Oceanography, Ichthyoplankton, and Bottom Fishes of Bering Strait and Chukchi Sea

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RUSALCA issue:

Climate variability and change detection

Problem for fish –

- Little to no baseline data for comparison

Our RUSALCA objective

- To document the juvenile fish and ichthyoplankton species in the study area and provide a baseline from which to measure future changes

photo by Terry Whitledge

“General” knowledge of fish

- Fish community structure is temperature/water mass dependent
- Bering Sea species move into the Chukchi Sea in warm years
- Changes in distribution of fish in Chukchi Sea are associated with influx of warm Alaska Coastal Water (Gillespie et al. 1997; Smith et al. 1997a, 1997b; *Amer. Fish. Soc. Symp. 19*)

Specific knowledge of fishes

- Larval Bering flounder (*Hippoglossoides robustus*) transported near the coast in ACW (Wyllie-Echeverria et al. 1997)
- Larval arctic cod (*Boreogadus saida*) are found in both ACW and RCW in the northeast Chukchi Sea (Wyllie-Echeverria et al. 1997)
- Highest abundance of adult arctic cod occurs in BSW, followed by ACW, with lower numbers in RCW (Gillespie et al. 1997)

Starting point:

- It is speculated that the many frontal systems in Arctic waters affect food availability and funnel the high productivity from the Chukchi through the upper trophic levels (Weingartner 1997)

Hypotheses

- The frontal structure of the Chukchi Sea defines fish communities (species composition and abundance) by limiting transfer among water masses
- The physical oceanographic structures on either side of the fronts should affect fish habitat

Sampling Objective

- Collect fish eggs, larvae and juveniles from specific water masses to estimate relative fish abundance and distribution

photo by Catherine Mecklenburg

photo by Terry Whitledge

Samples - Ichthyoplankton

- Target fish eggs and fish larvae with quantitative collections by 60 cm paired Bongo plankton net, with 505 micron mesh, one oblique tow at each site

- Additional fish larvae provided at sea by the zooplankton project (Hopcroft and Kosobokova) were used for trace elements analysis and for voucher collections
- Incidental catches of larger invertebrate zooplankton by this project were provided to the zooplankton project and for trophic research (Iken and Bluhm)
- Some larval fishes were provided to non-RUSALCA projects for genetics

Samples – Juvenile groundfishes

- Target small bottom fishes with quantitative collections by 3.05 m plumb-staff beam trawl, with 7 mm mesh and 4 mm codend liner; one quantitative tow per site

- Additional fishes were provided to this project for trace elements analysis by the adult fish project (Mecklenburg et al.)

- Fish tissues and invertebrates were provided by this project for trophic and community analysis (Iken and Bluhm)

- Voucher specimens of juvenile and adult fishes were provided by this project to the adult fish project, and to various museums and institutes (e.g., ZIN, California Academy of Sciences, NOAA)

- Tissues for fatty acid analysis were provided for a non-RUSALCA project (Alan Springer, UAF)

Additional Samples – for Trace Elements Chemical Analysis

- At most stations
  - Surface water
  - Bottom water
- At VanVeen sites
  - Sediment

Beam trawl –

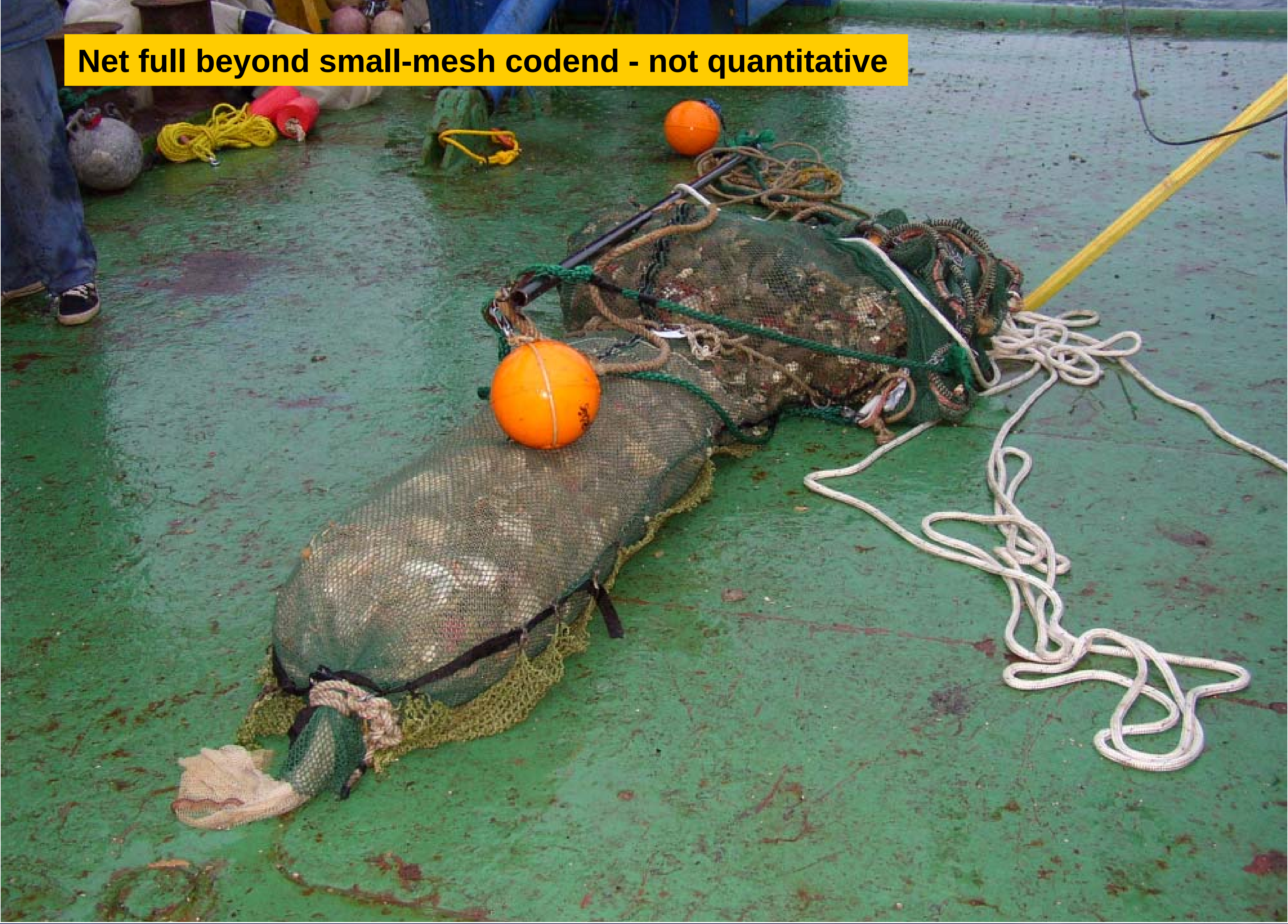
- Very successful at collecting a variety of small bottom fishes (<200 mm) and epibenthic invertebrates
- This gear can be fished effectively over mud, sand and gravel substrates
- N=14 sites, each with one "quantitative" tow for area fished
  - These 14 tows are standardized to # individuals/1000m^2; but as tow distance was calculated at only 5 sites, and was estimated based on tow duration and average towing speed for the other 9 sites, the abundance values are imprecise and must be interpreted with caution.
- N=5 tows over 3 sites with "non-quantitative" tows
  - Tows filled beyond codend (n=2 tows)
  - Net damage affecting retention of catch (n=3 tows)

Beam trawl - heavy catch

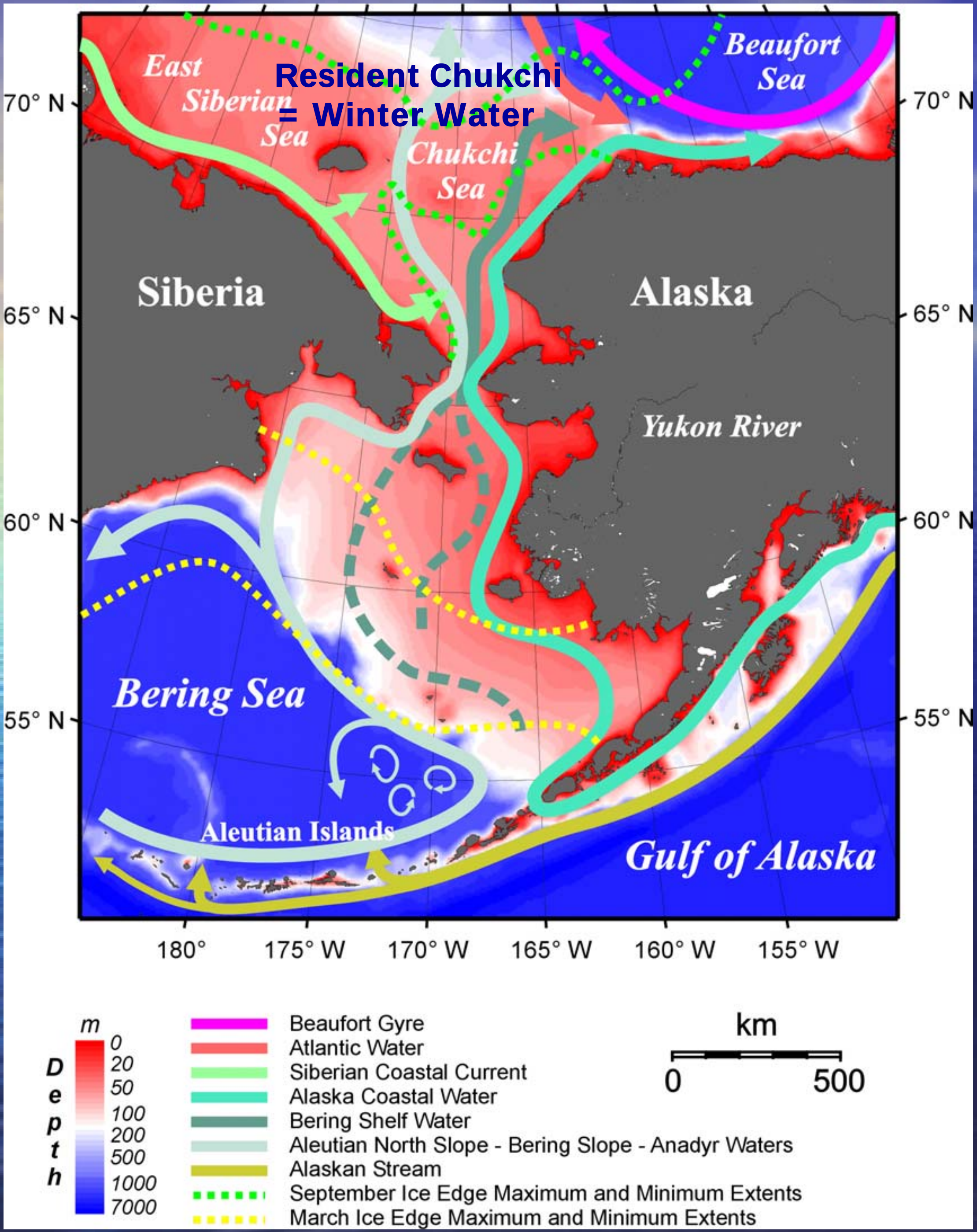
Codend filled with mud and tore net;
lost much of the catch – not quantitative

Net repair

Net full beyond small-mesh codend - not quantitative




Good catch!



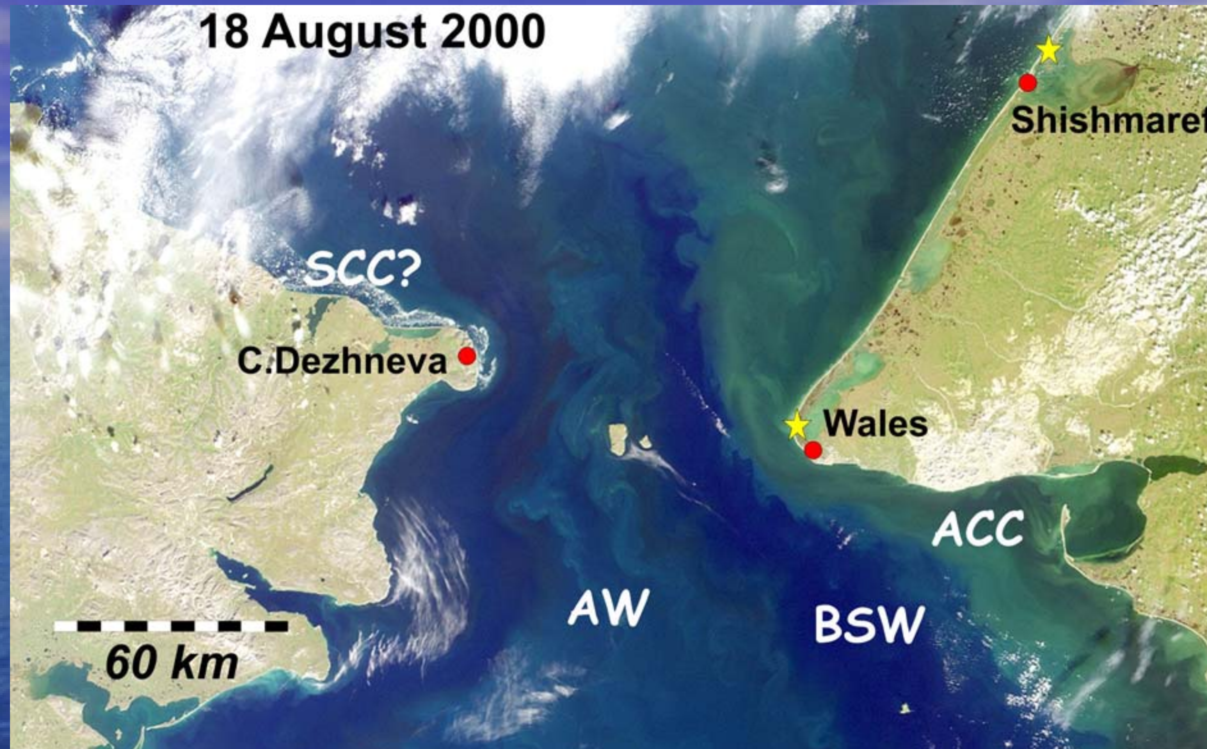
Southern Chukchi Sea water transported from Bering Sea

- ACW isolated to east by strong front
- BSW west of front mid-shelf
- AW / SSC? Southwest

Northern Chukchi Sea water from north

- RCW = Winter Water north & central
  - from NW - Siberian Sea (Pickart)
  - from upper layers of Arctic Ocean or shelf water left from previous winter (Weingartner)

Surface water masses



MODIS IMAGE

Four water masses - Bering into Chukchi Sea

*Properties established in Bering Sea and further south

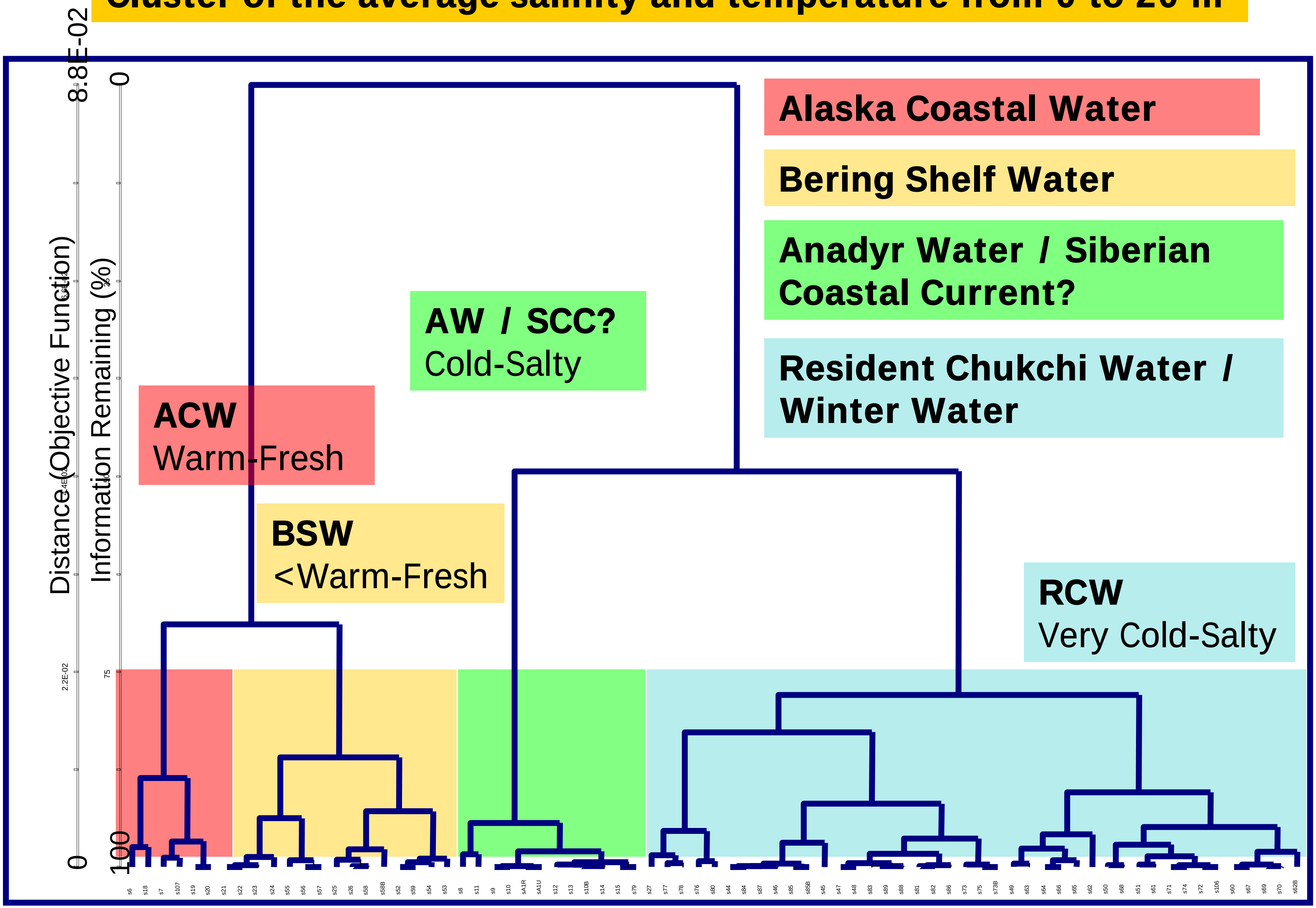
(Weingartner RUSALCA 2005)

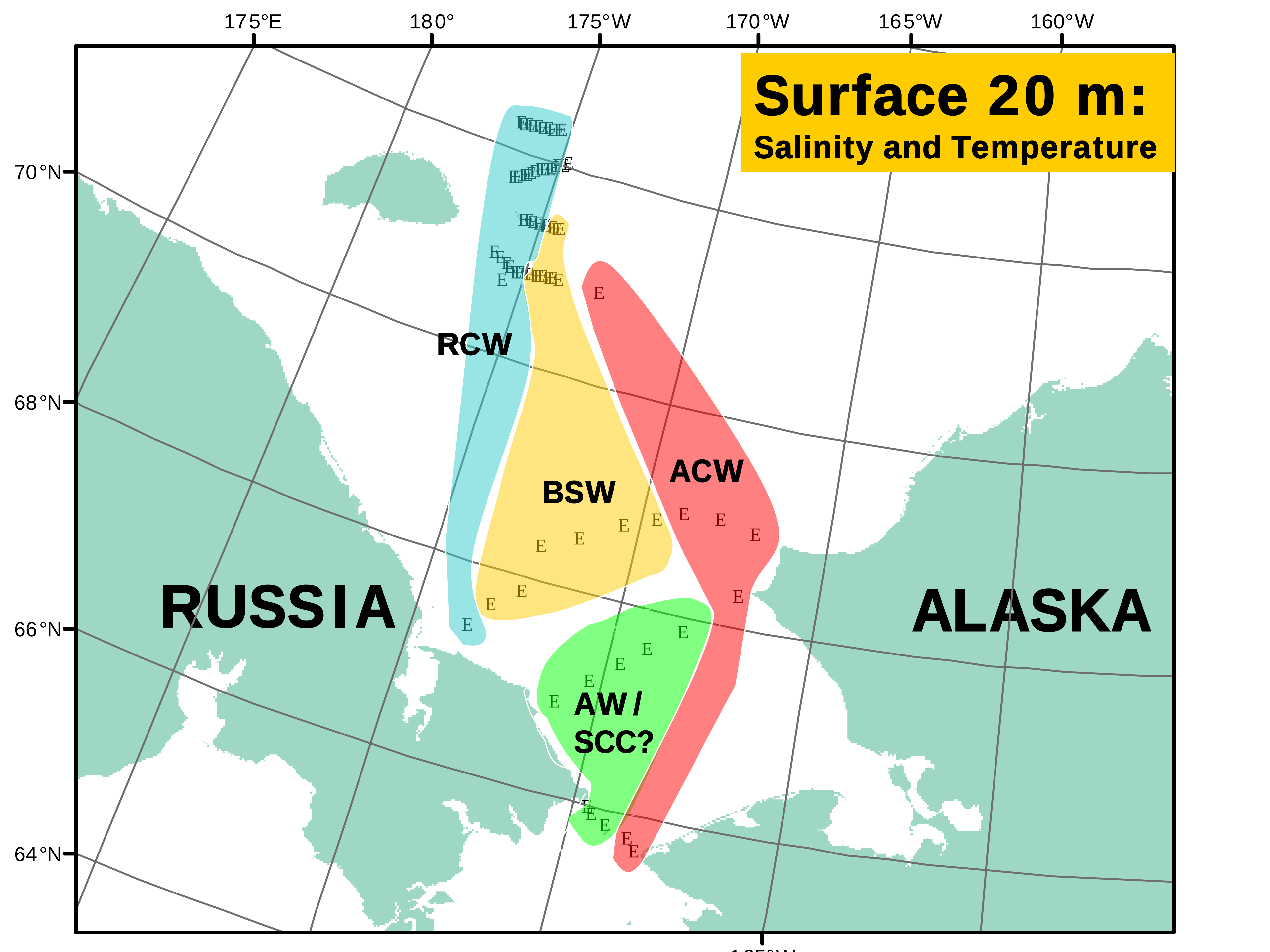
1) Alaskan Coastal Current (ACC)*
2) Bering Shelf Water (BSW)*
3) Anadyr Water (AW)*
4) Siberian Coastal Current (SCC) [East Siberian Sea]

AW and BSW mix north of the strait to form Bering Sea Water in the Chukchi

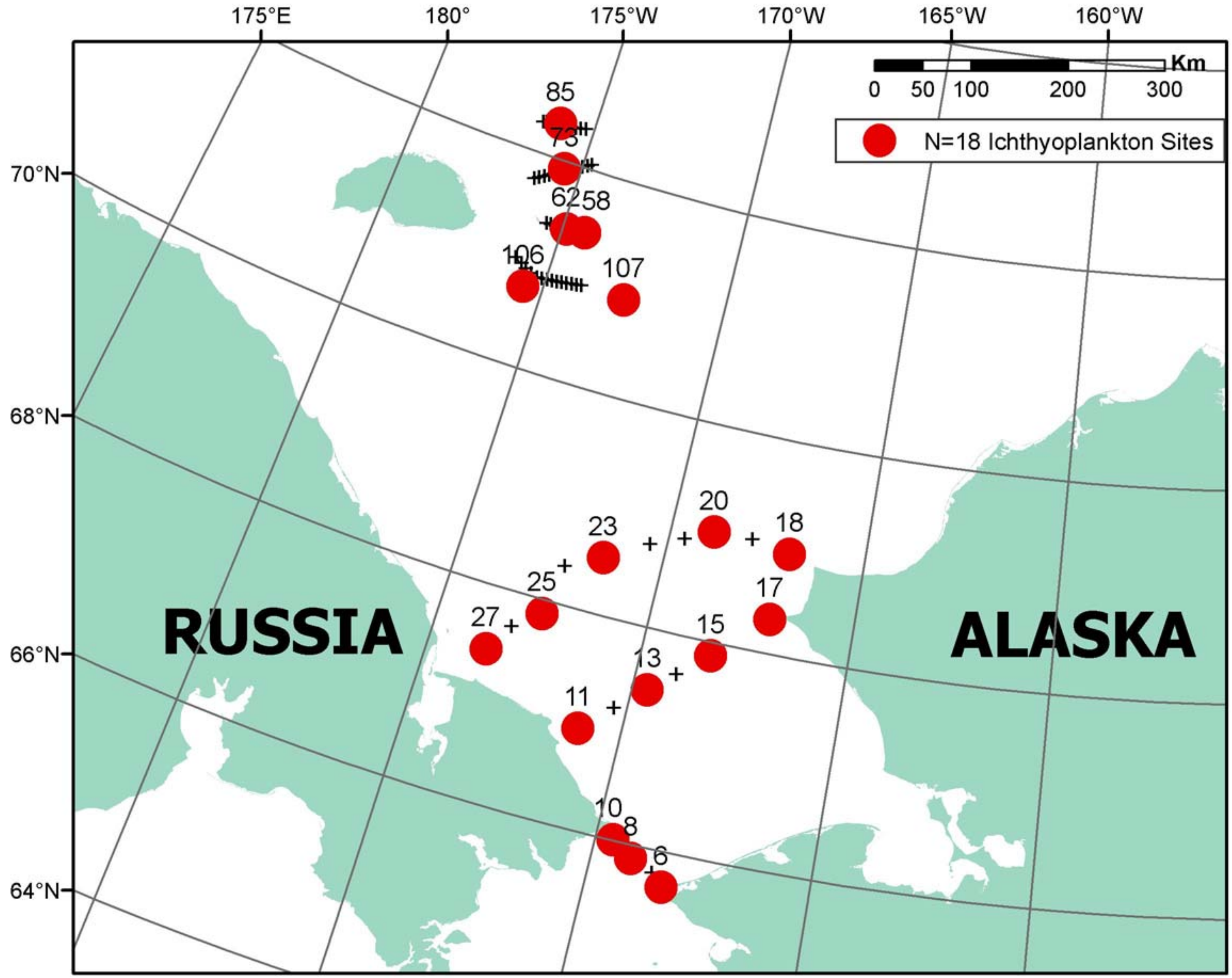
Surface water masses:

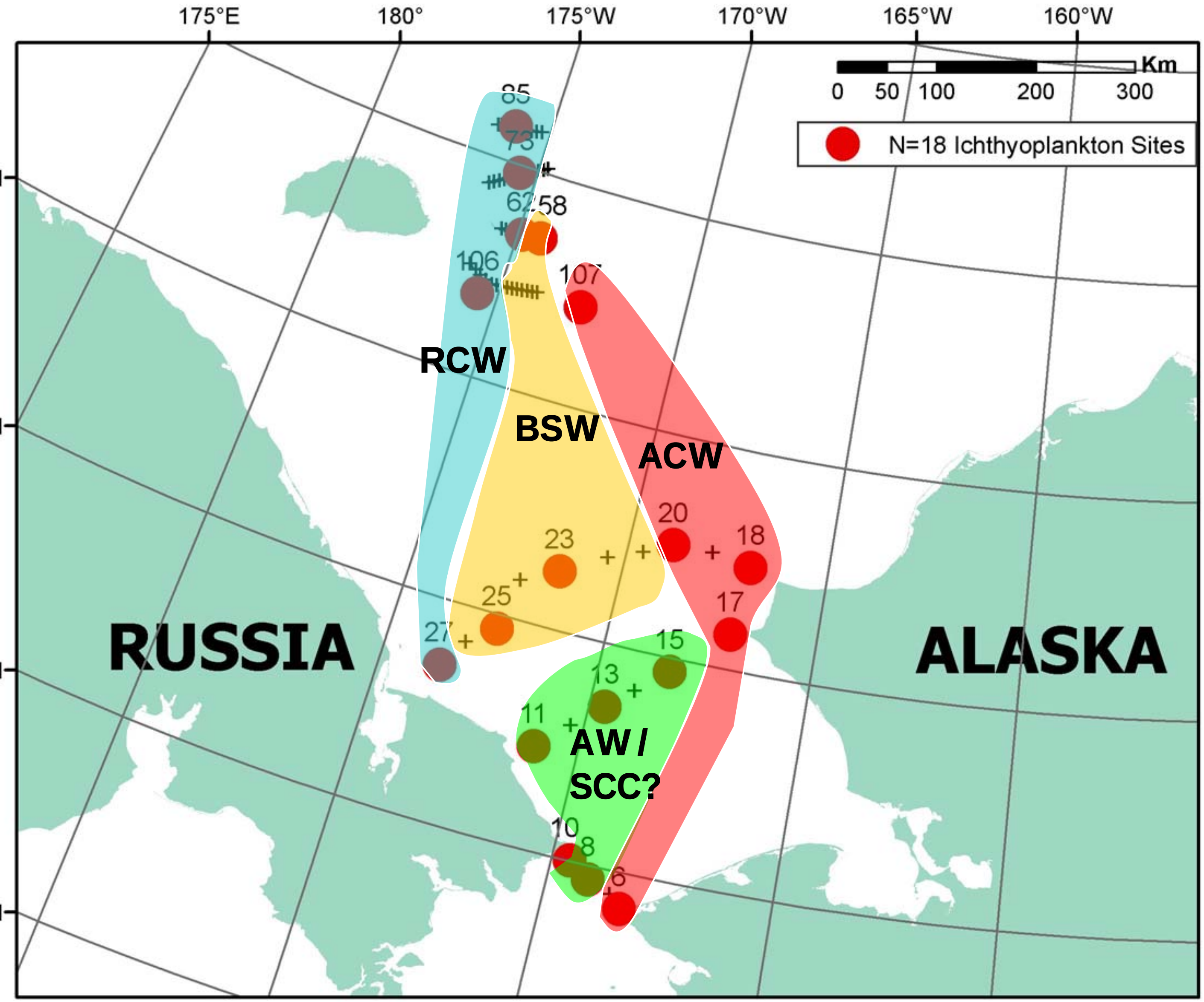
Cluster of the average salinity and temperature from 0 to 20 m





Surface 20 m:
Salinity and Temperature
175°E
180°
175°W
170°W
165°W
160°W
70°N
68°N
66°N
64°N
RCW
BSW
ACW
AW /
SCC?
RUSSIA
ALASKA


175°E
180°
175°W
170°W
165°W
160°W
70°N
68°N
66°N
64°N
Km
0 50 100 200 300
N=18 Ichthyoplankton Sites
85
73
62
58
106
107
23
20
18
25
17
27
15
13
11
10
8
6
RUSSIA
ALASKA


175°E
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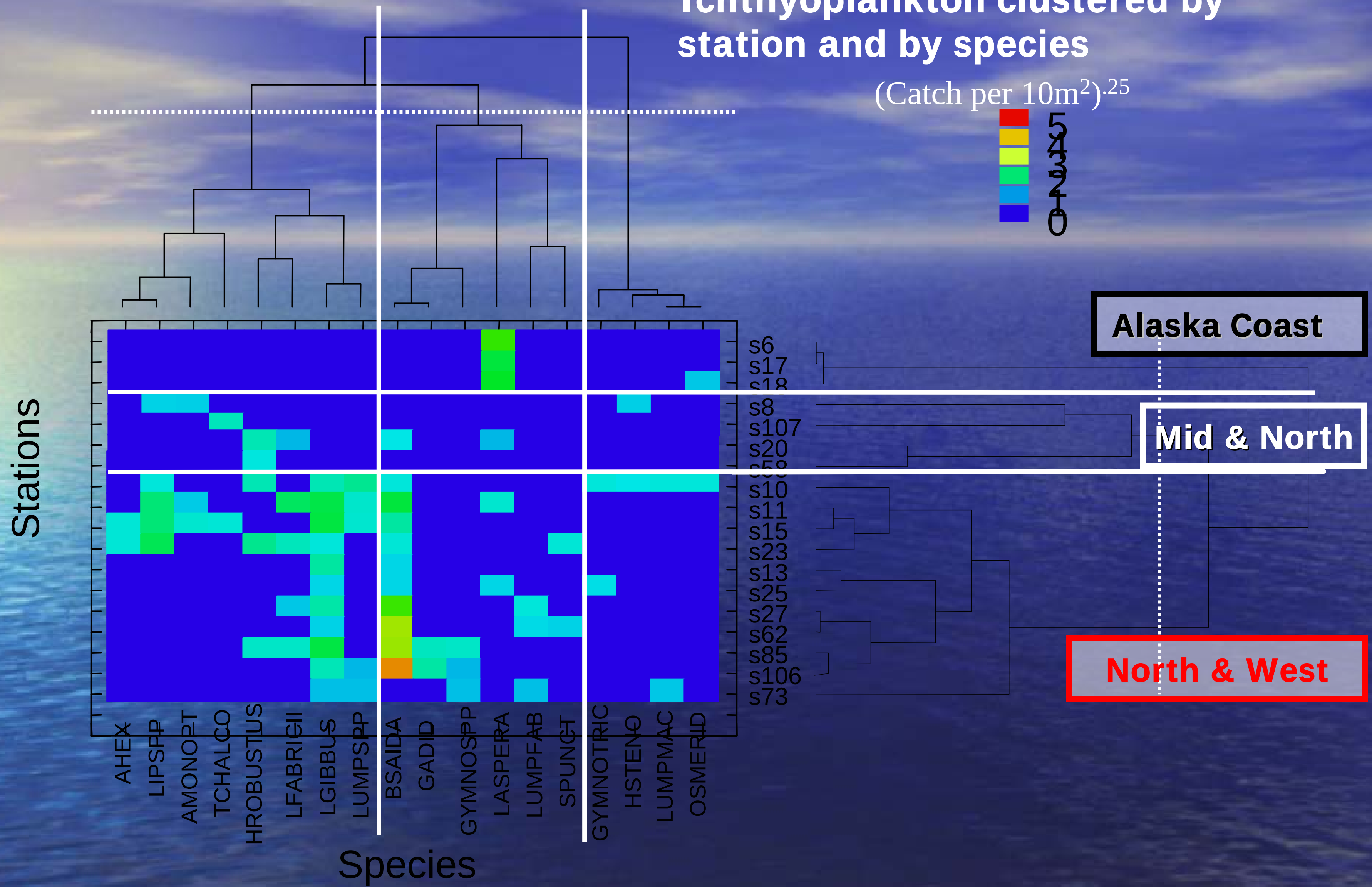
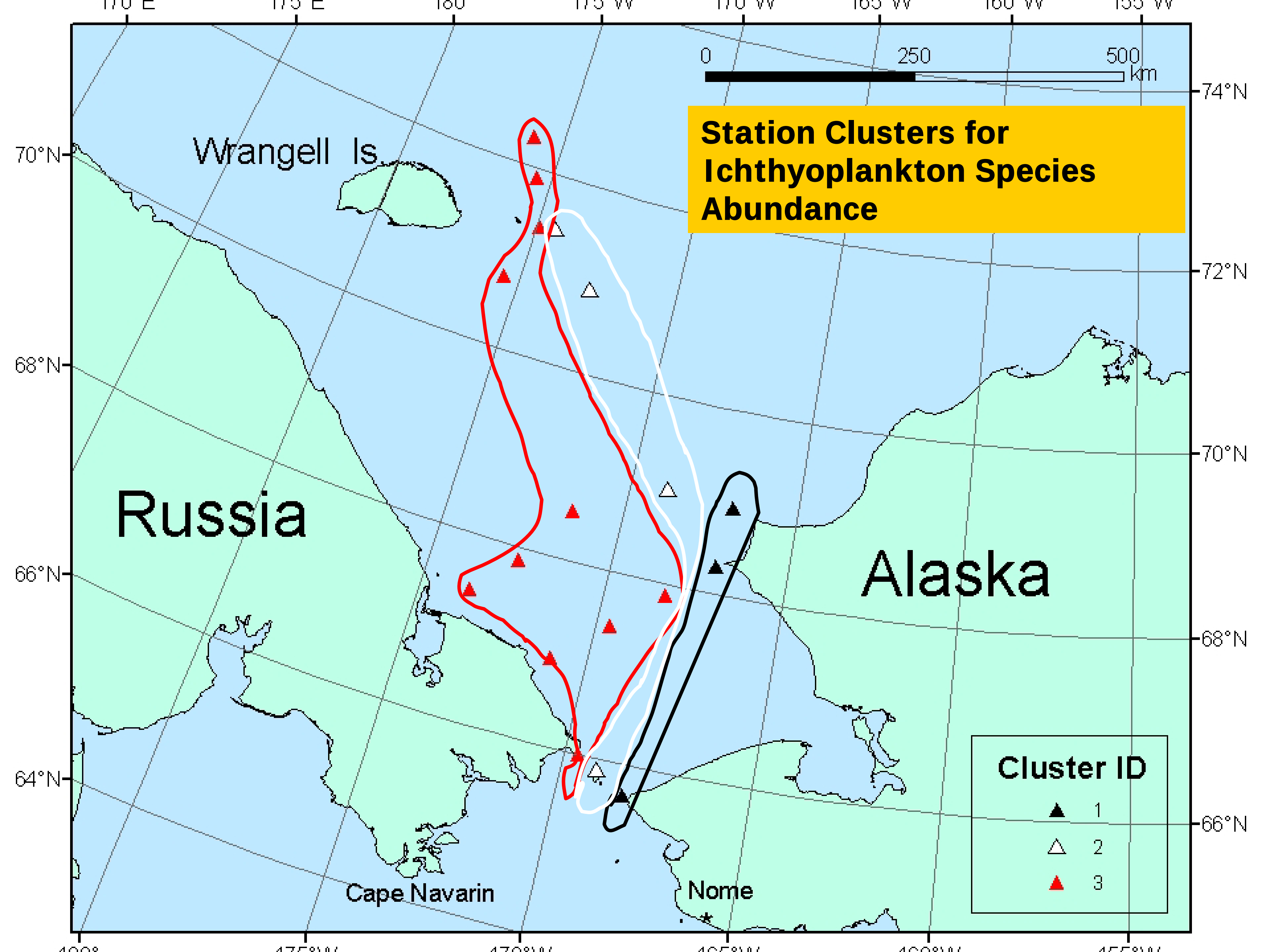
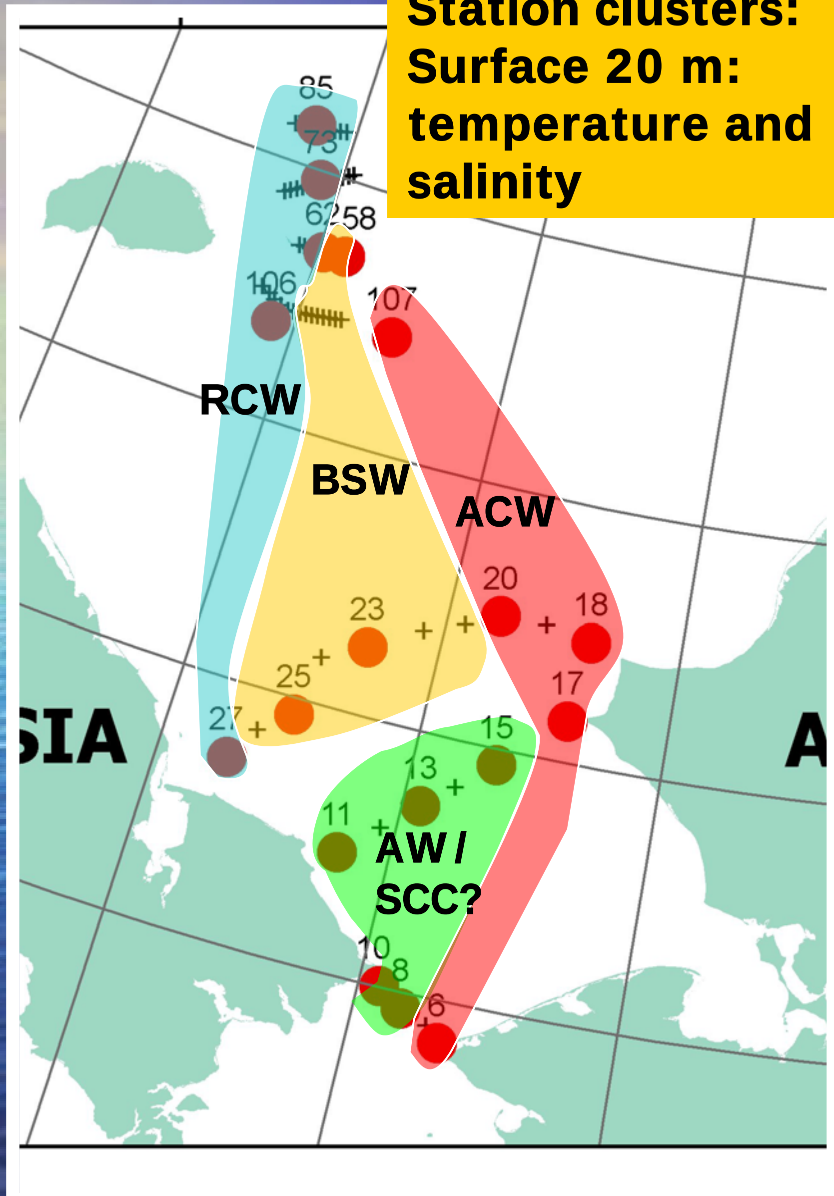
Ichthyoplankton clustered by station and by species



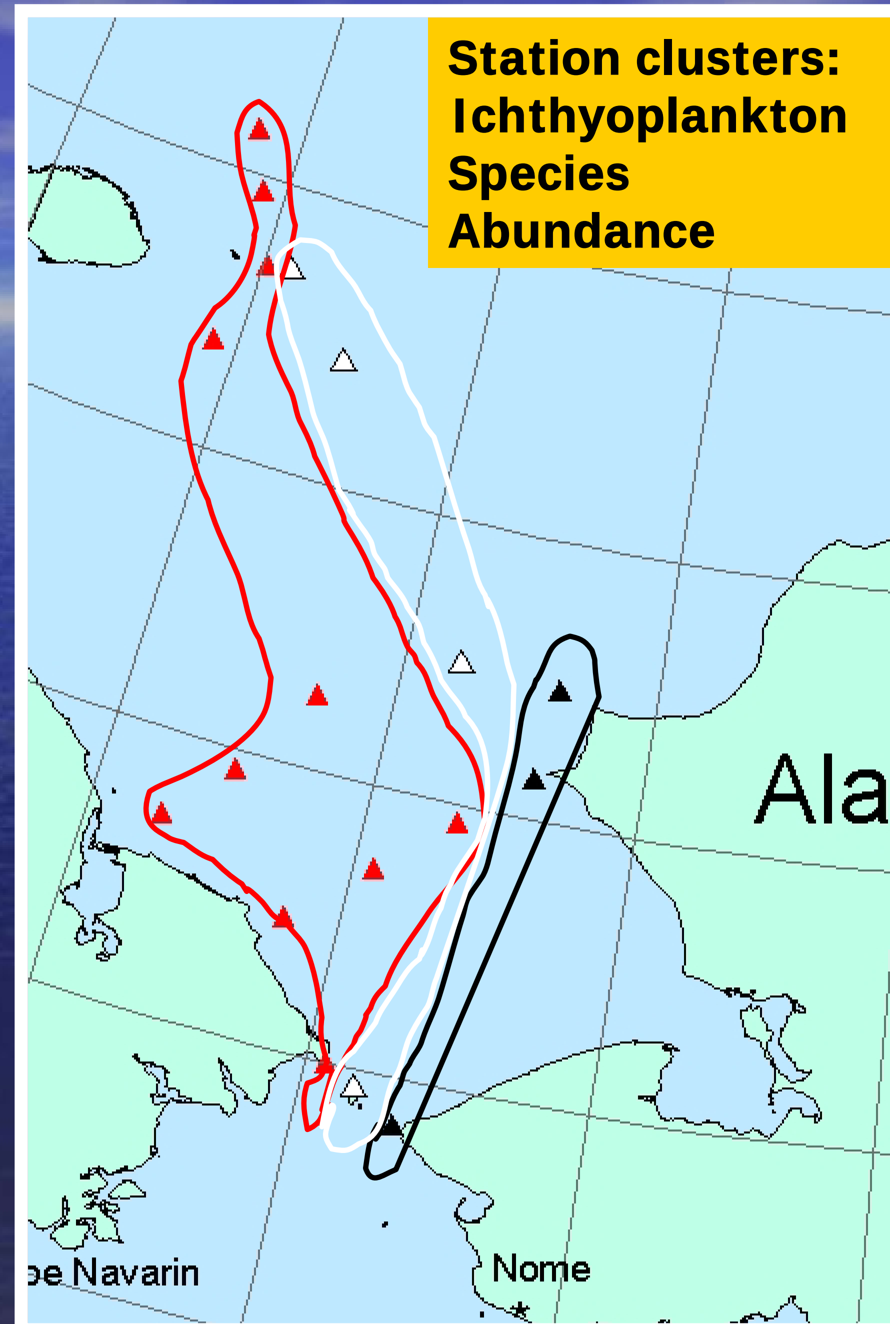


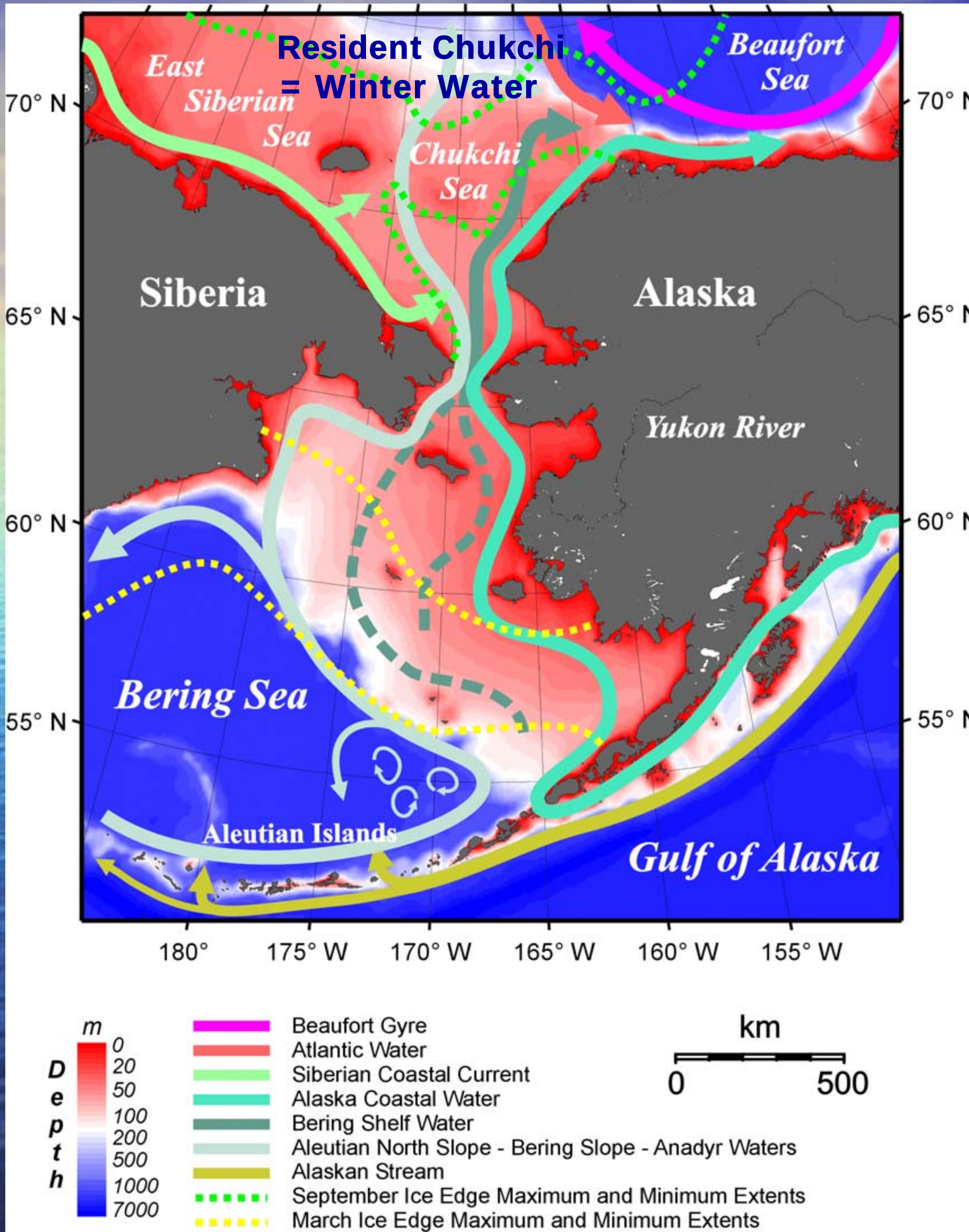
Station Clusters for Ichthyoplankton Species Abundance
0
250
500
km
Wrangell Is
Russia
Alaska
Cape Navarin
Nome
70°N
68°N
66°N
64°N
74°N
72°N
70°N
68°N
66°N
Cluster ID
1
2
3

Station clusters: Surface 20 m: temperature and salinity



Station clusters: Ichthyoplankton Species Abundance





<u>Southern</u> Chukchi Sea water transported from Bering Sea

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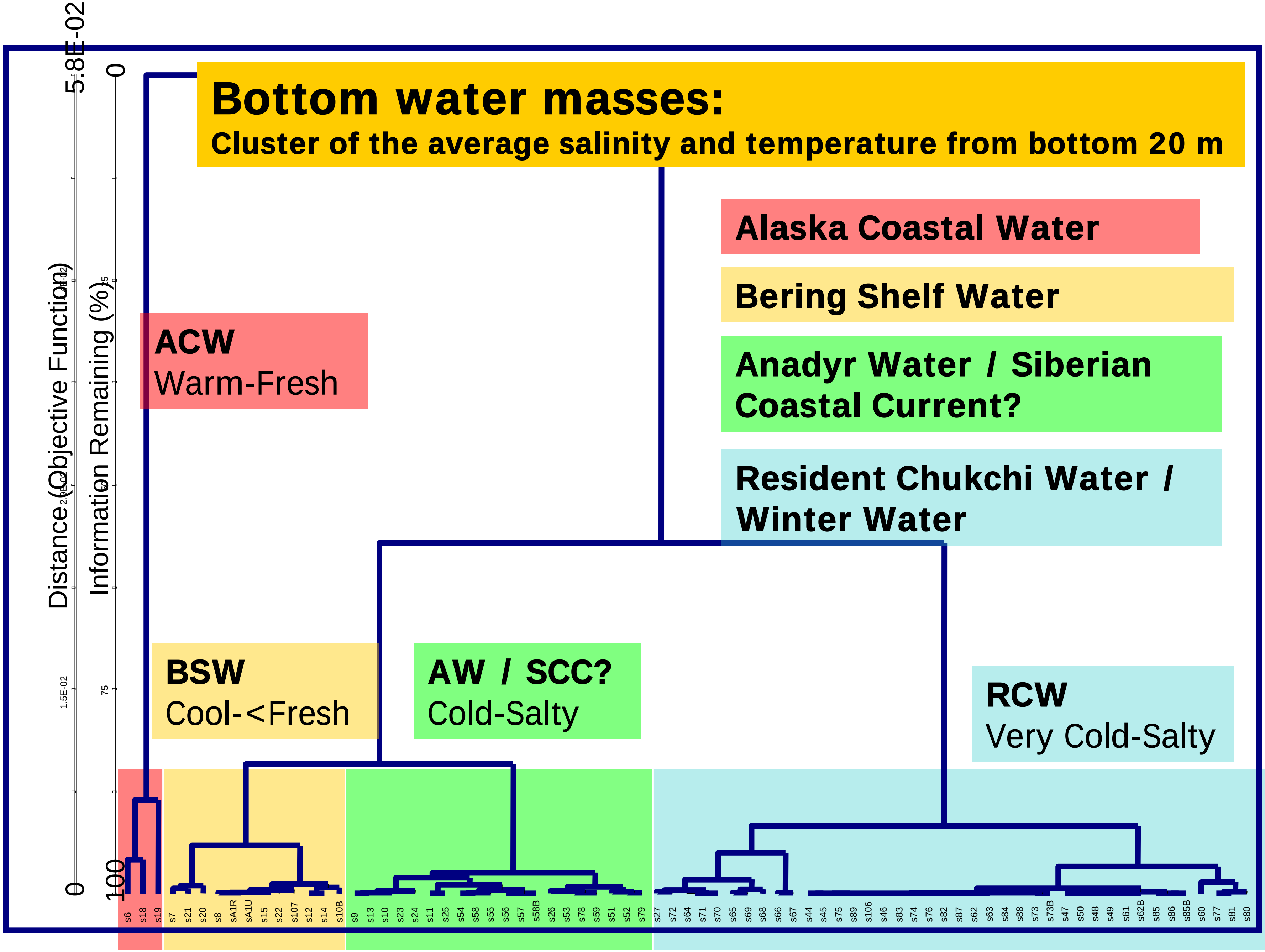
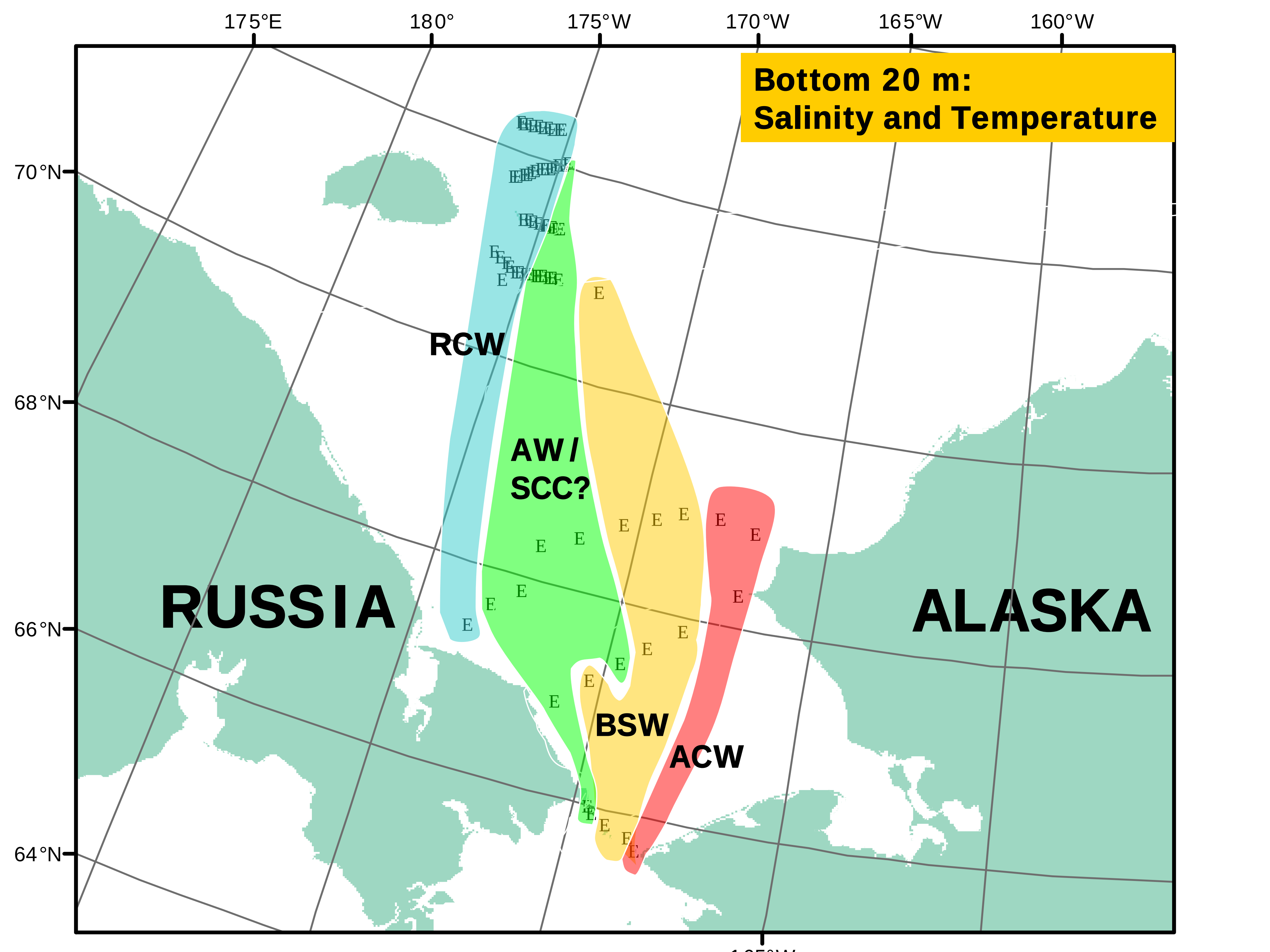


Bottom water masses:
Cluster of the average salinity and temperature from bottom 20 m
Alaska Coastal Water
Bering Shelf Water
Anadyr Water / Siberian Coastal Current?
Resident Chukchi Water / Winter Water
ACW
Warm-Fresh
BSW
Cool-<Fresh
AW / SCC?
Cold-Salty
RCW
Very Cold-Salty
Distance (Objective Function)
Information Remaining (%)
5.8E-02
1.5E-02
0
100
75
0
s6 s18 s19 s7 s21 s20 s8 sA1R sA1U s15 s22 s107 s12 s14 s10B s9 s13 s10 s23 s24 s11 s25 s54 s58 s55 s56 s57 s58B s26 s53 s78 s59 s51 s52 s79 s27 s72 s64 s71 s70 s65 s69 s68 s66 s67 s44 s45 s75 s89 s106 s46 s83 s74 s76 s82 s87 s62 s63 s84 s88 s73 s73B s47 s50 s48 s49 s61 s62B s85 s86 s85B s60 s77 s81 s80



Bottom 20 m:
Salinity and Temperature
175°E
180°
175°W
170°W
165°W
160°W
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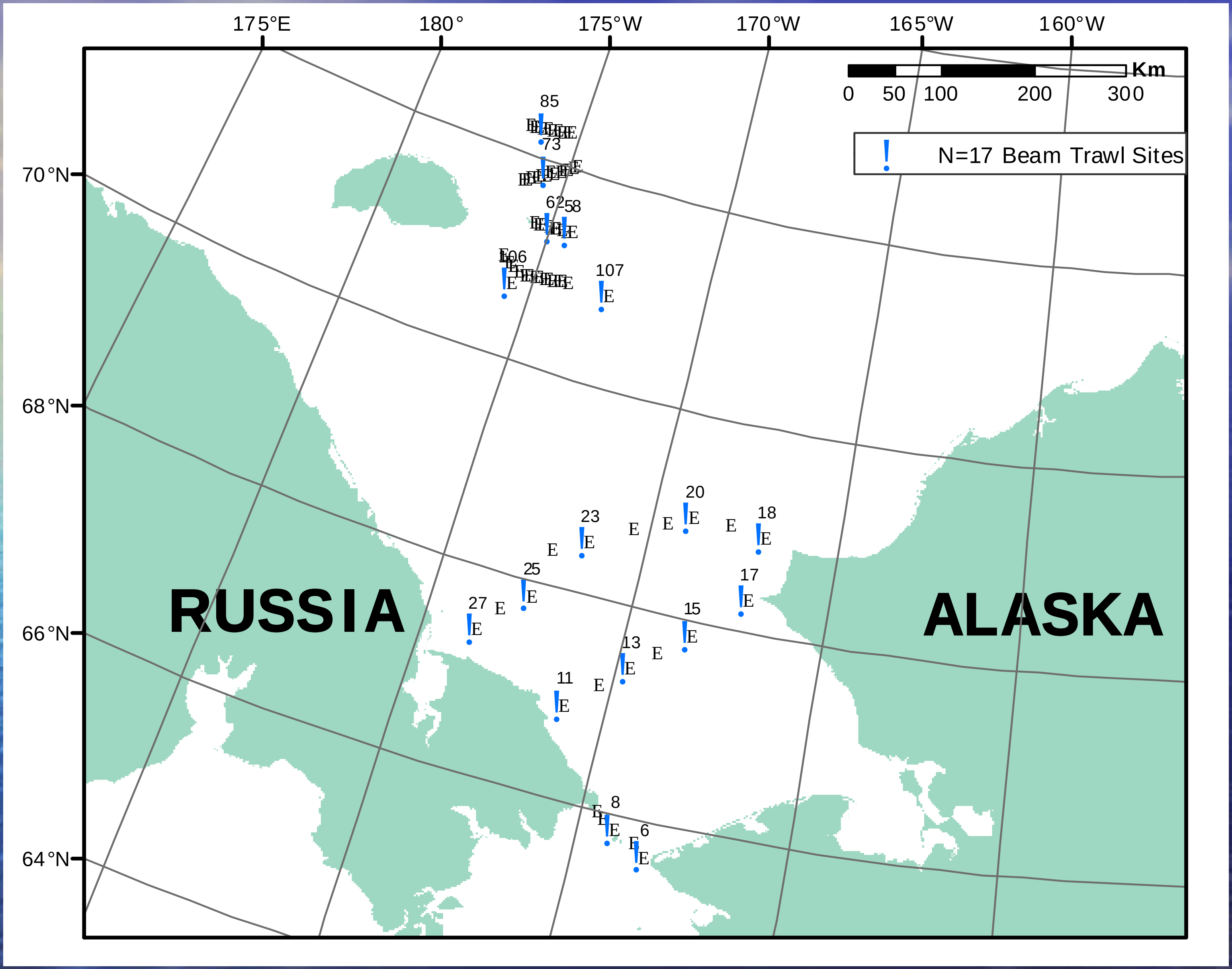
68°N
66°N
64°N
RCW
AW /
SCC?
BSW
ACW
RUSSIA
ALASKA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Km
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N=17 Beam Trawl Sites
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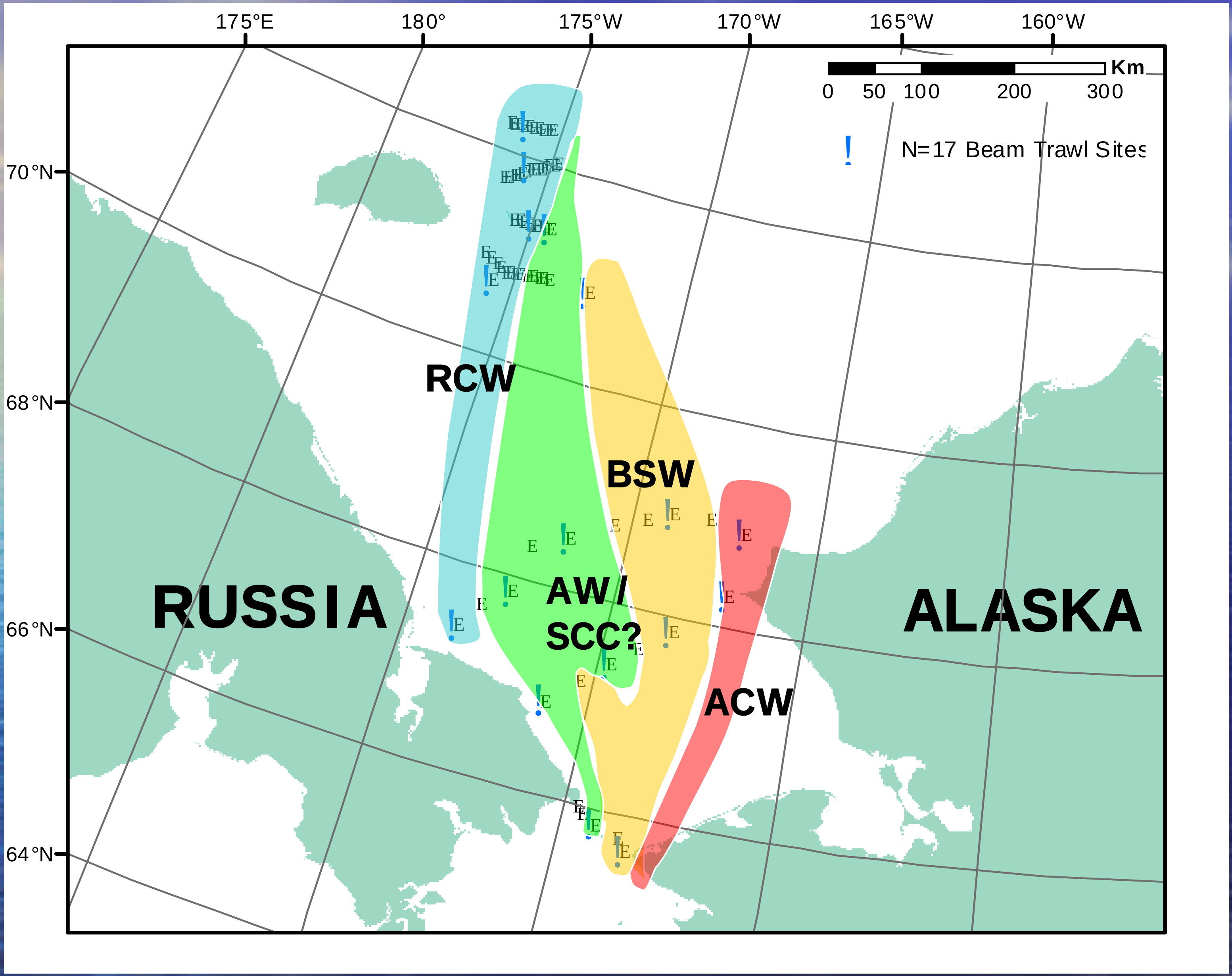
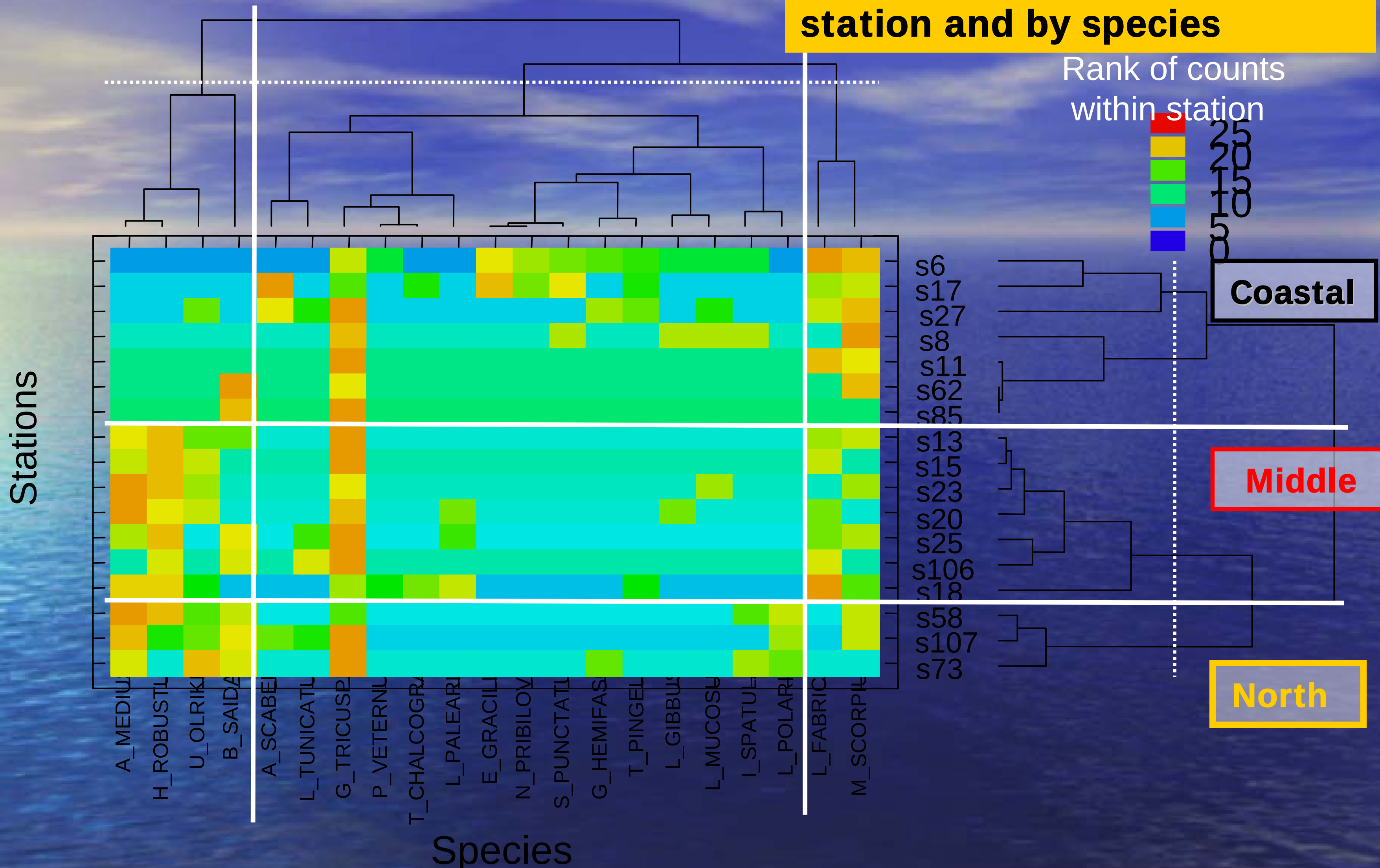
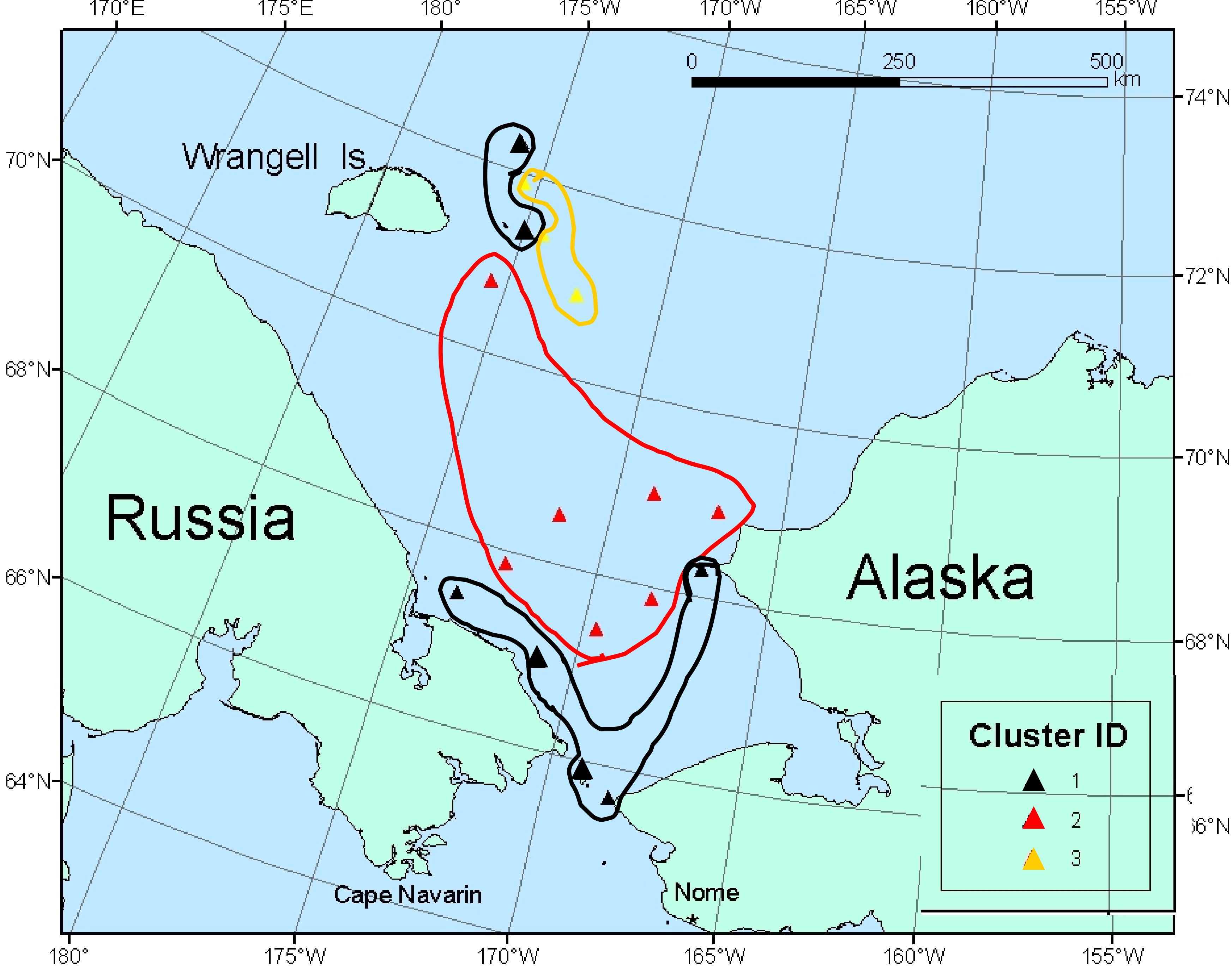
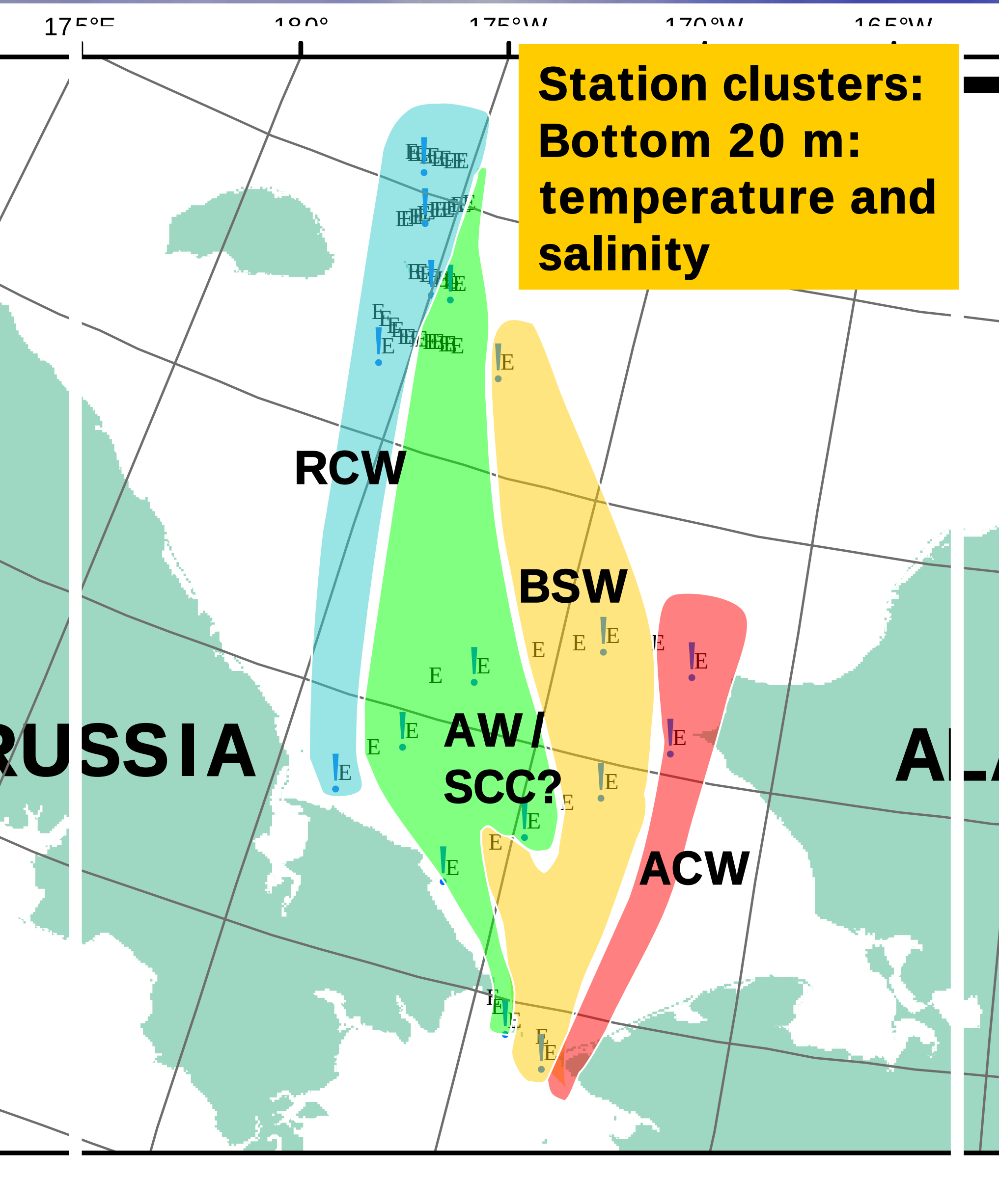


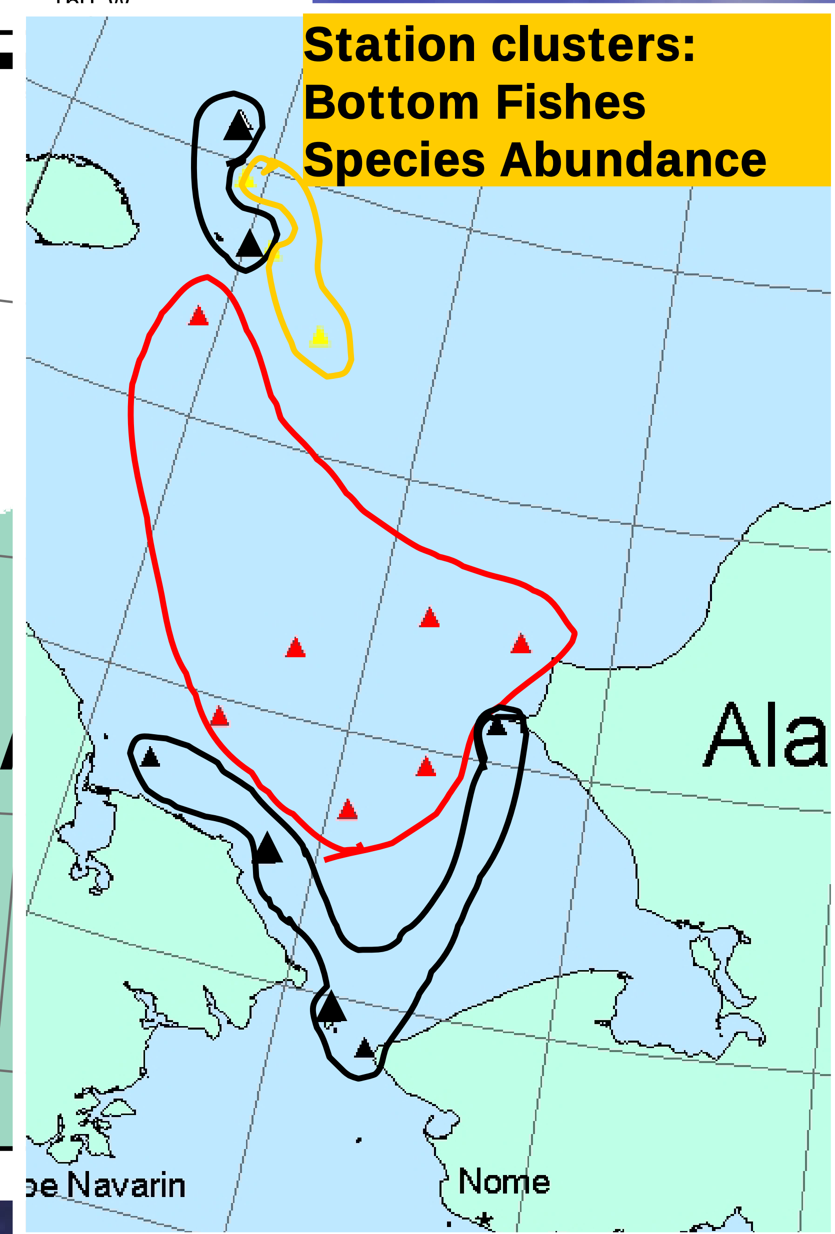
175°E
180°
175°W
170°W
165°W
160°W
70°N
68°N
66°N
64°N
Km
0 50 100 200 300
N=17 Beam Trawl Sites
RCW
BSW
AW/
SCC?
ACW
RUSSIA
ALASKA

Bottom fishes clustered by station and by species




170°E
175°E
180°
175°W
170°W
165°W
160°W
155°W
0
250
500
km
74°N
72°N
70°N
68°N
66°N
64°N
Wrangell Is
Russia
Alaska
Cape Navarin
Nome
Cluster ID
1
2
3
180°
175°W
170°W
165°W
160°W
155°W
70°N
68°N
66°N
64°N


Station clusters:
Bottom 20 m:
temperature and
salinity
180°
175°W
170°W
165°W
RCW
BSW
AW /
SCC?
ACW


Station clusters:
Bottom Fishes
Species Abundance
Nome

13 species of fishes in ichthyoplankton and on the bottom

			Ichthyoplankton			Beam Trawl
Family	Scientific Name	Common Name	Eggs	Larvae	Juv.	Juv/Adult
Cods	*Boreogadus saida*	Arctic cod		X	X	X
	Eleginus gracilis	Saffron cod			X	X
	Theragra chalcogramma	Walleye pollock		X		X
Sculpins	*Gymnocanthus tricuspis*	Arctic staghorn sculpin		X	X	X
Poachers	*Ulcinia olriki*	Arctic alligatorfish		X		X
Snailfishes	*Liparis* spp.	Unidentified snailfishes		X		X
	Liparis fabricii	Gelatinous seasnail		X		X
	Liparis gibbus	Variegated snailfish		X		X
	Liparis tunicatus	Kelp snailfish		X		X
Pricklebacks	*Lumpenus fabricii*	Slender eelblenny		X		X
	Stichaeus punctatus	Arctic shanny		X		X
Flatfishes	*Hippoglossoides robustus*	Bering flounder	X	X		X
	Limanda aspera	Yellowfin sole		X		X

6 taxa of fish larvae not captured by beam trawl

Common Family	Scientific Name	Common Name
Smelts	Osmeridae	Unidentified smelts
Poachers	*Aspidophoroides monopterygius*	Alligatorfish
Pricklebacks	*Leptoclinus maculatus*	Daubed shanny
Sand lances	*Ammodytes hexapterus*	Pacific sandlance
Flatfishes	*Hippoglossus stenolepis*	Pacific halibut
	Pleuronectes glacialis	Arctic flounder

19 taxa caught by bottom trawl but not by Bongo plankton net

Sculpins (n=7

Artediellus scaber
Myoxocephalus scorpius
Enophrys diceraus
Nautichthys pribilovius
Icelus spatula
Triglops pingelii
Myoxocephalus polyacanthocephalus

Eelpouts (n=7)

Gymnelus bilabrus
Lycodes palearis
Gymnelus hemifasciatus
Lycodes polaris
Gymnelus viridis
Lycodes raridens
Lycodes mucosus

Poachers (n=2)

Pallasina barbata
Podothecus veternus

Pricklebacks (n=1) *Anisarchus medius*
Greenlings (n=1) *Hexagrammos stelleri*
Gunnels (n=1) *Pholis fasciata*

Abundant ichthyoplankton species – 3 species constitute 43% of the ichthyoplankton catch. Each other taxon composes ≤5% of the total ichthyoplankton catch

Limanda aspera Yellowfin sole	8.8%
Hippoglossoides robustus Bering flounder	10.8%
Boreogadus saida Arctic cod	23.0%

Juvenile/Adult groundfishes caught by beam trawl – 9 species constitute 91% of the catch by number

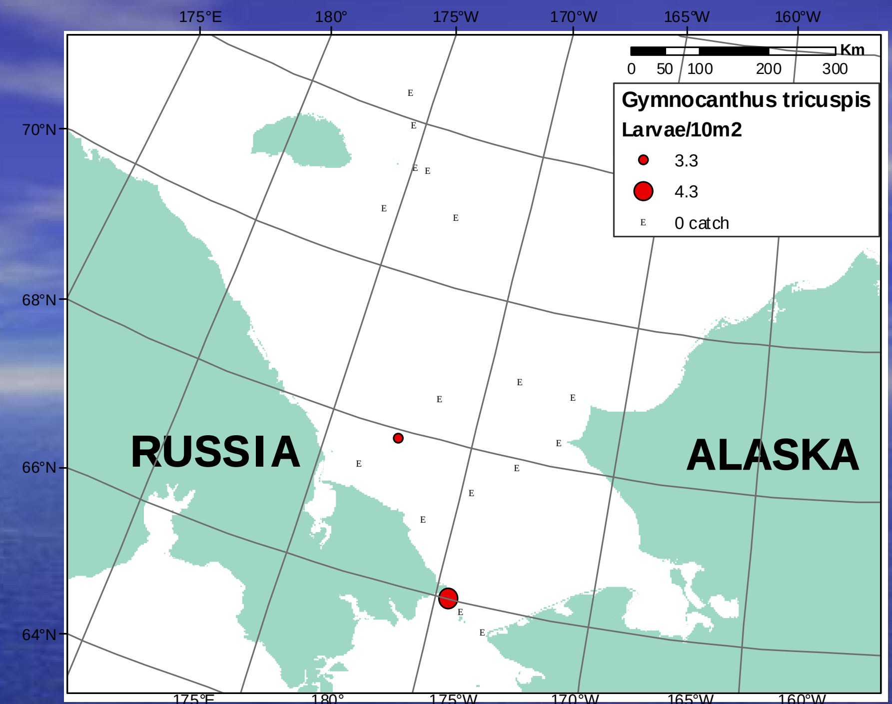
Boreogadus saida	Arctic cod	2.9%
Stichaeus punctatus	Arctic shanny	4.8%
Eleginus gracilis	Saffron cod	5.3%
Hippoglossoides robustus	Bering flounder	5.6%
Lumpenus fabricii	Slender eelblenny	6.7%
Anisarchus medius	Stout eelblenny	7.8%
Artediellus scaber	Hamecon	9.6%
Myoxocephalus scorpius	Shorthorn sculpin	14.5%
Gymnocanthus tricuspis	Arctic staghorn sculpin	33.8%

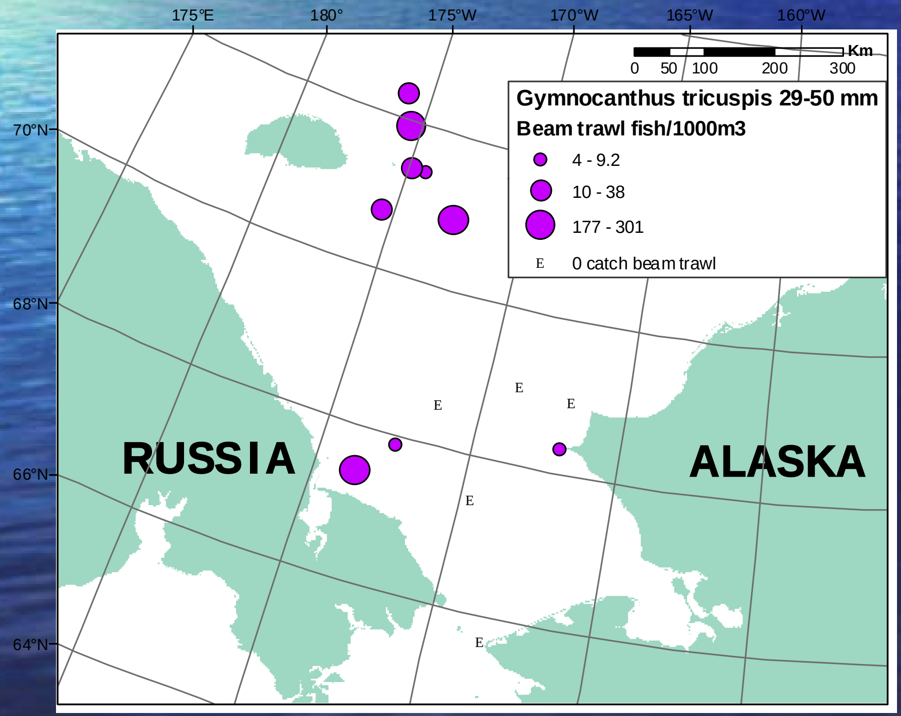
Gymnocanthus tricuspis

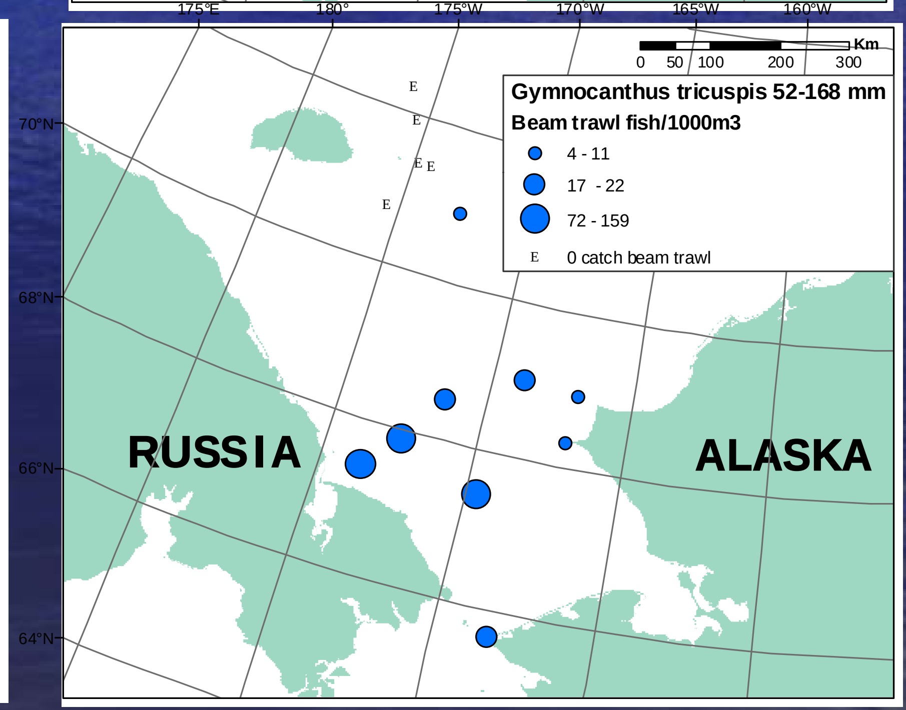
Arctic staghorn sculpin

(Most abundant – Mecklenburg et al.)

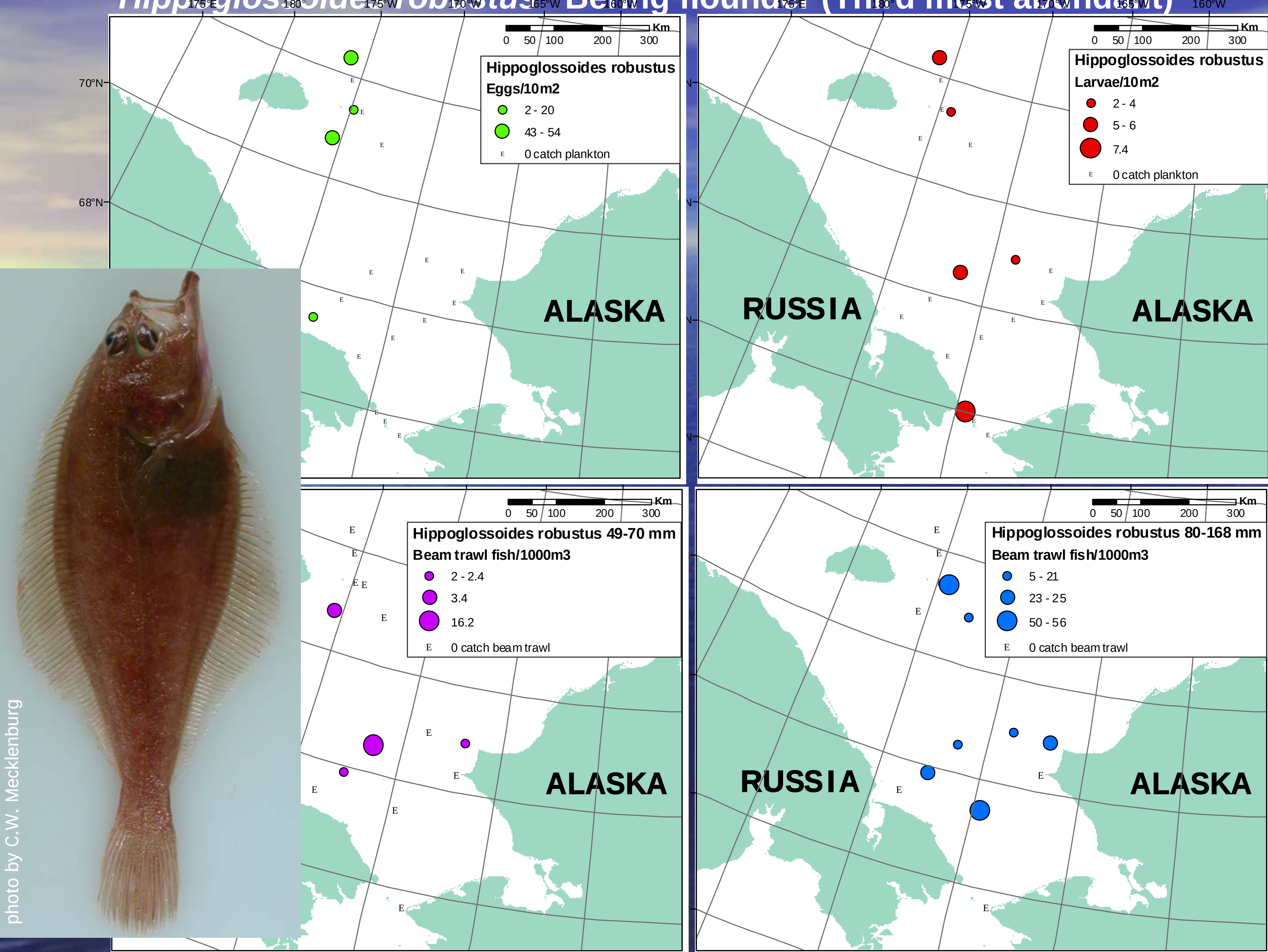
photo by Catherine Mecklenburg







Hippoglossoides robustus Bering flounder (Third most abundant)

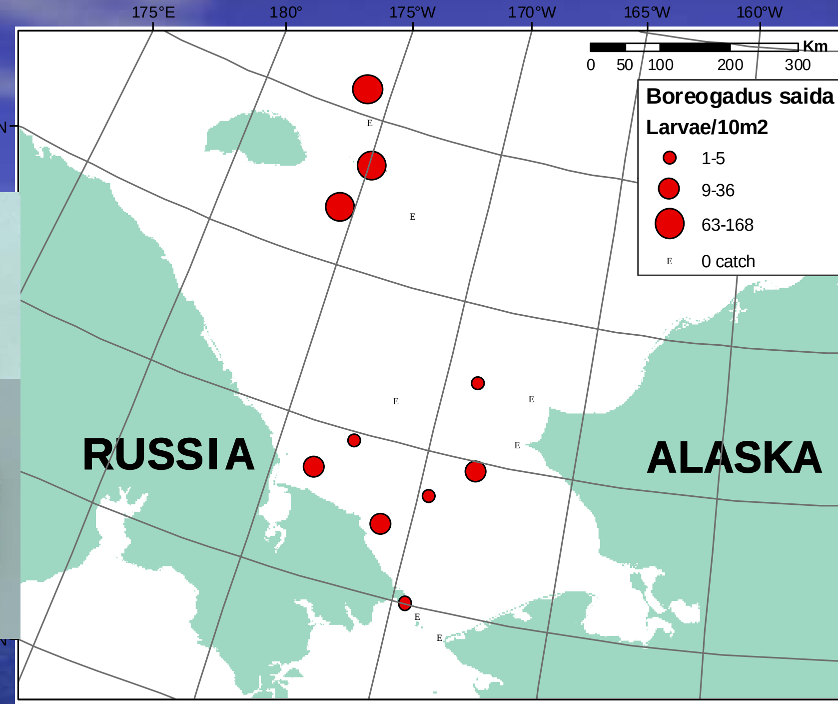


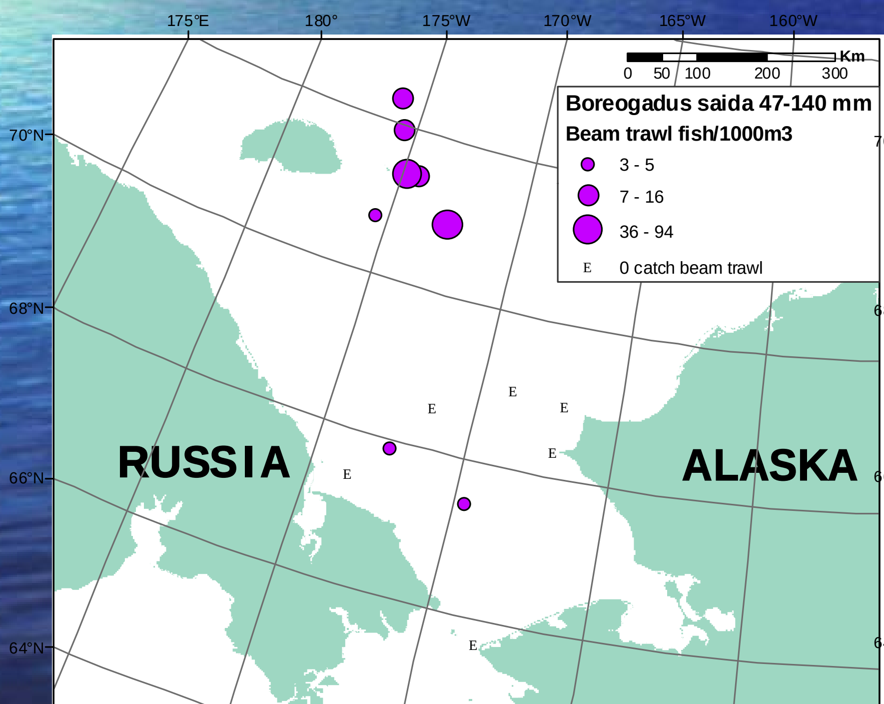
Boreogadus saida

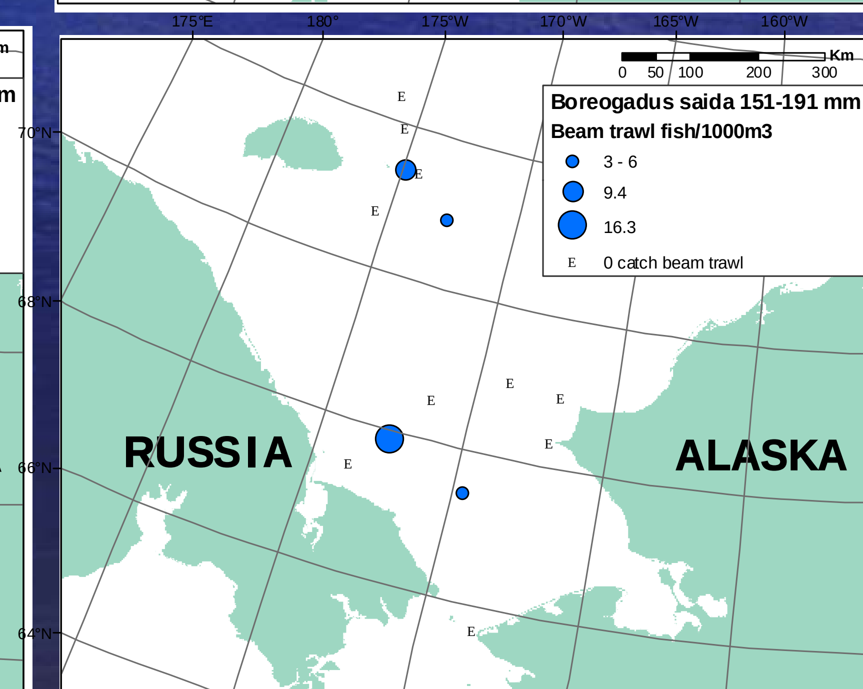
Arctic cod

(Fourth most abundant)

photos by Catherine Mecklenburg

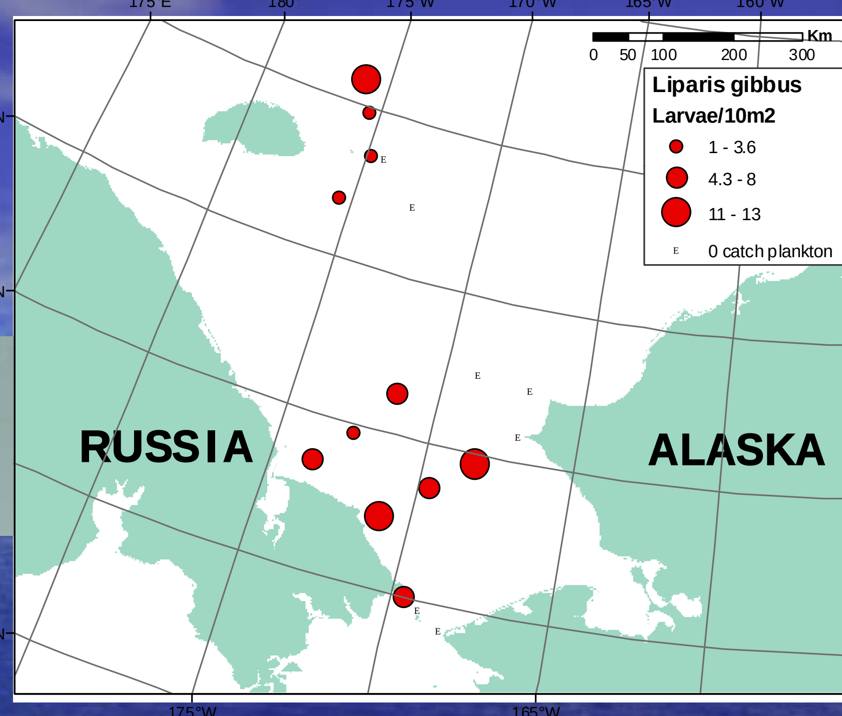


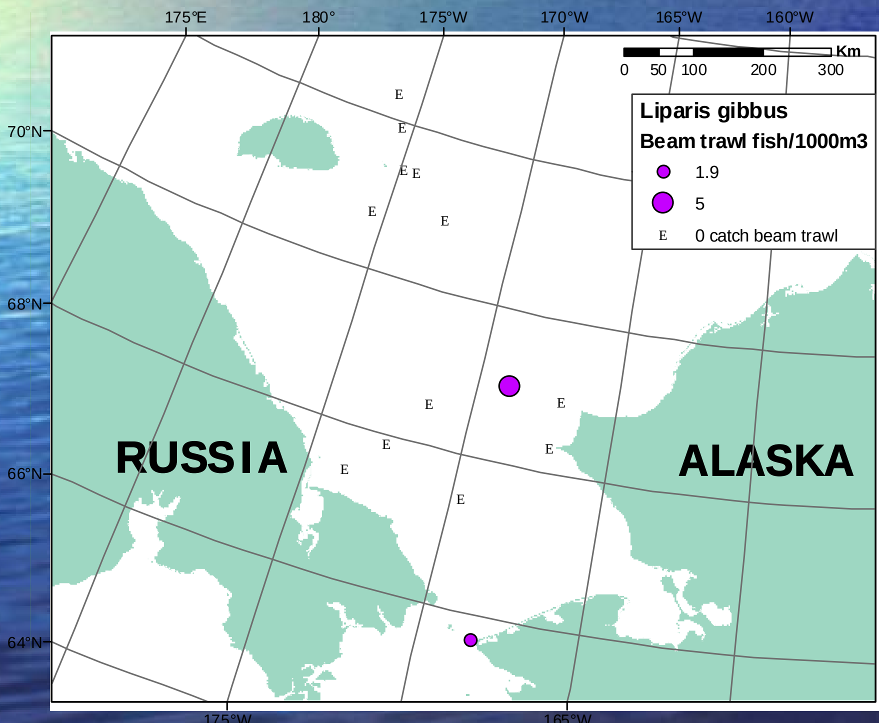




Liparis gibbus

Variegated snailfish



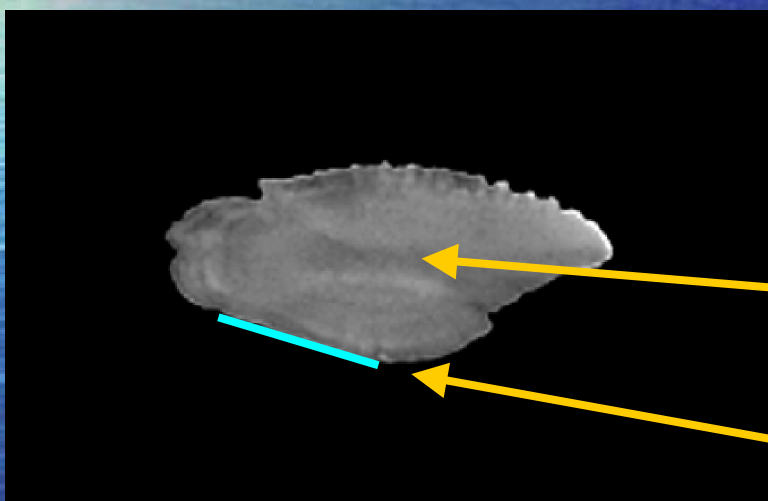


photos by C.W. Mecklenburg

Trace elements analysis - otoliths

Right sagittal otolith of an adult starry rockfish (*Sebastes constellatus*)

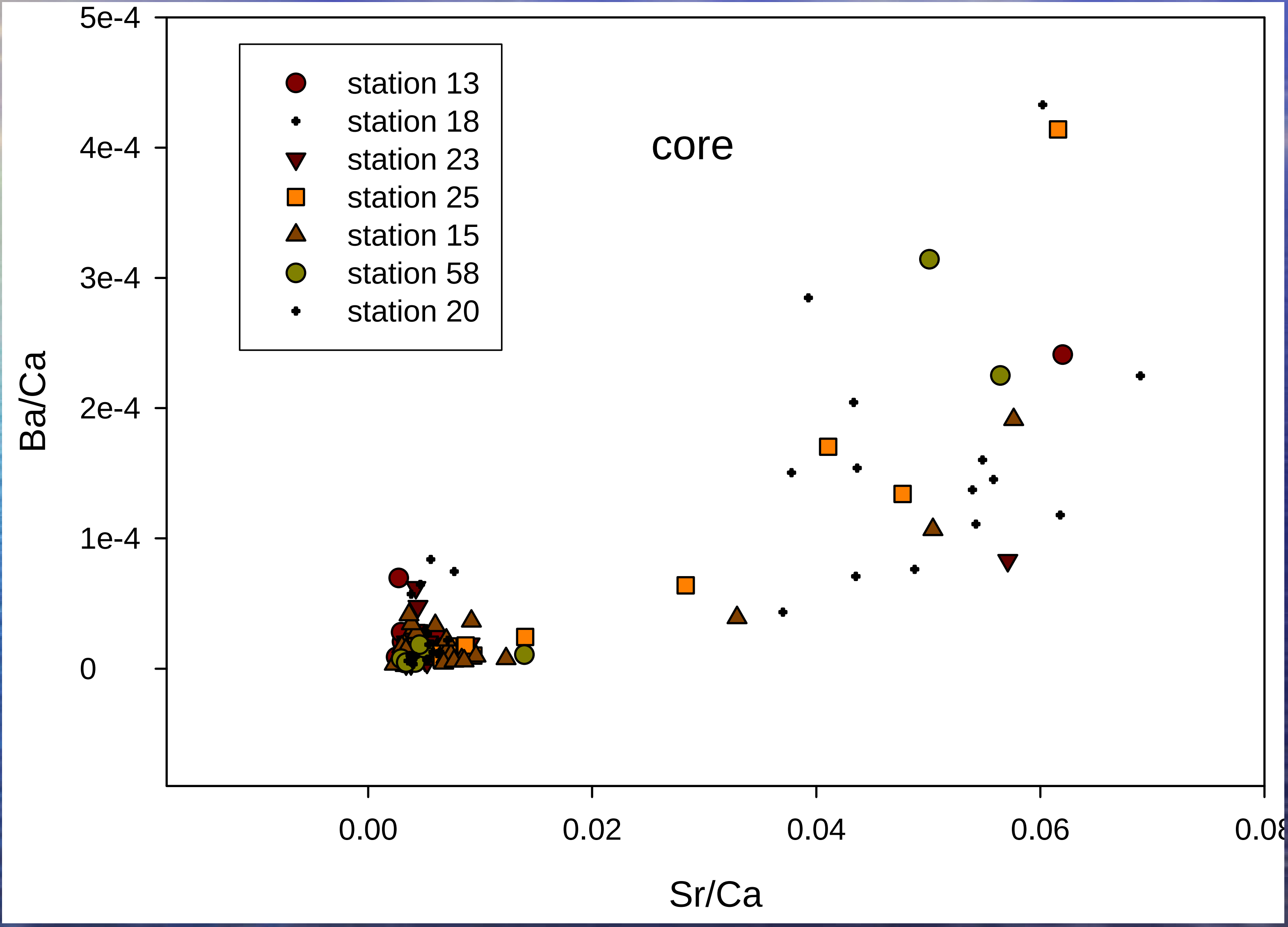
Trace elements analysis of otoliths can detect differences between locations as little as 10 km apart



Core: ~ hatch date

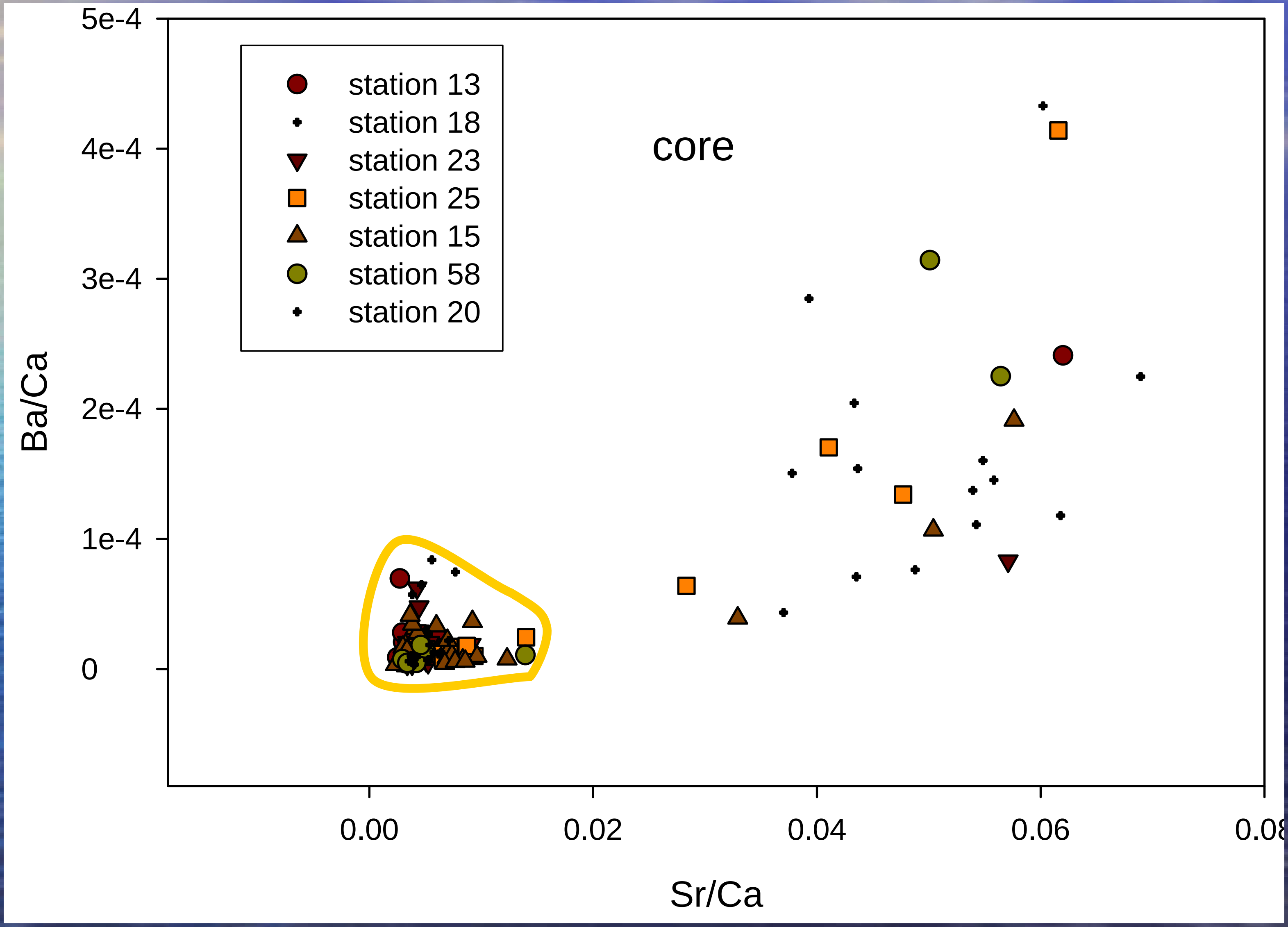
Edge: last 2 weeks before capture

Bering flounder – trace elements of otolith core

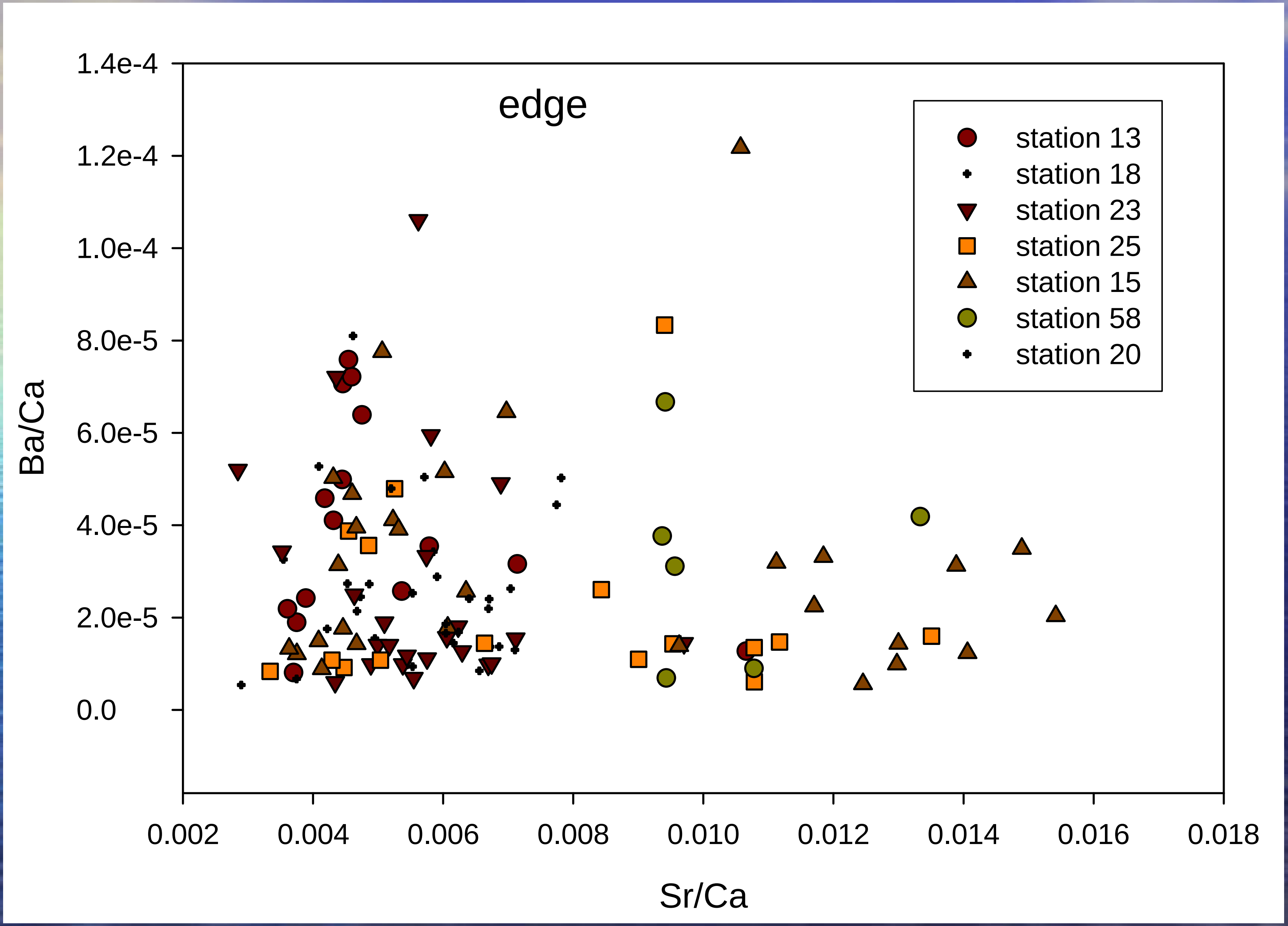


Bering flounder – trace elements of otolith core

N=148 cores across several sites; 80% of these fish appear to originate from the same spawning stock



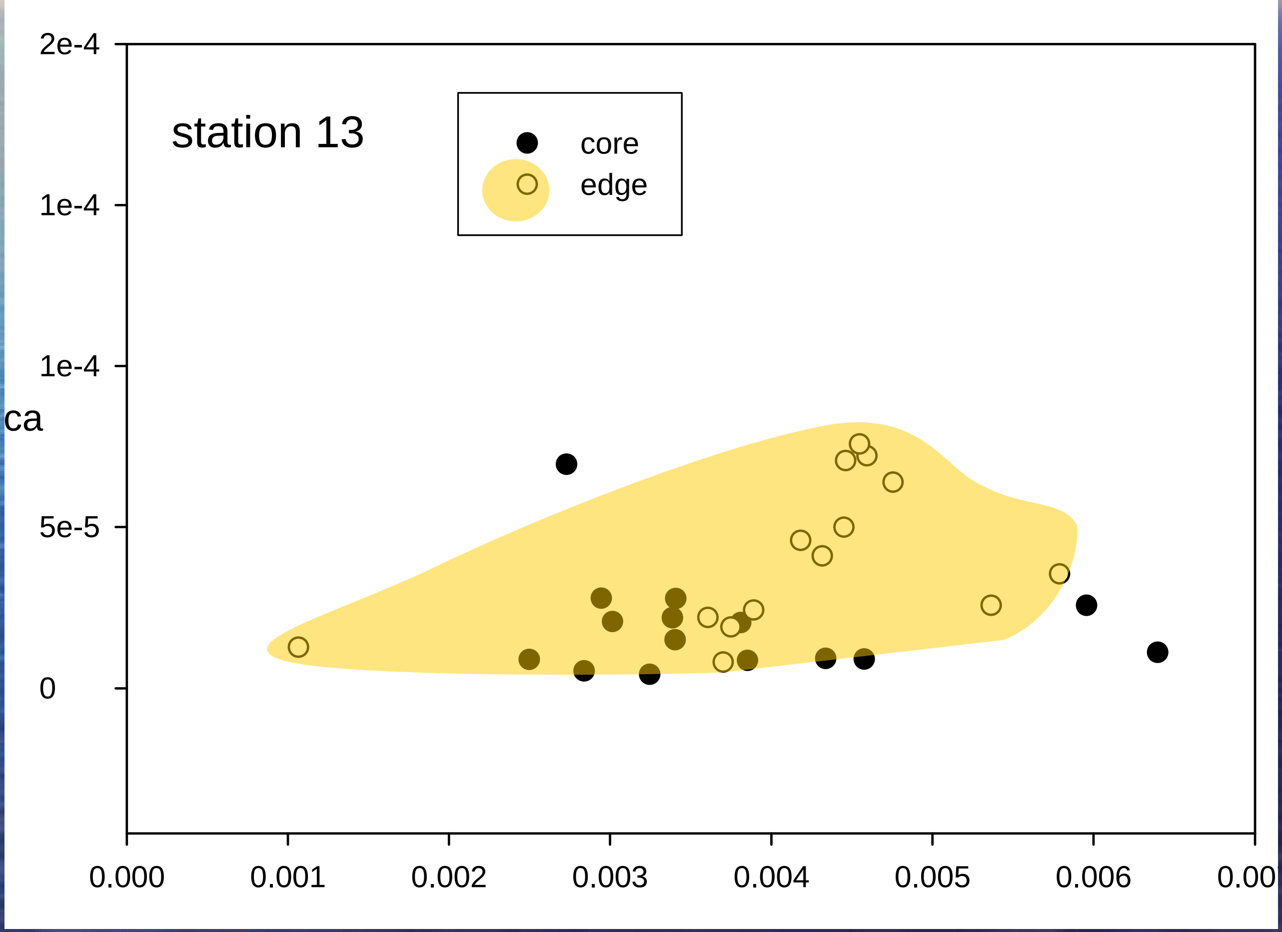
Bering flounder – trace elements of otolith edge



Bering flounder – trace elements of otolith

Stn 13: similar values for core and edge; these fish are located very near where they hatched

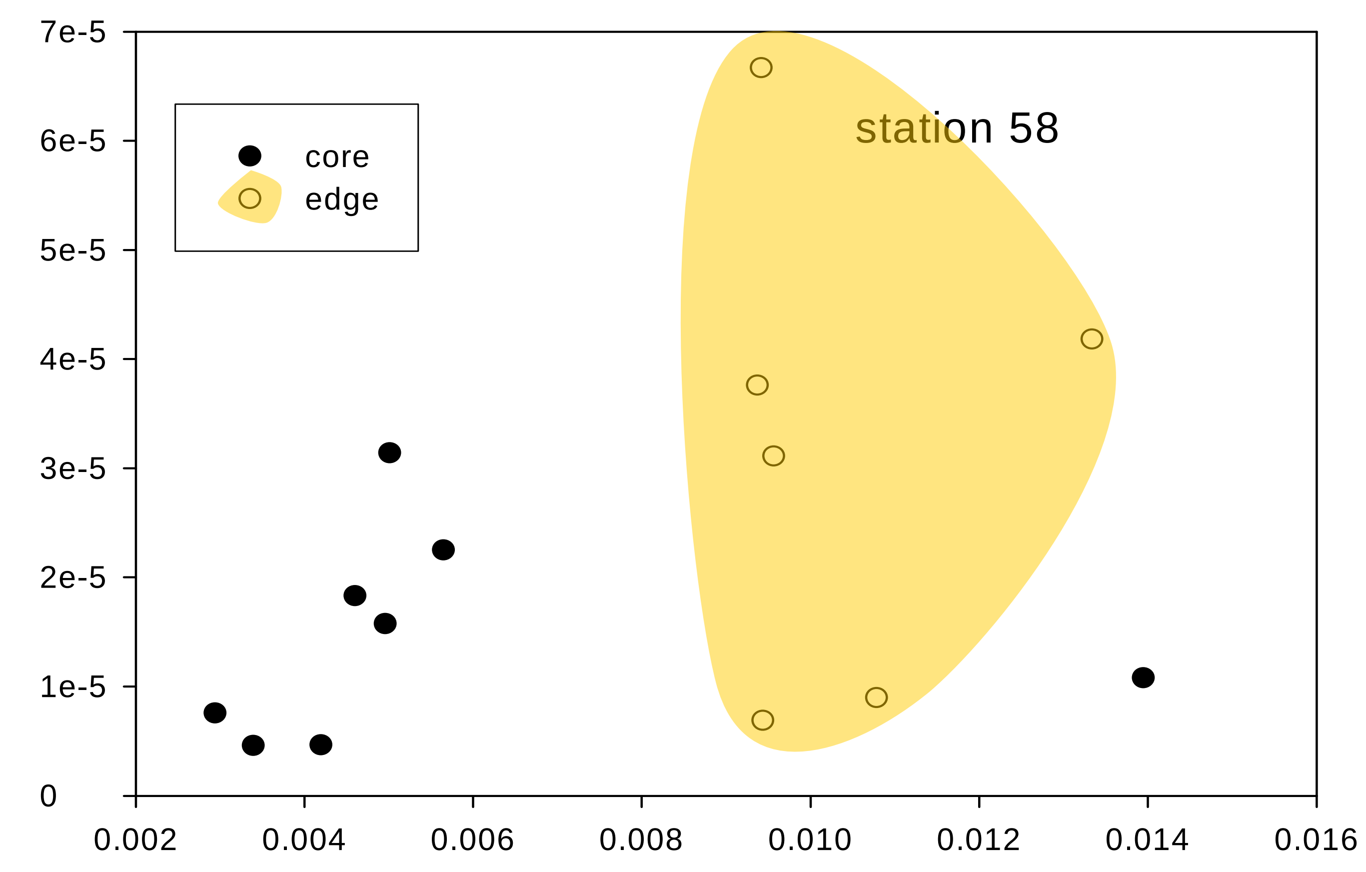
N=16 fish (80-120 mm)



Bering flounder – trace elements of otolith

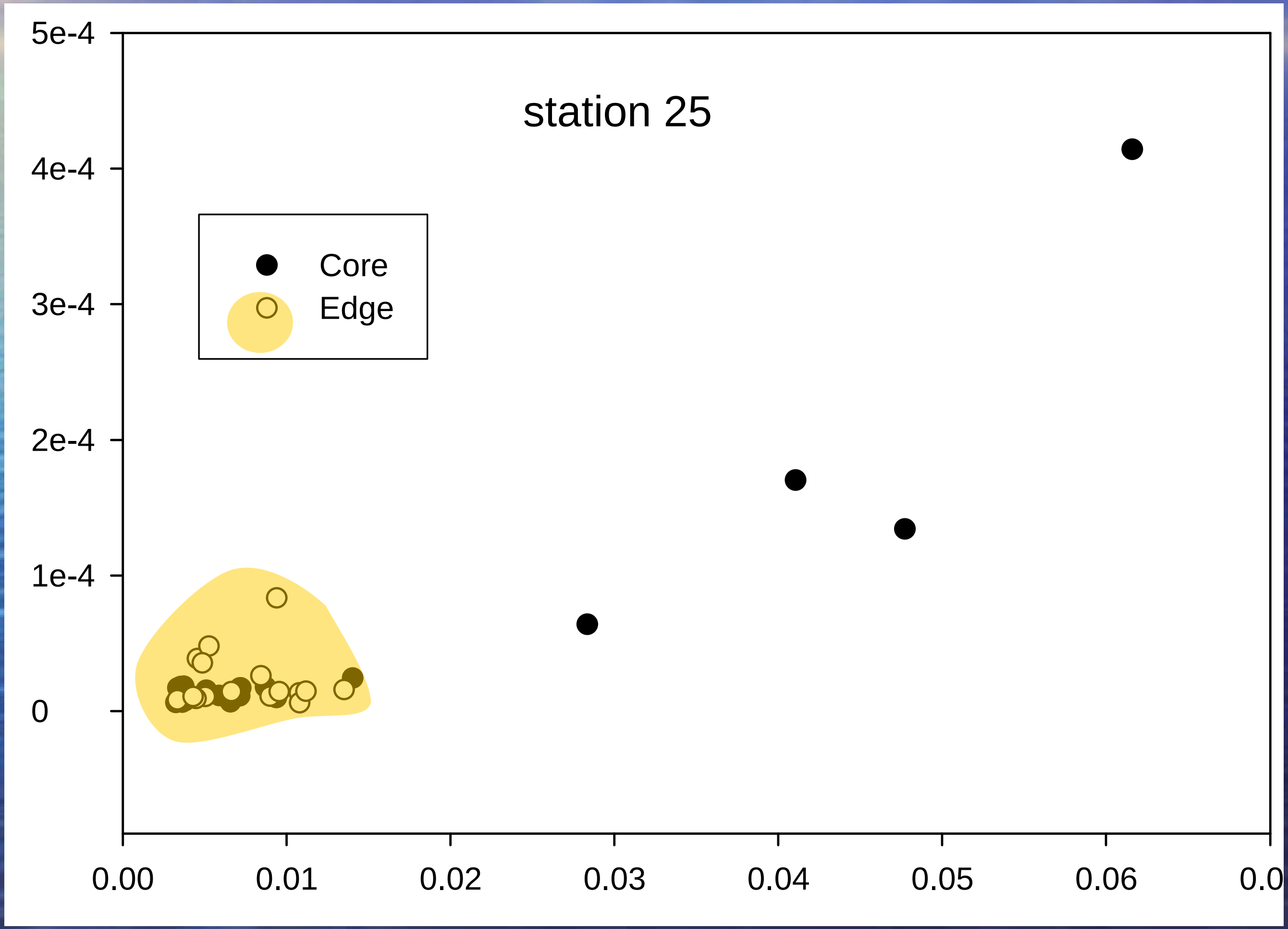
Stn 58: different values for core and edge; these fish have migrated from where they hatched

N=8 core samples, 6 edge samples (73-230 mm)



Bering flounder – trace elements of otolith

Stn 25: n=16 fish with similar core and edge (40-260 mm)
n=4 fish hatched a distance away from capture site (94-116 mm)



Remaining Objectives for Fish

- Statistically quantify the physical characteristics that define ichthyoplankton and juvenile groundfish communities and habitat
- Compare ichthyoplankton, juvenile fish and adult fish distributions and communities among oceanographic domains
- Complete otolith analysis and incorporate

Remaining Interdisciplinary Objectives

- Integrate findings from this study with those of physical oceanographers
- Community analysis – bottom fishes and epibenthic invertebrates
- Community analysis – ichthyoplankton and zooplankton

Detecting climate variability and change

- Quantifying changes in the Arctic is difficult without baseline data
  - (1) there is no single clear cause of ecosystem change
  - (2) the effects will not be abrupt
  - (3) the area over which change occurs is massive
- Documenting present conditions in Chukchi Sea from physical through higher trophic levels is essential

Photo by Terry Whitledge

Photo by Bodil Bluhm