salmon species	q	Frequency of occurrence (%)	Numbers (million fish)	Biomass (thousand tons)
Oncorhynchus gorbuscha	0.3	17.2	4.21	1.63
Oncorhynchus keta	0.3	55.2	24.17	26.96
	0.4	20.7	3.56	0.74
	total	63.8	27.73	27.70
Oncorhynchus nerka	0.3	31.0	8.94	10.28
	0.4	1.7	0.10	0.02
	total	31.0	9.04	10.30
Oncorhynchus kisutch	0.3	37.9	13.59	10.37
Oncorhynchus tshawytscha	0.3	5.17	0.37	1.32
All salmon species	total	**82.8**	**54.95**	**51.33**

Survey area is equal to 697,500 km^2

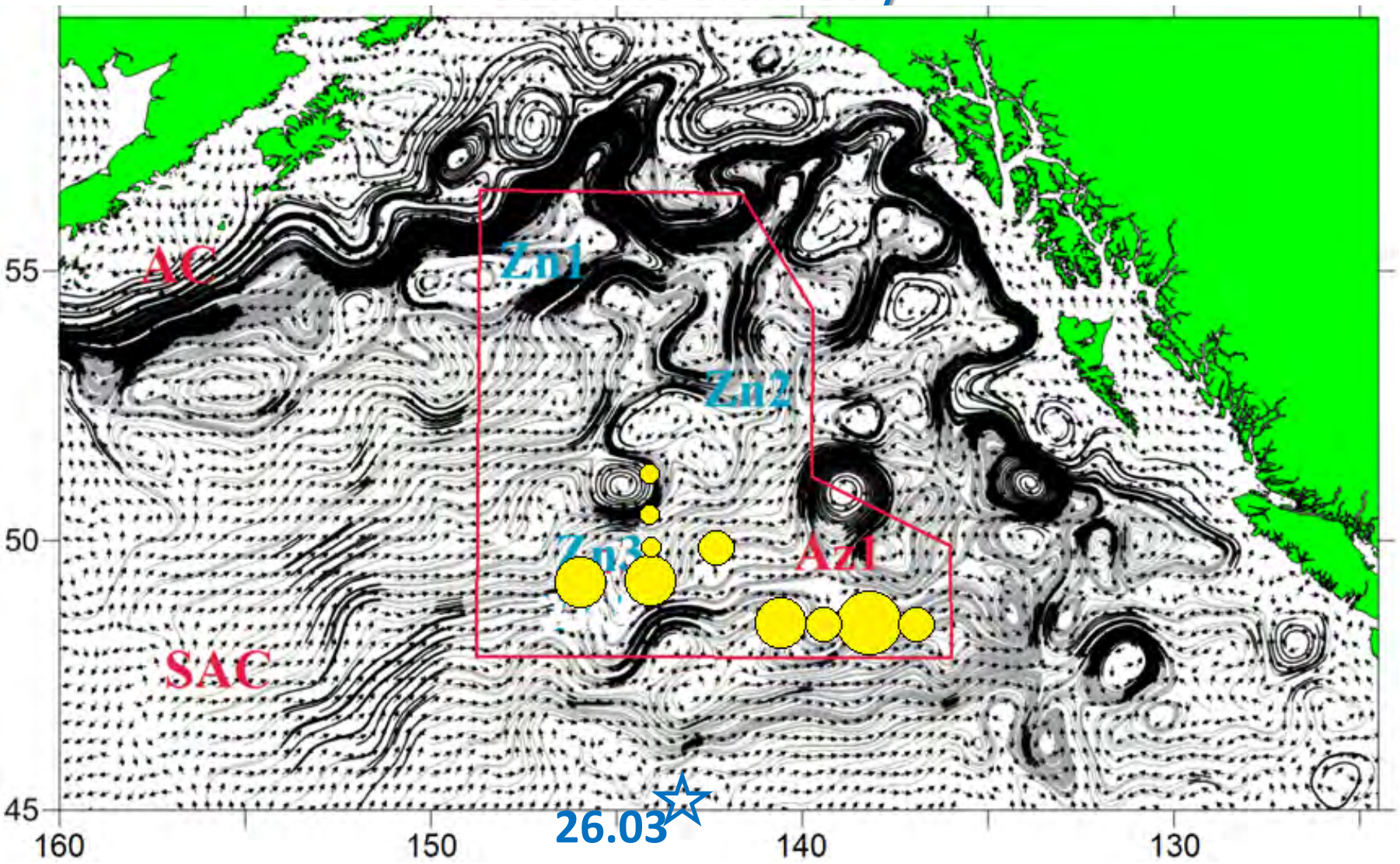
Pink salmon catch distribution and estimated distribution density (fish per km^2) in comparison with historical winter data from the northwestern Pacific Ocean obtained by the same trawl survey method in 1979-2004





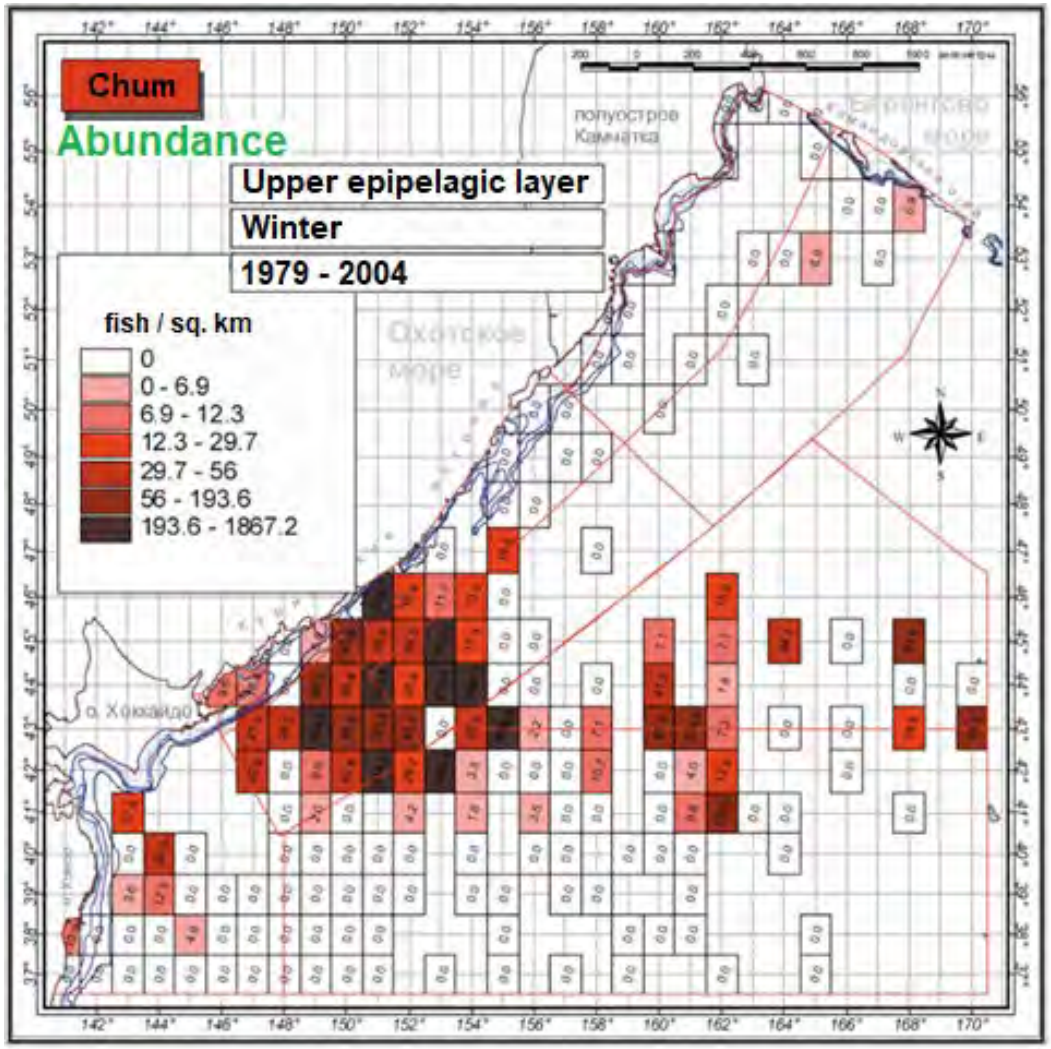


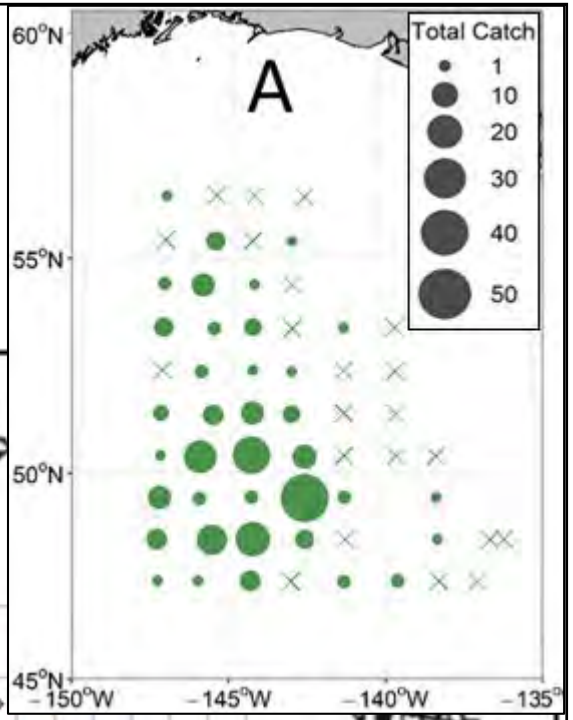
Currents in the Gulf of Alaska in March 2019 based on satellite altimetry

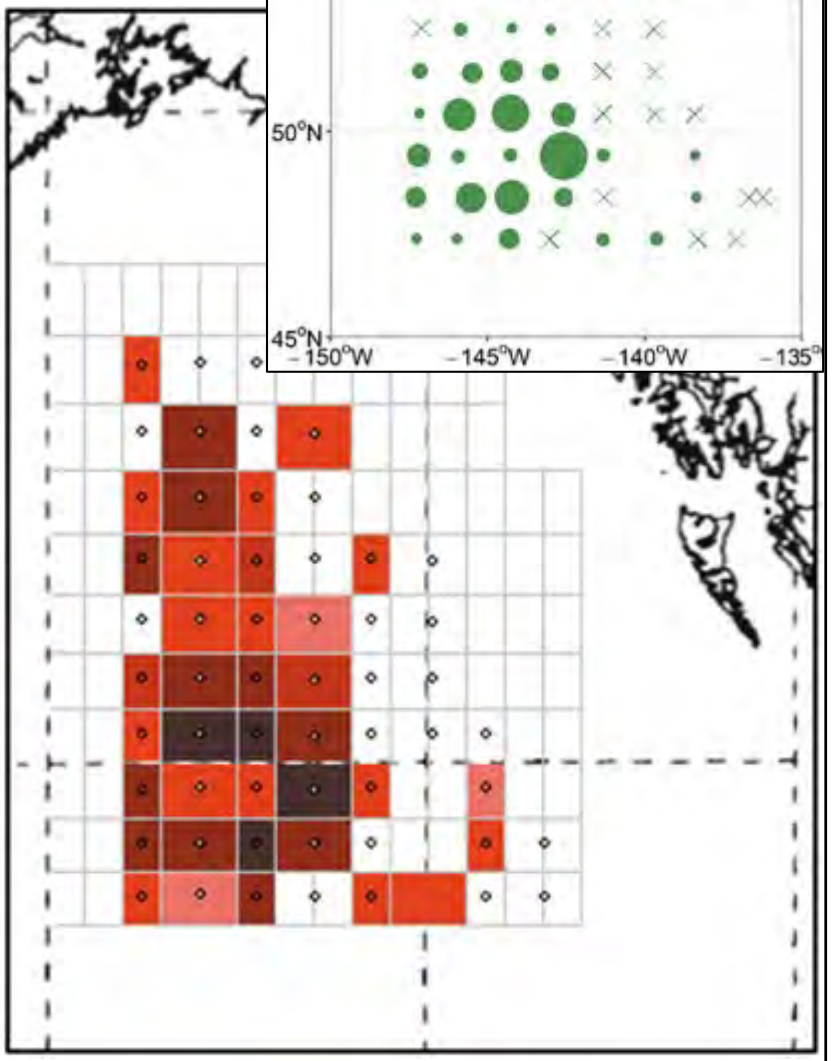


SAC – the Subarctic Current, three cyclonic eddies and one anticyclonic eddy are also indicated. Pink salmon catches showed by yellow circles

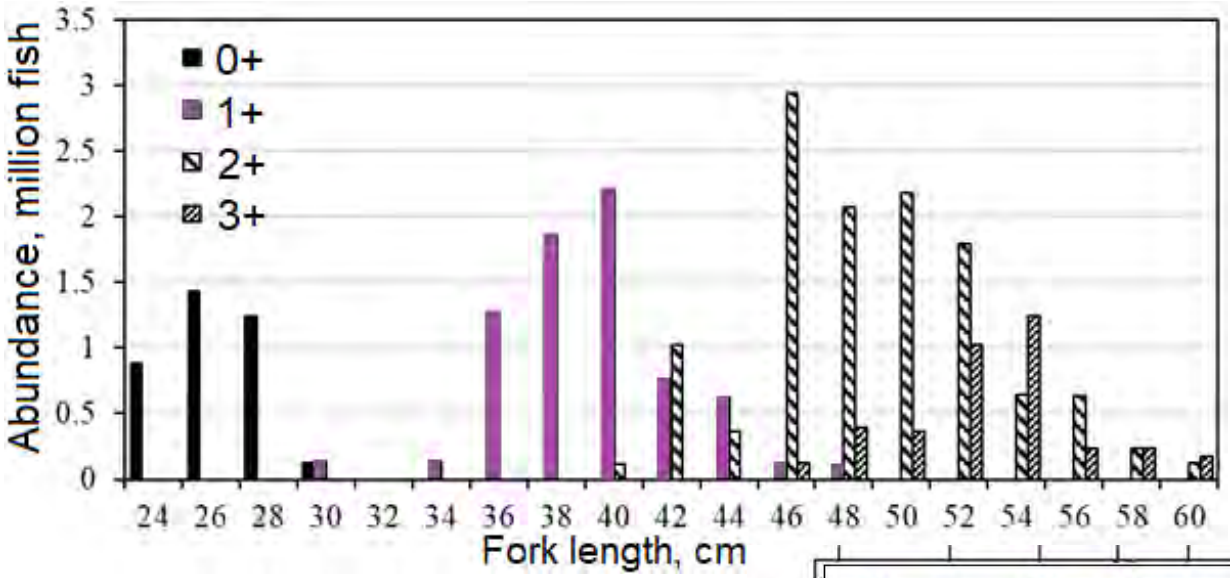
Chum salmon catch distribution (A) and distribution density (fish per km^2) in comparison with historical data from the northwestern Pacific Ocean obtained by the same trawl survey method in 1979-2004



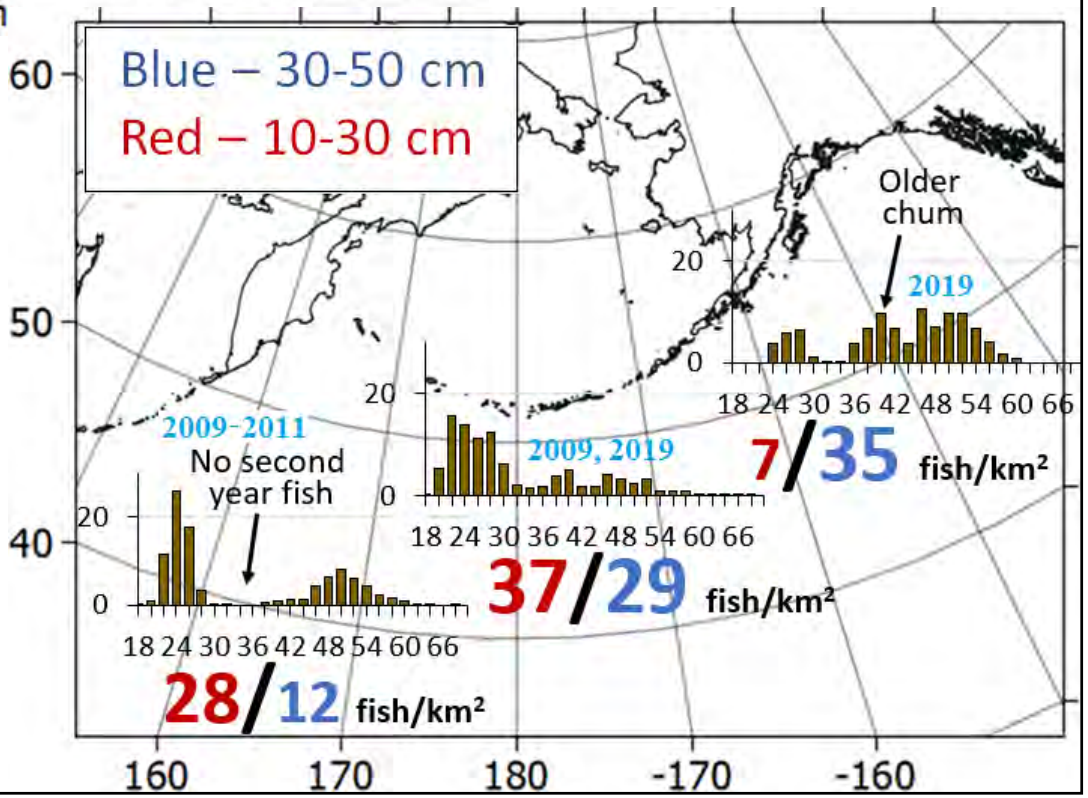




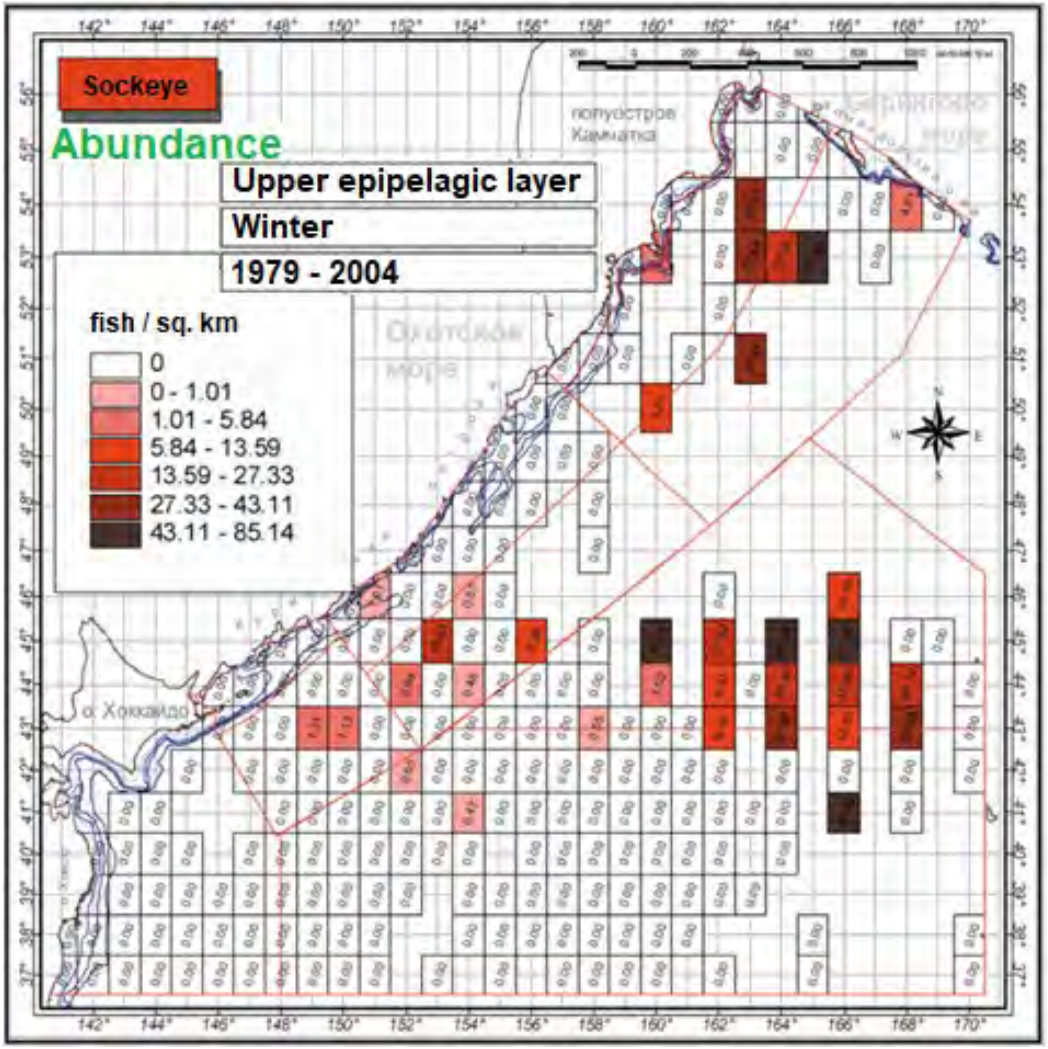
Chum salmon age vs. length distribution in the Gulf of Alaska in winter 2019

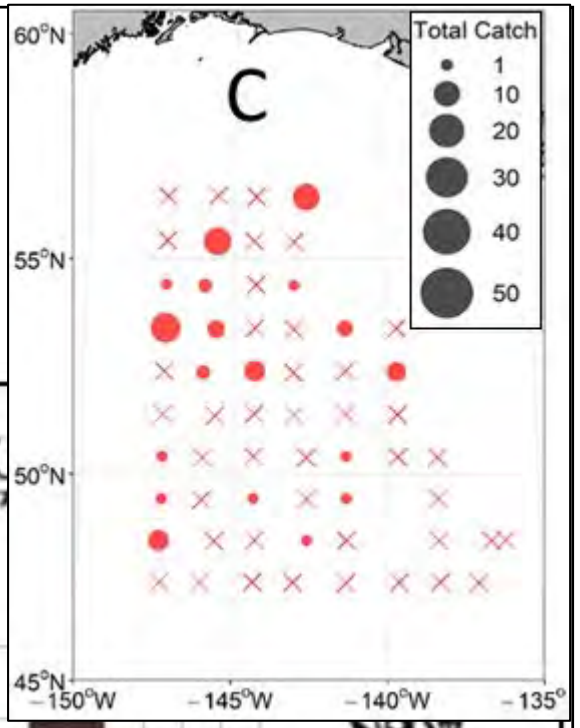


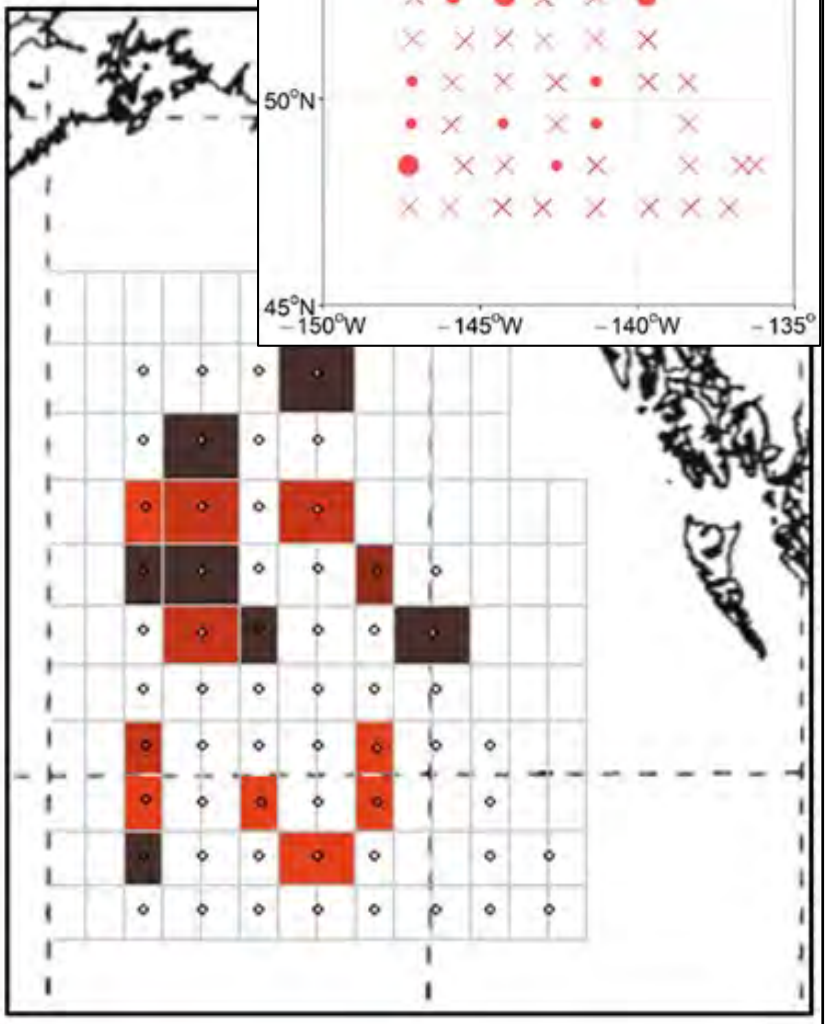
Comparison of **Chum salmon** length distribution in the North Pacific in winter



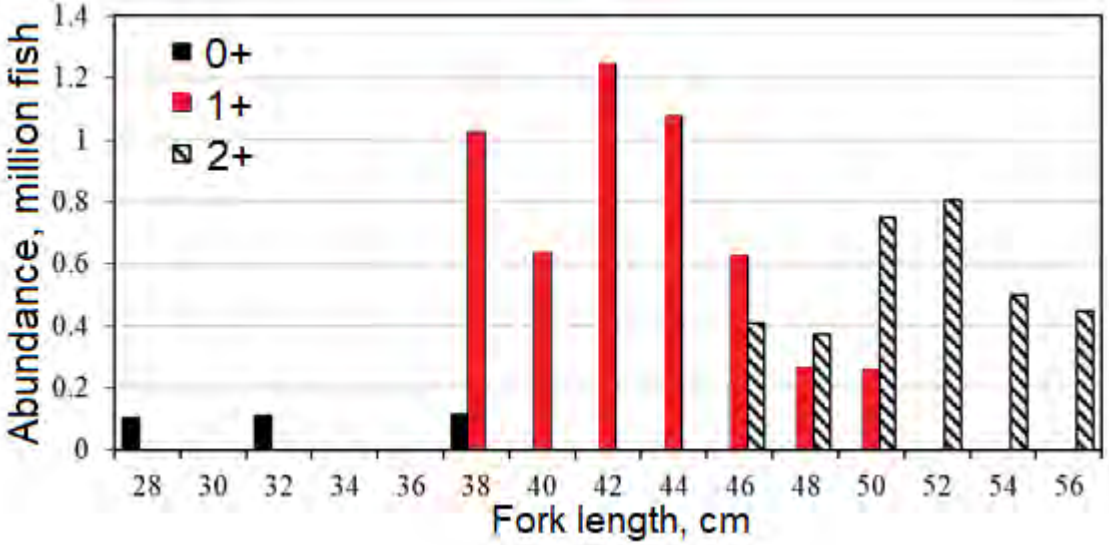
Sockeye salmon catch distribution (C) and distribution density (fish per km^2) in comparison with historical data from the northwestern Pacific Ocean obtained by the same trawl survey method in 1979-2004



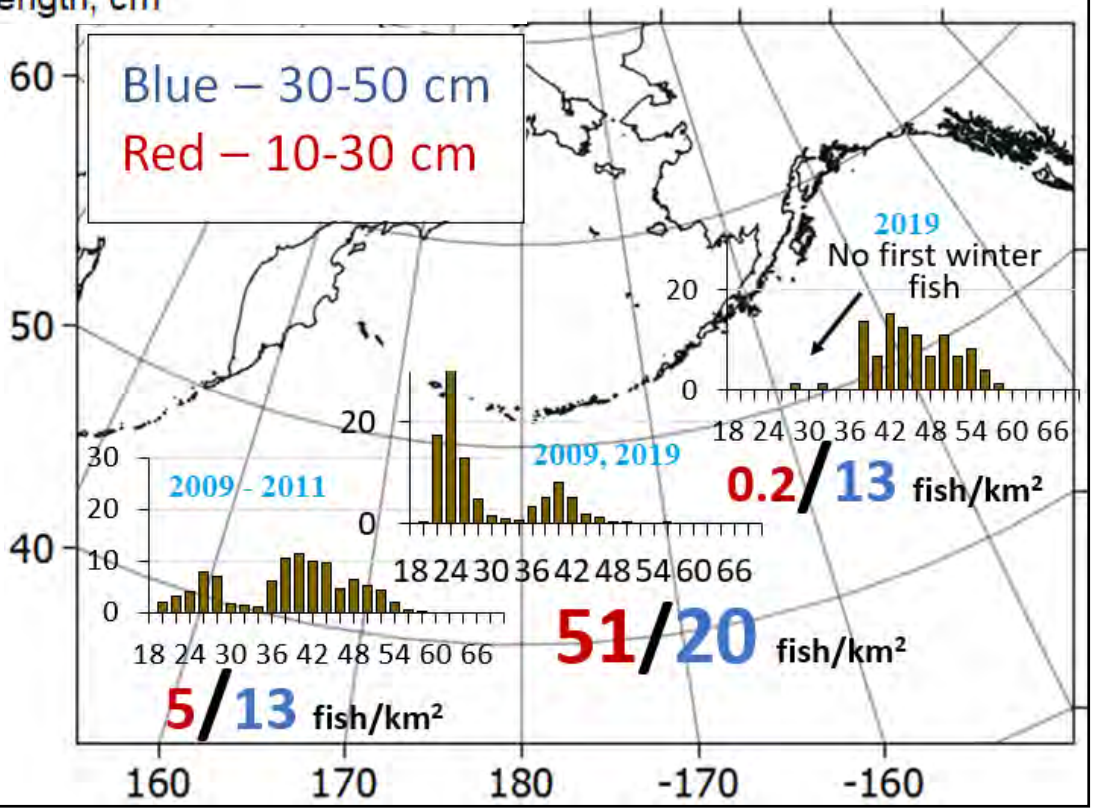




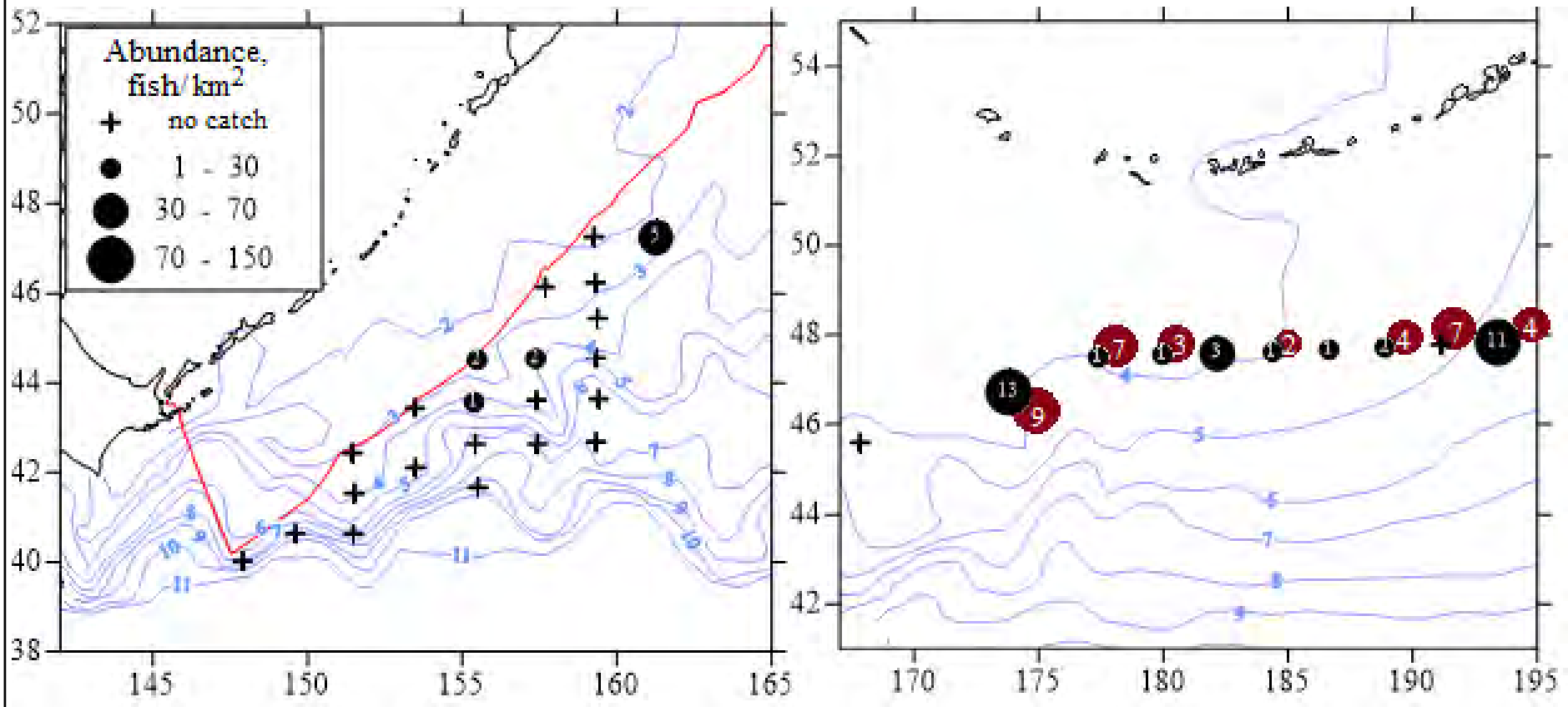
Sockeye salmon age vs. length distribution in the Gulf of Alaska in winter 2019



Comparison of **Sockeye salmon** length distribution in the North Pacific in winter



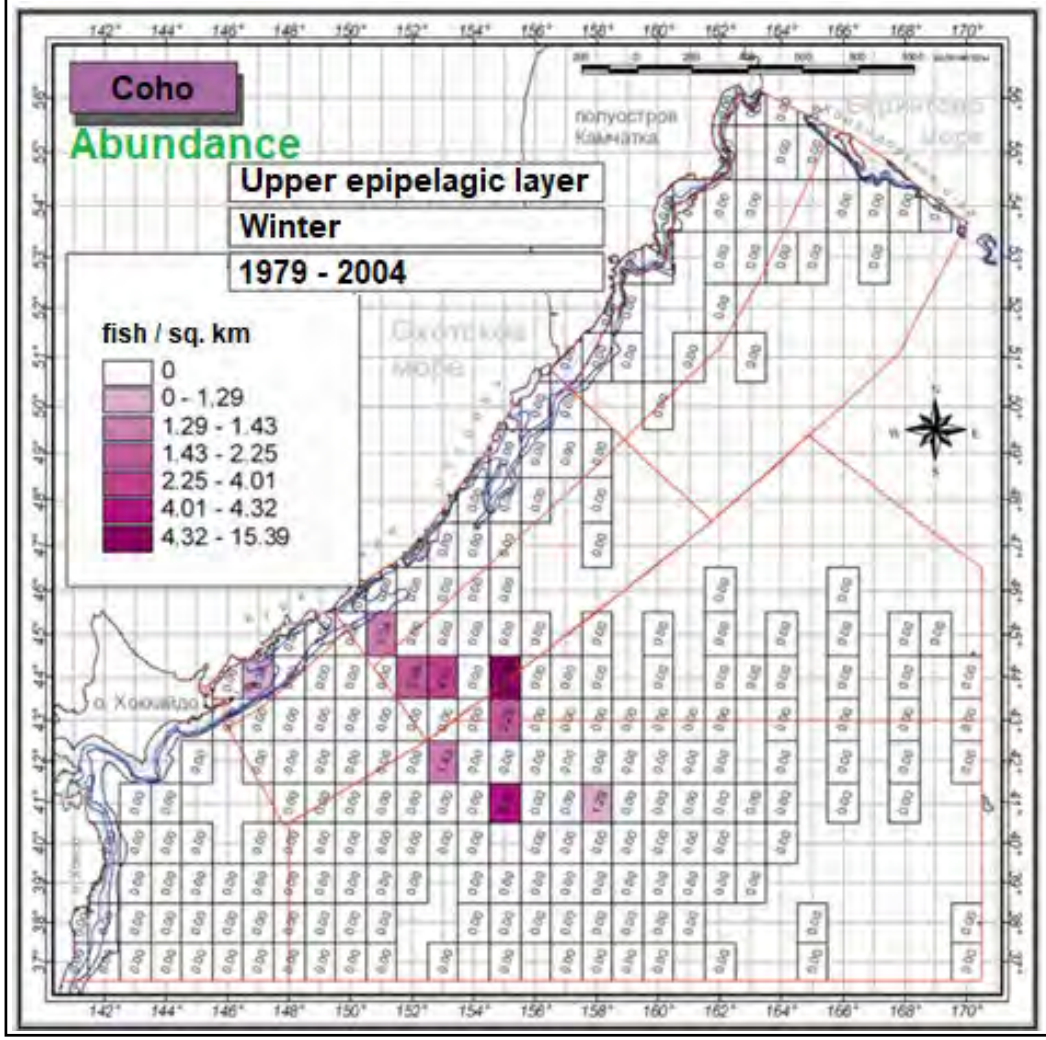
Sockeye salmon catch distribution in the northwestern and central Pacific Ocean in January-February 2019

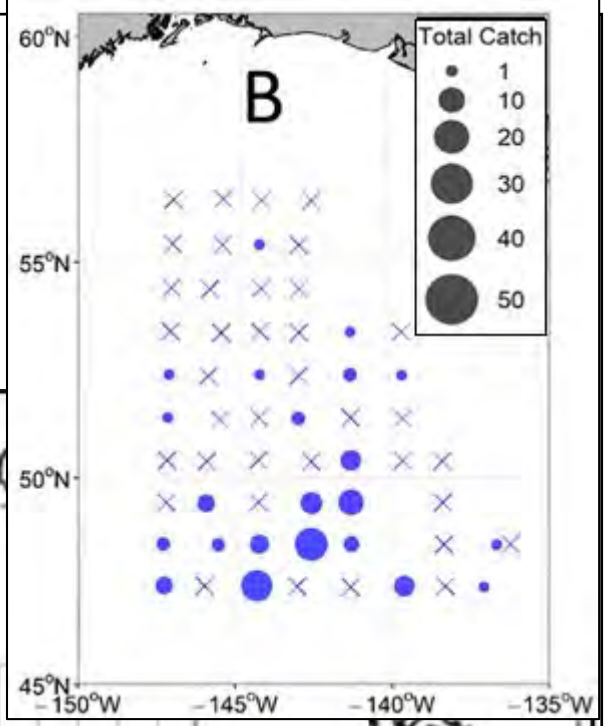


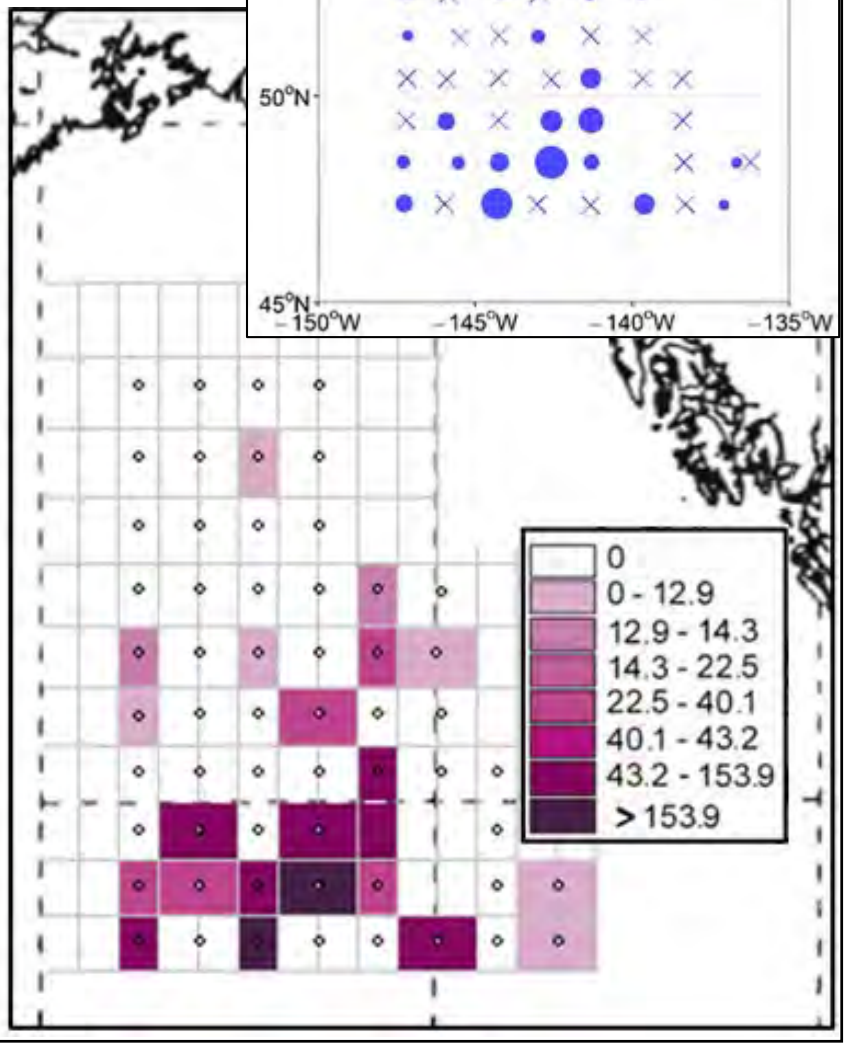
Number of fish in trawl catches are shown separately:

- Black color – fish of second marine year
- Brown color – fish of first marine year

Coho salmon catch distribution (B) and distribution density (fish per km^2) in comparison with historical data from the northwestern Pacific Ocean obtained by the same trawl survey method in 1979-2004







Pink salmon catch statistics in the main commercial fishery regions nearby the survey area, 1971-2019

* 2019 data are preliminary

Proceeding from the fishery harvest, pink salmon run in 2019 is estimated as follows:

320 million fish
to the Russian costs;

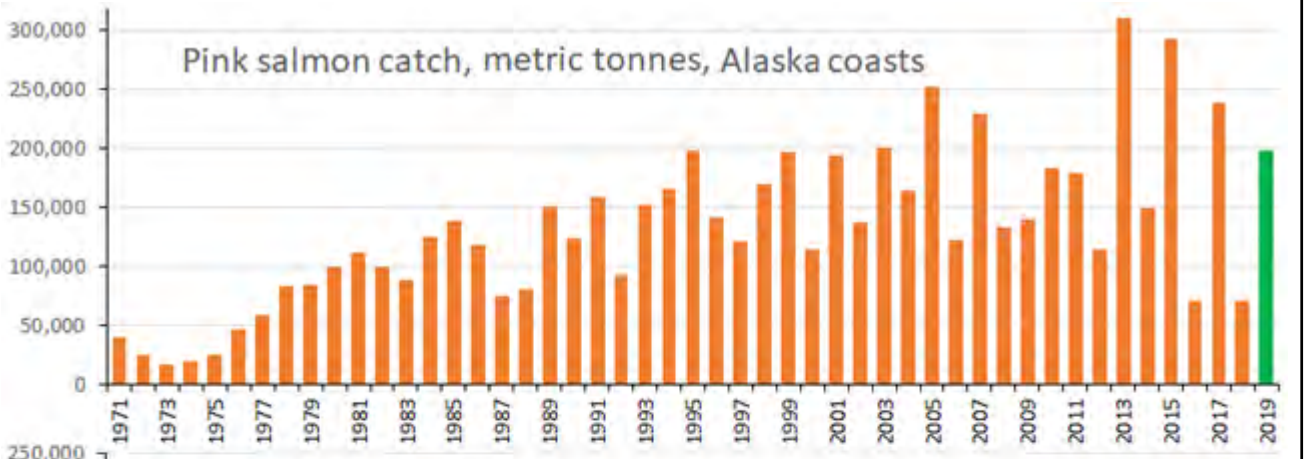
290 million fish
to the Alaska costs;

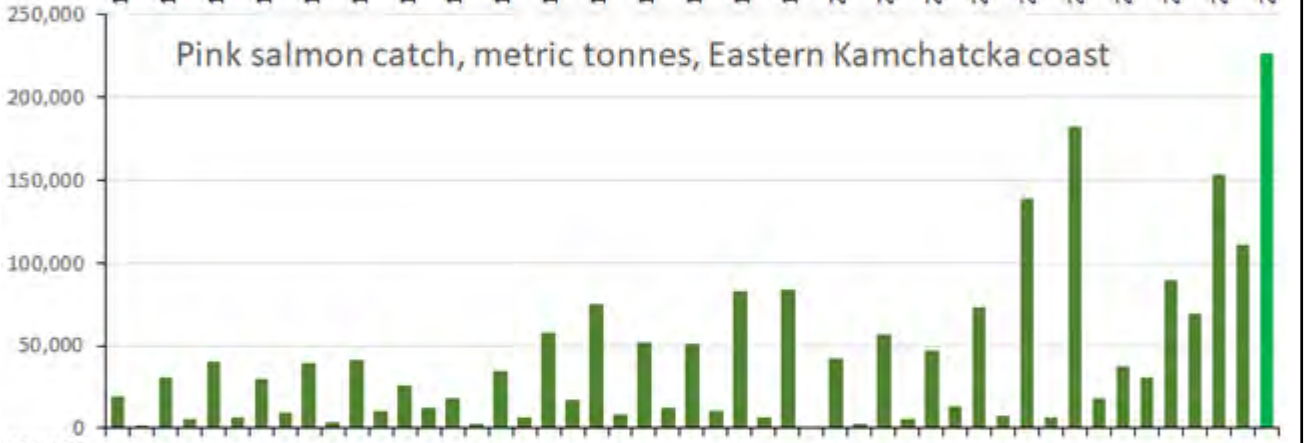
20 million fish
to the Hokkaido coasts;

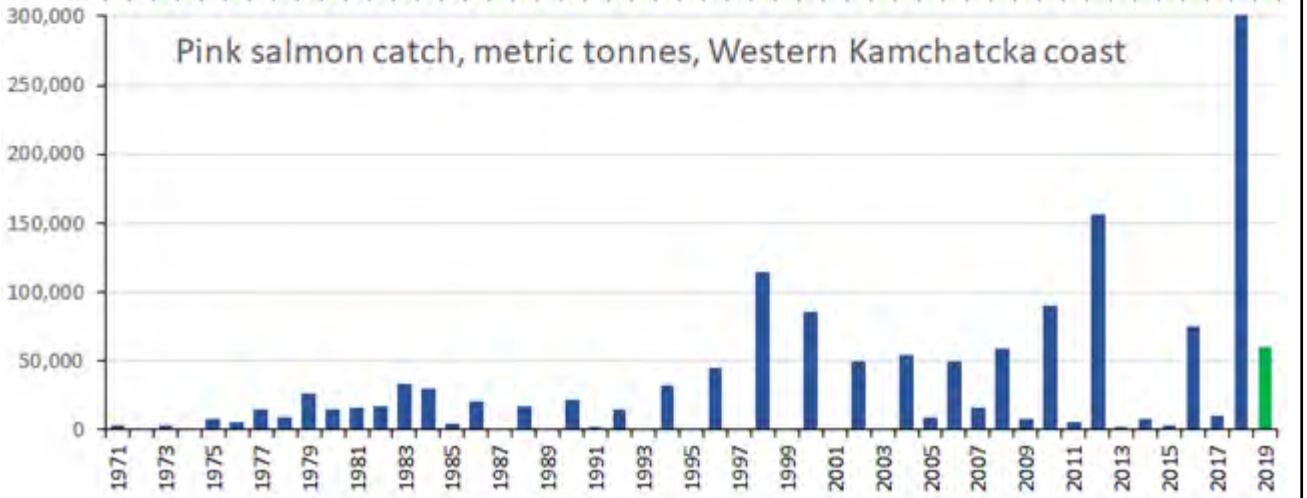
20 million fish
to the British Columbia costs

Total pink salmon run in 2019 is estimated in about

650,000,000 fish

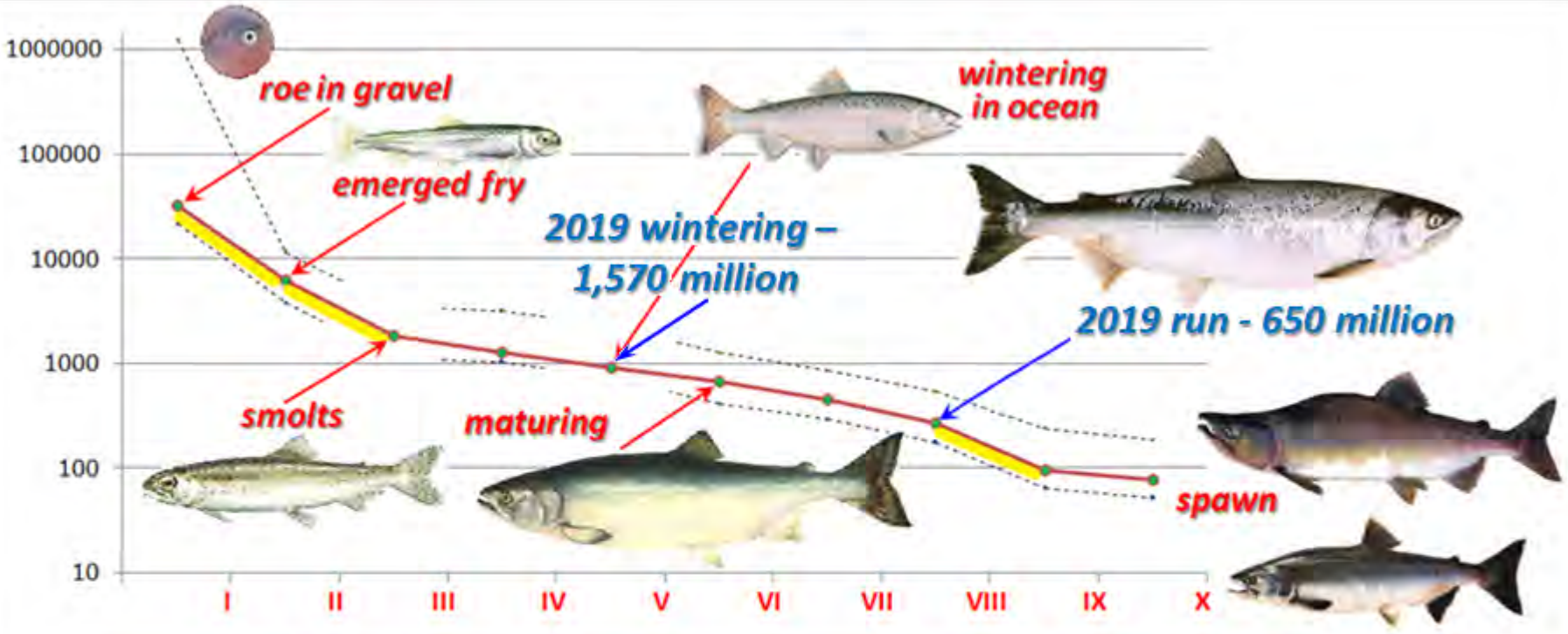






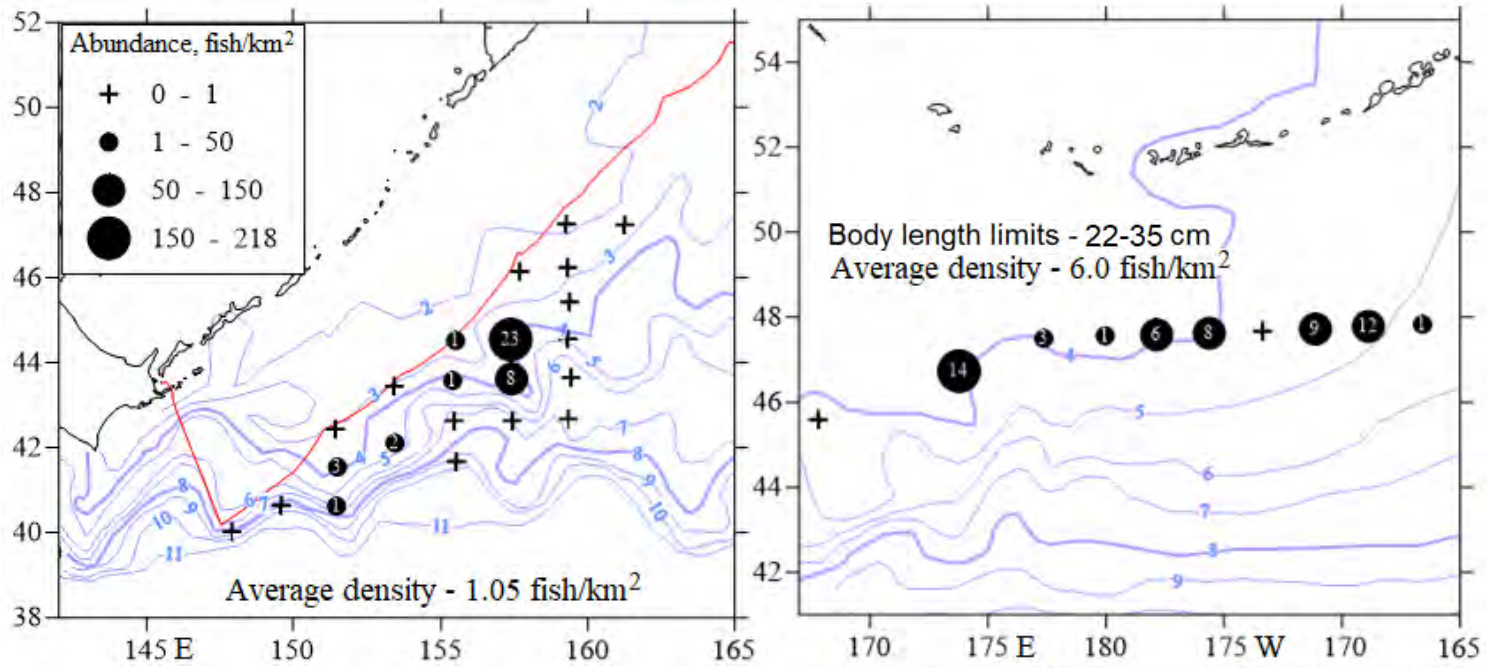
As calculated by previously estimated proportion (Radchenko 2012), **1,570,000,000** fish of pink salmon dwelt the North Pacific Ocean in February-March of 2019 while we found about **3.5%** of this abundance on about **11.6%** of potential pink salmon wintering area.

Where was a Fish?



I	II	III	IV	V	VI	VII	VIII	IX	X	Phases
21448	3860	1136	1020	730	418	300	176	65	52	Numbers, 10^6 fish
3,4	0,7	3,3	157,1	351,9	465,3	401,6	245,1	84,5	65,0	Biomass, 10^3 mt
22	22	1	20	1	7	6	20	22	22	Case numbers (years)

Pink salmon catch distribution in the northwestern North Pacific (16-28 January 2019) and along the trans-Pacific section (30 January – 02 February 2019), fish per km^2

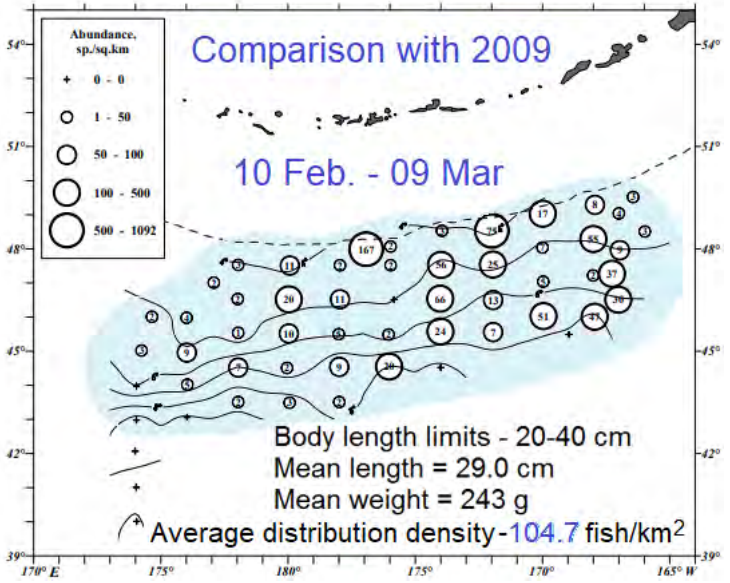


In winter:

Pink salmon distribution density in the central Pacific Ocean was lower in 2019 in **17.5** times than in 2009

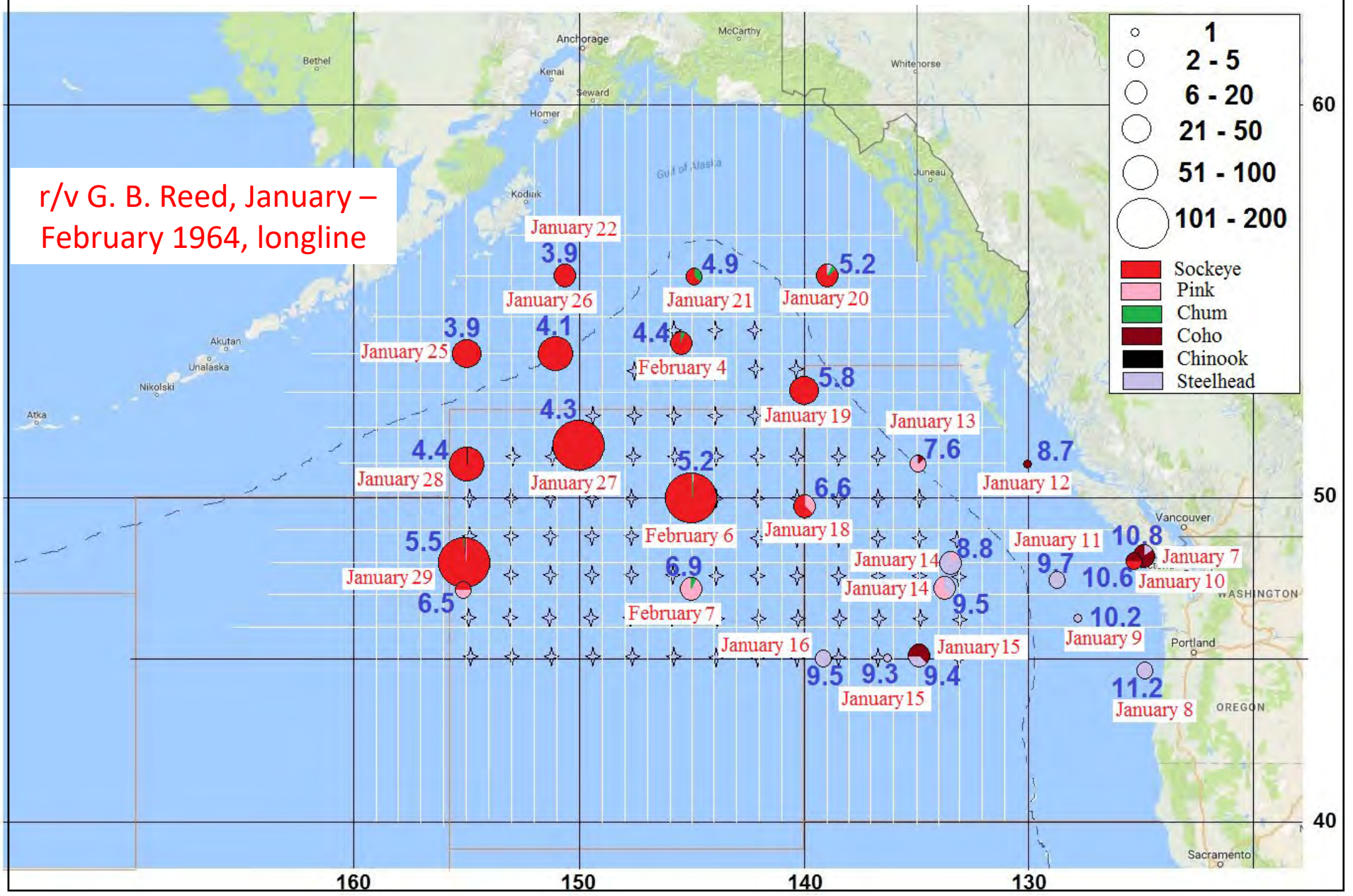
In fishery season:

Pink salmon catch in Alaska was **22%** lower in 2009; in the eastern Kamchatka – **39%** lower; in the western Kamchatka – **88%** lower than in 2019.

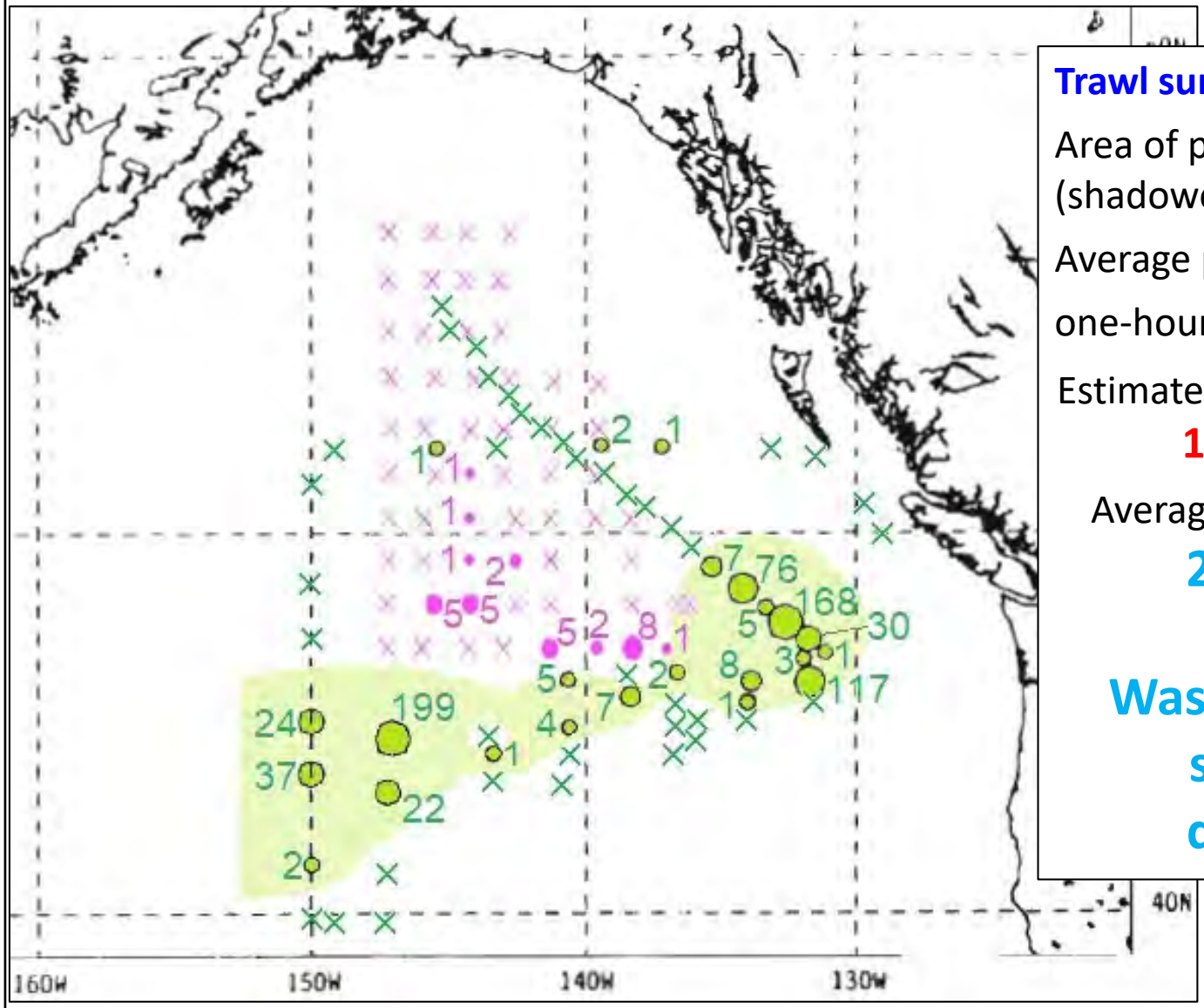


Where was a Fish?

January-February 1964, longline (FRBC 1966)



Comparison of **Pink salmon** catch distribution in the northwestern North Pacific in **21 February – 15 March 2019** and **06 April – 14 May 1990**, fish per one-hour trawl haul



Trawl survey aboard r/v *TINRO*:

Area of pink salmon occurrence (shadowed) - about 625,000 km^2

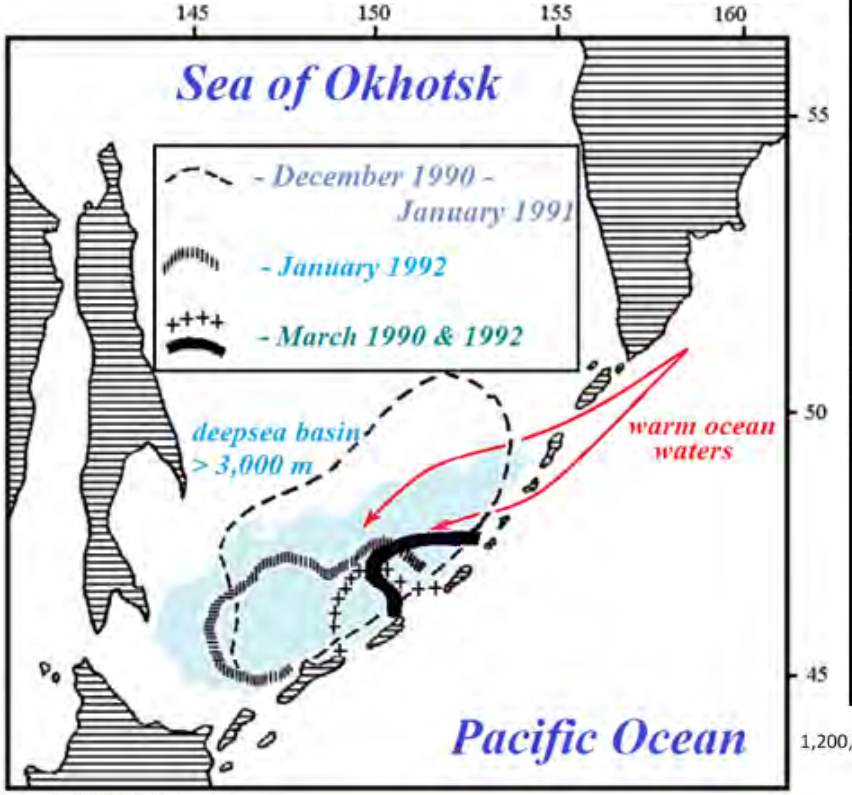
Average pink salmon catch per one-hour trawl haul: **35.9** fish

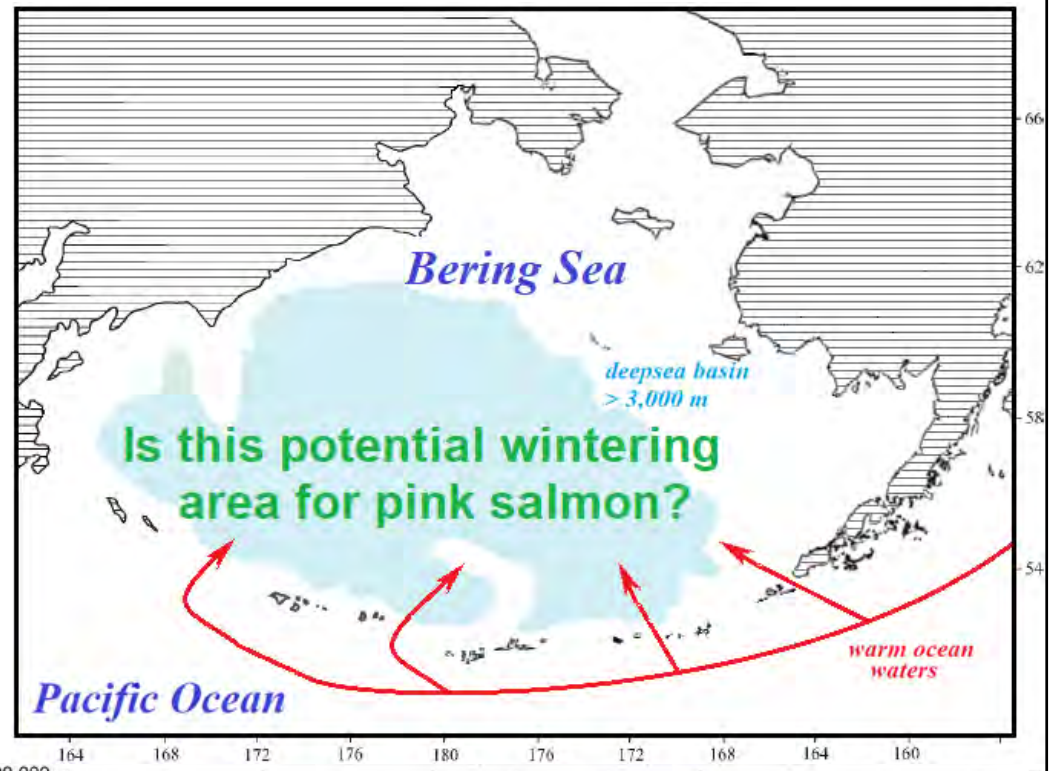
Estimated pink salmon numbers: **146,900,000** fish

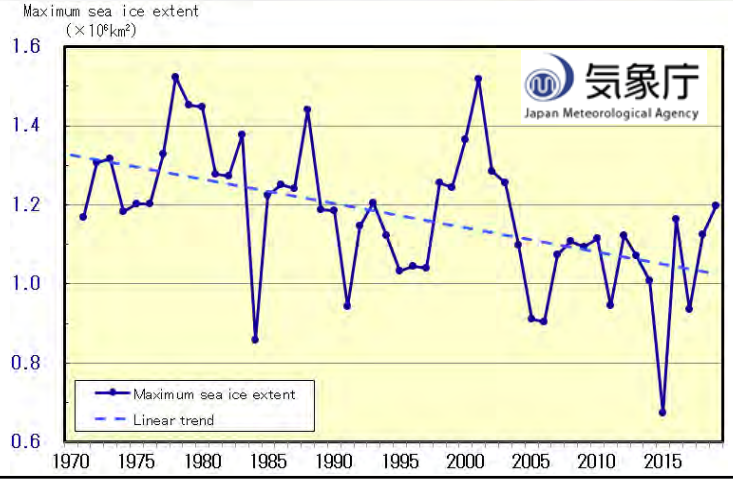
Average distribution density: **235** fish per km^2

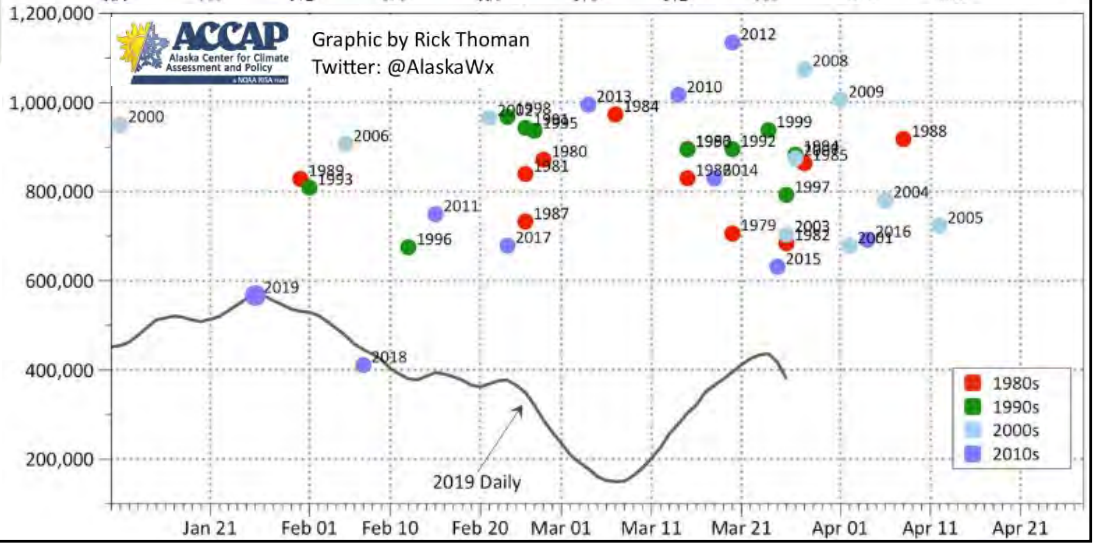
Was there a shift to south in Fish distribution?

Bering Sea ecosystem has undergone major changes in winter with less ice coverage in 2018 and 2019

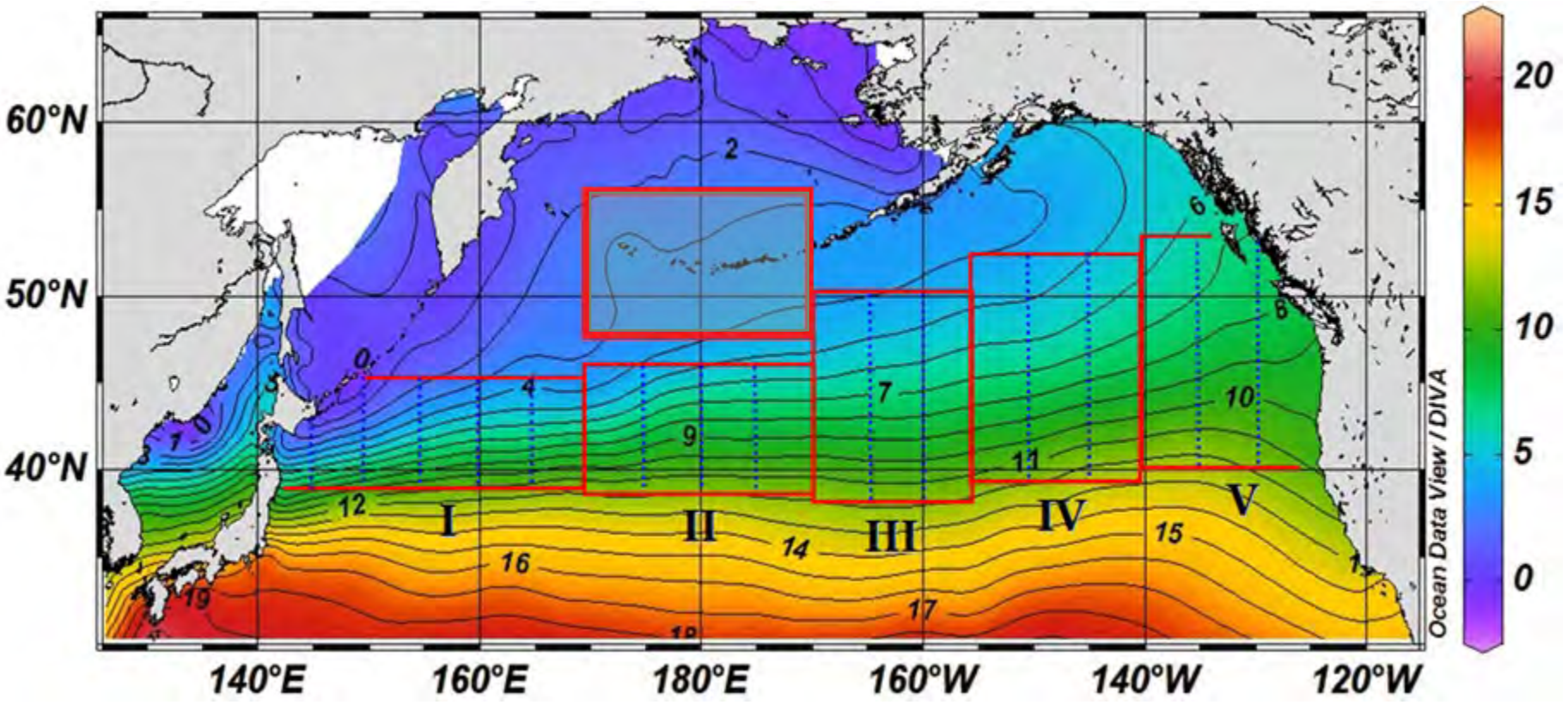








Initial map of the Pan-Pacific integrated survey proposal



Should it be supplemented by one more survey polygon?

Conclusions

1. No northern shift was revealed in Pacific salmon distribution throughout the survey area

2. Main concentrations of pink salmon remained beyond the southern limit of the integrated survey area despite other locations are also possible

3. Chum salmon was the most abundant salmon species in the Gulf of Alaska in winter and mainly distributed in the periphery zones of cyclonic eddy and anticyclonic meander of the Subarctic Current (northern branch)

4. Sockeye salmon mostly occurred in the northern part of survey area with SST less than 7ºC. Our survey covered not more than 15% of potential geographical range of North American sockeye stocks distribution

5. Day-time catches of sockeye salmon were less tenfold than night-time catches, in average, that may be related to their feeding behavior

6. Coho salmon distribution density is a degree of magnitude higher in the Gulf of Alaska than in the northwestern North Pacific. Estimated abundance was over expectations

7. Coverage of the whole Pacific salmon wintering area might require other survey polygons in addition to the initial Pan-Pacific survey proposal