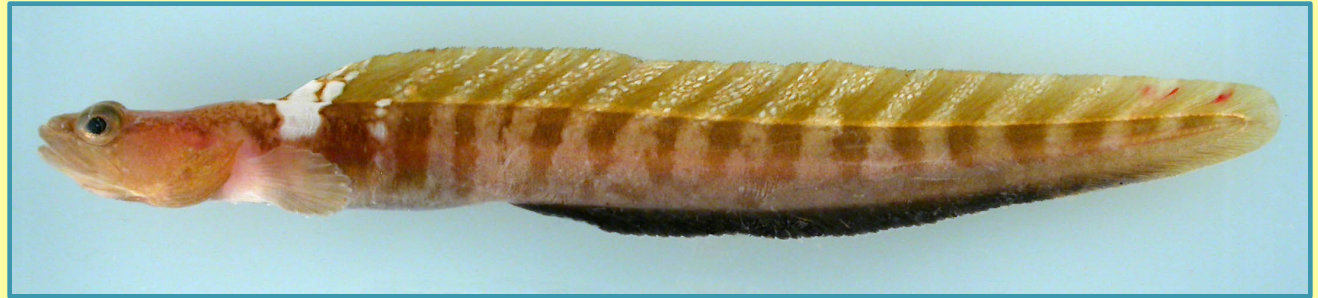
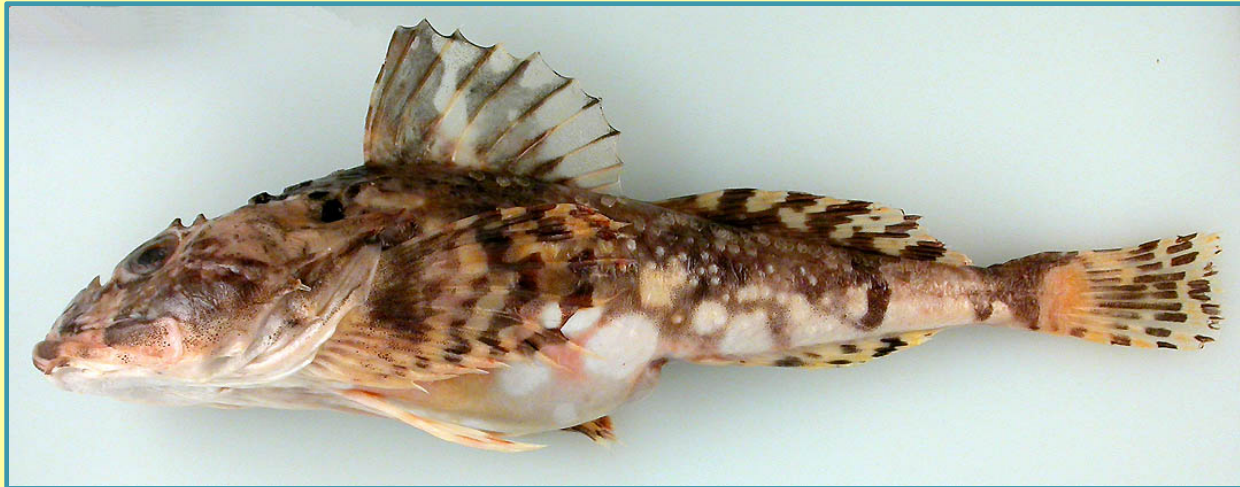


RUSALCA 2009

**Postcruise
Workshop**



Taxonomy and Zoogeography of Arctic Marine Fishes and Detection of Change



Montenegro, 10 October 2010

**Presentation by
Kitty and Tony Mecklenburg**

Minor revisions, 17 Feb 2011

Nota Bene:

This presentation is a descendant of previous works and collaborations, as well as containing much new data which could not have been collected without help and cooperation, and we are grateful to all who contributed. Please see the full Acknowledgments in:

Mecklenburg CW, Stein DL, Sheiko BA, Chernova NV, Mecklenburg TA, Holladay BA (2007) Russian–American Long-term Census of the Arctic: benthic fishes trawled in the Chukchi Sea and Bering Strait, August 2004. *Northwestern Naturalist* 88:168–187

Mecklenburg CW, Møller PR, Steinke D (2010) Biodiversity of arctic marine fishes: taxonomy and zoogeography. *Marine Biodiversity* DOI 10.1007/s12526-010-0070-z

The latter paper was in press at the time of the Montenegro workshop. Published online on 1 December 2010, publication in print form should not be far behind. Many of the slides in this workshop presentation illustrate results or discussions in the paper.

Photographs used in this presentation are by CW Mecklenburg unless otherwise credited, and maps by TA Mecklenburg.

RUSALCA 2009 Fish Taxonomy & Zoogeography Studies

USA:

Catherine W. Mecklenburg

Research Associate, California Academy of Sciences;
Point Stephens Research, Auke Bay, Alaska

T. Anthony Mecklenburg

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Russia:

Natalia V. Chernova

Zoological Institute, Russian Academy of Sciences,
St. Petersburg

Outline of Presentation:

- 1) Fishes caught by RUSALCA 2009 bottom trawls
- 2) Arctic Marine Fish Museum Specimens evaluation & database
- 3) DNA sequencing (“barcoding”) of Arctic fishes
- 4) Taxonomic solutions, distribution patterns, & change
- 5) Fishes caught by RUSALCA in the Chukchi Borderland, 2009

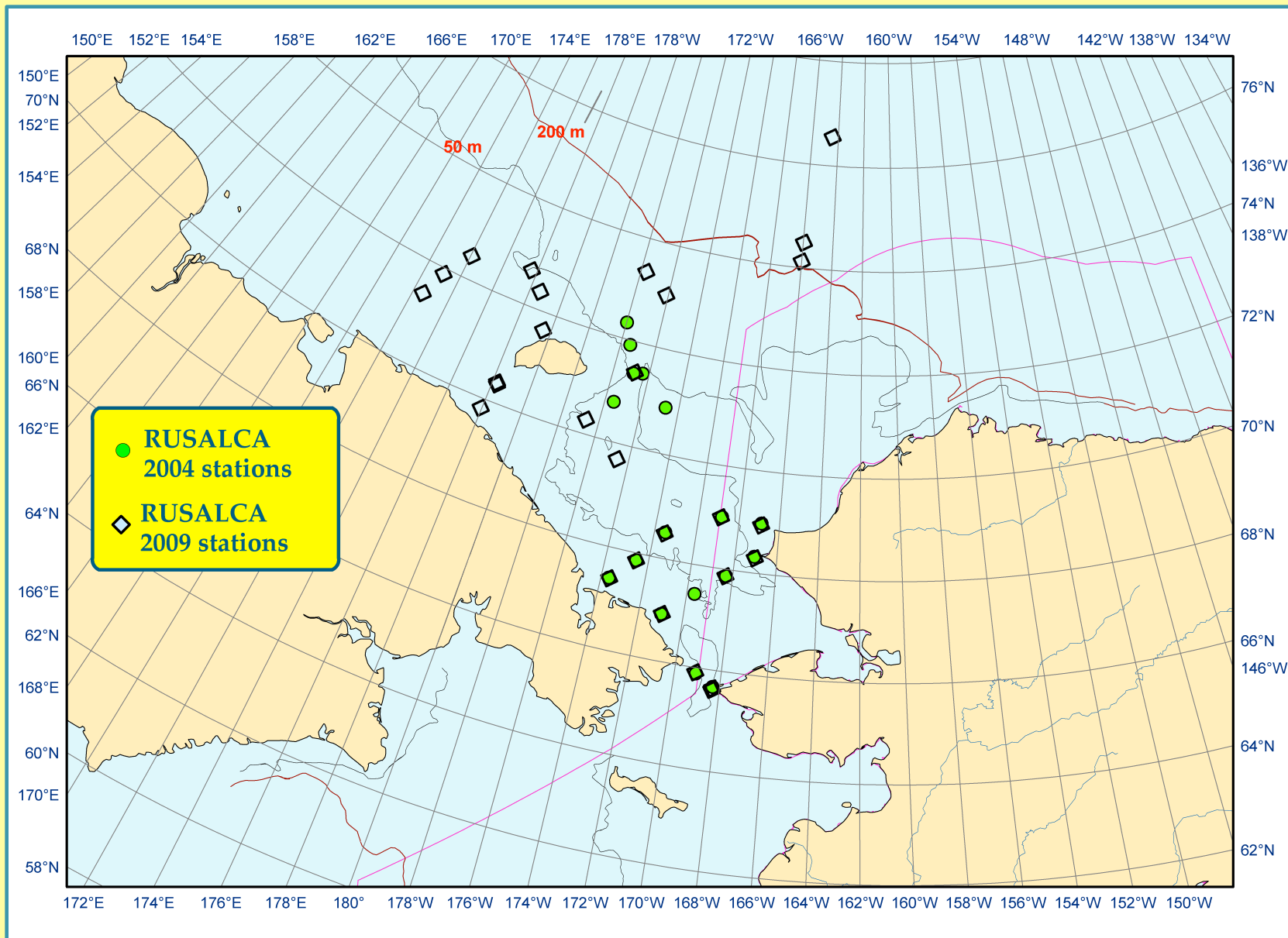
RUSALCA

2009:

Bottom Trawling

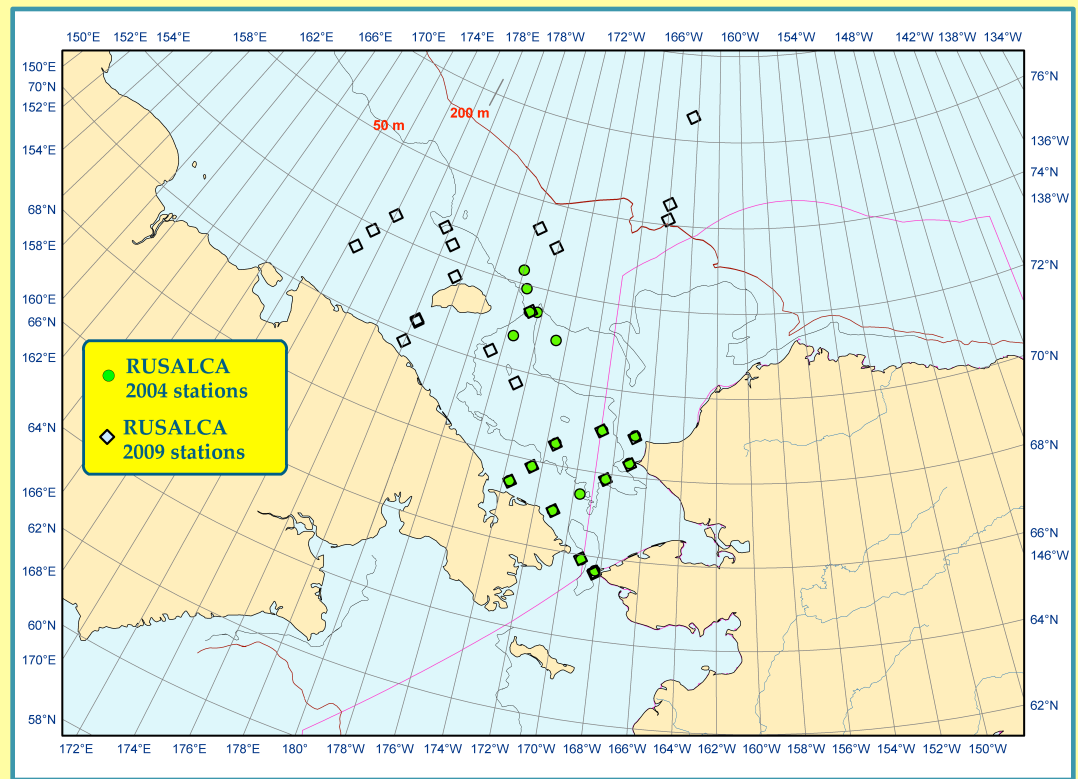
Cruise objectives:

- 1) Trawl for bottom fishes at the same stations sampled in 2004, as well as additional stations if conditions permitted.
- 2) Document the catch by preserving examples of each species caught and archiving them in museums' permanent fish collections.
- 3) Obtain tissue samples for DNA sequencing.
- 4) Collect specimens for taxonomic research.
- 5) Photograph live and fresh specimens.



Otter trawl stations, RUSALCA 2004 and 2009

RUSALCA 2009: Otter Trawl



26 stations, including most of the same stations as in 2004, plus 8 new sites in the East Siberian Sea, 2 on the outer continental shelf, and 3 on the upper slope and Chukchi Cap.

Caught 46 species vs. 34 in 2004.

11,578 individual fishes, vs. 1,838 in 2004.

In 2009 the study area was larger, more stations were sampled, net was bigger and had a smaller mesh, and more habitats were sampled, including the continental slope.



Boreogadus saida
Arctic Cod



Gymnocanthus tricuspis
Arctic Staghorn Sculpin



Lumpenus fabricii
Slender Eelblenny



Myoxocephalus scorpius
Shorthorn Sculpin



Hippoglossoides robustus
Bering Flounder



Lycodes polaris
Polar Eelpout



Anisarchus medius
Stout Eelblenny

Most abundant species

C.W. Mecklenburg & T. A. Mecklenburg, October 2010, Taxonomy and zoogeography of arctic marine fishes and detection of change, RUSALCA 2009 Postcruise Workshop, Montenegro



Aspidophoroides monoptyerygius
Alligatorfish



Leptoclinus maculatus
Daubed Shanny



Himesogrammus praecisus
Hurline Snakeblenny



Blepsias bilobus
Sailfin Sculpin



Limanda sakhalinensis
Sakhalin Sole



Lycodes turneri
Estuarine Eelpout

New species for RUSALCA



Lycodes raridens
Marbled Eelpout

2 stations in Long Strait
(LS1, LS3)



Leptoclinus maculatus
Daubed Shanny

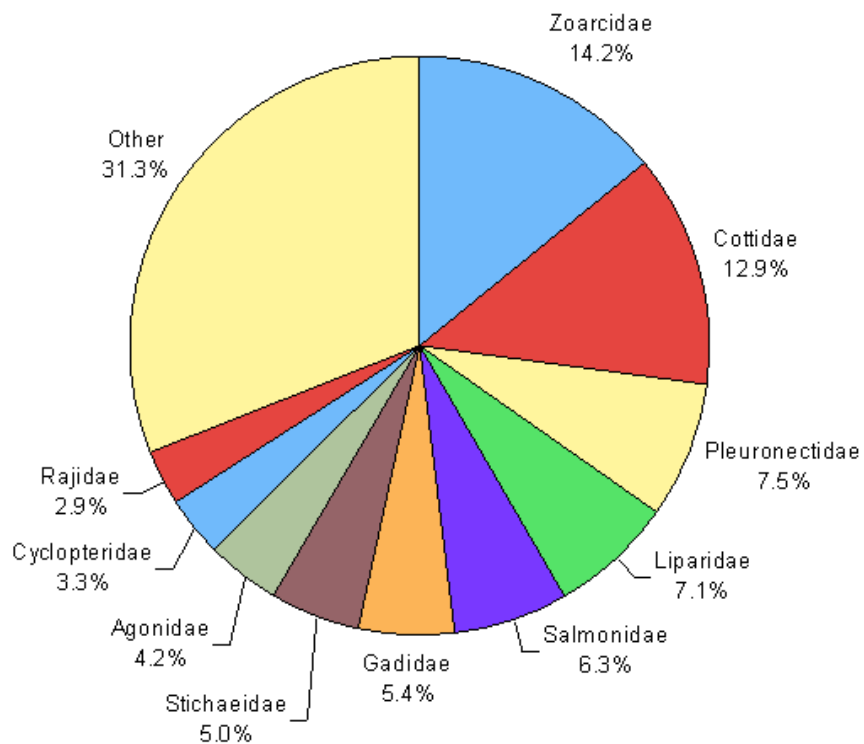
1 station NW of Wrangel Island and 1
in Long Strait (LS1)



Hippoglossoides robustus
Bering Flounder

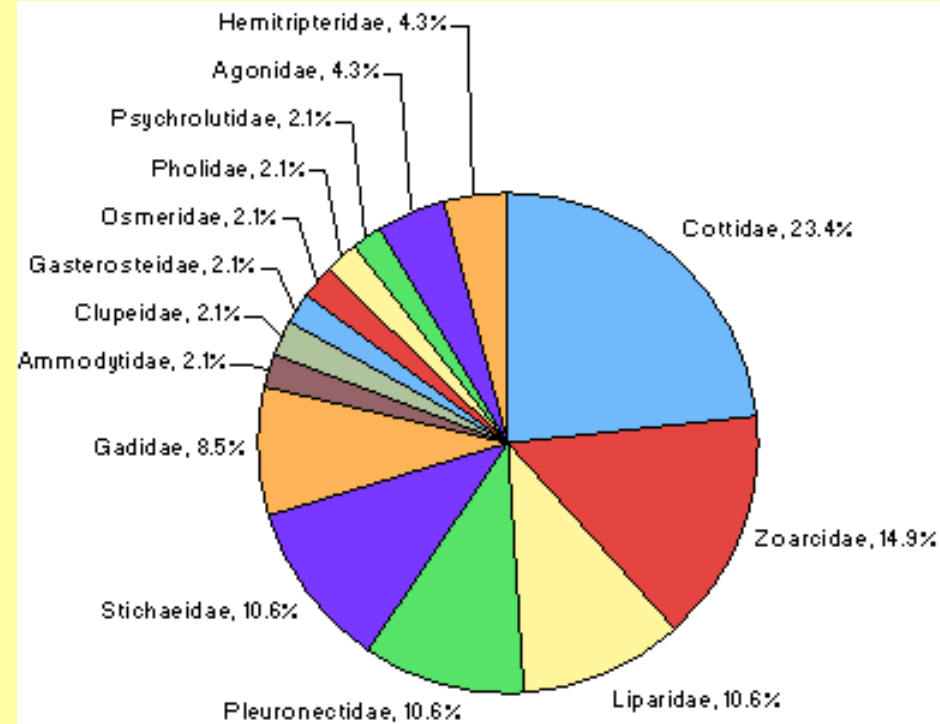
1 station in Long Strait (LS1) and 1 on
outer shelf W of Wrangel Island (SS5)

First records for East Siberian Sea



All arctic marine fish species

45 families, 242 species (all fishing gears, including surface trawls) (Mecklenburg et al. In press).



RUSALCA 2009 species

14 families, 49 species (otter & beam trawls)

RUSALCA

2009:

Documentation of Otter and Beam Trawl Catches

Voucher specimens and specimens for research were deposited in 3 museums:

108 = California Academy of Sciences (CAS)

103 = University of Alaska Museum (UAM)

247 = Zoological Institute, Russian Academy of Sciences (ZIN)

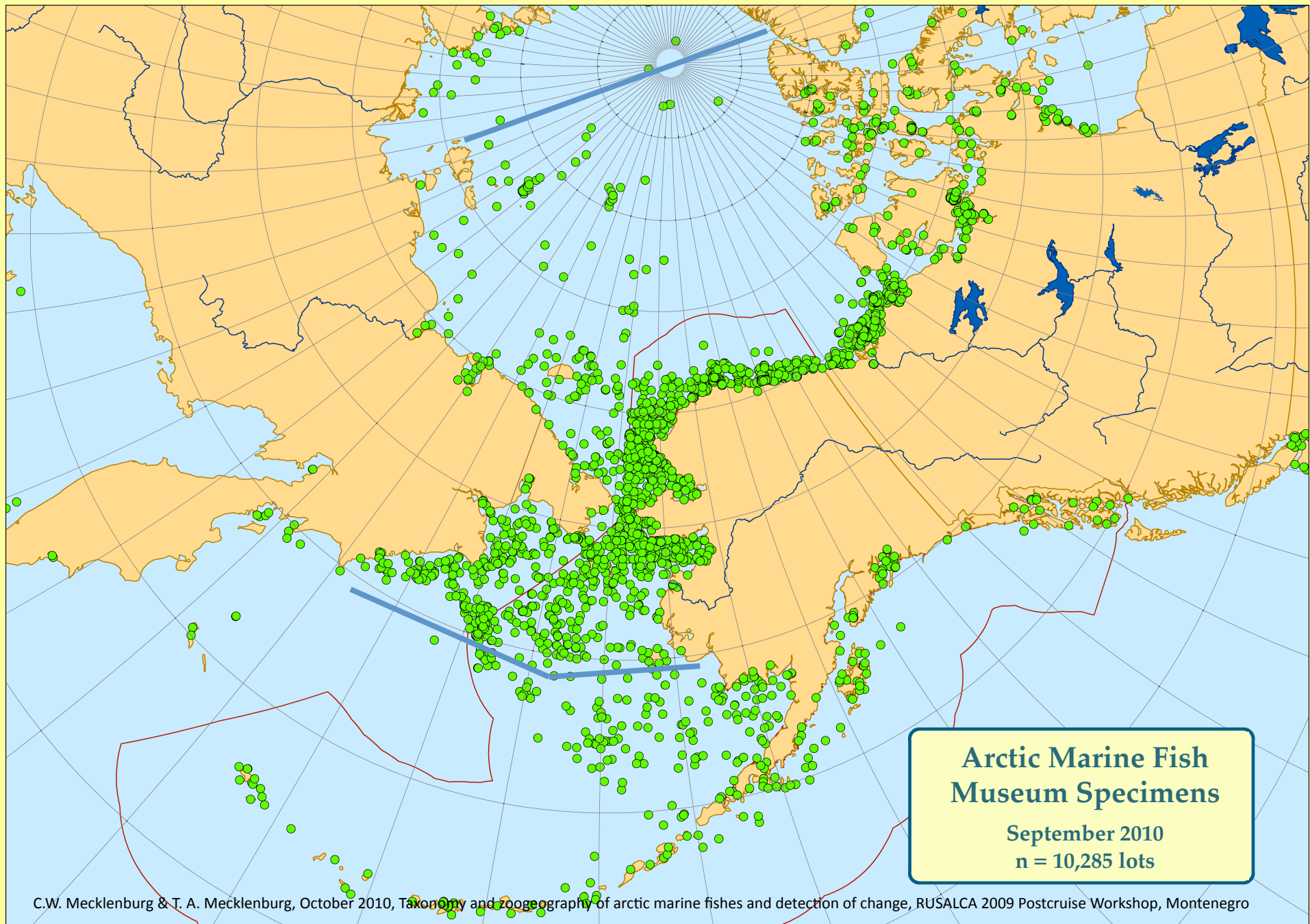
458 jars (1-50 specimens each)

Muscle tissue samples from 192 fishes (1 or more of each species) were sent to the University of Guelph, Biodiversity Institute of Ontario, Canada, for DNA sequencing by the Barcode of Life program. Analysis has been completed.

Muscle tissue samples from 100 fishes were given to the UAM tissue bank.

**RUSALCA
2009:**

**Verification of Museum Collections
of Arctic Marine Fishes**



C.W. Mecklenburg & T. A. Mecklenburg, October 2010, Taxonomy and zoogeography of arctic marine fishes and detection of change, RUSALCA 2009 Postcruise Workshop, Montenegro

Largest Western Arctic Marine Fish Collections Evaluated

Auke Bay Marine Laboratory, NOAA, NMFS, Juneau, Alaska

California Academy of Sciences, San Francisco

Canadian Museum of Nature, Gatineau, Quebec

Hokkaido University Museum of Zoology, Hakodate, Japan

National Museum of Natural History, Washington, D.C.

University of Alaska, Museum of the North, Fairbanks

University of British Columbia, Vancouver, Canada

University of Washington, Seattle

Zoological Institute, Russian Academy of Sciences, St. Petersburg*

*Collection reviewed by Natalia V. Chernova and Boris A. Sheiko, 2006-2007, for ArcOD.

Major Historical Collections Reviewed from Within the RUSALCA Study Area

Late 19th century American explorers

Arctic Research Lab, Pt. Barrow, in 1940s–1950s

U.S. Bureau of Commercial Fisheries, 1959, E Chukchi Sea

University of Alaska Fairbanks, 1973; E and W Chukchi Sea

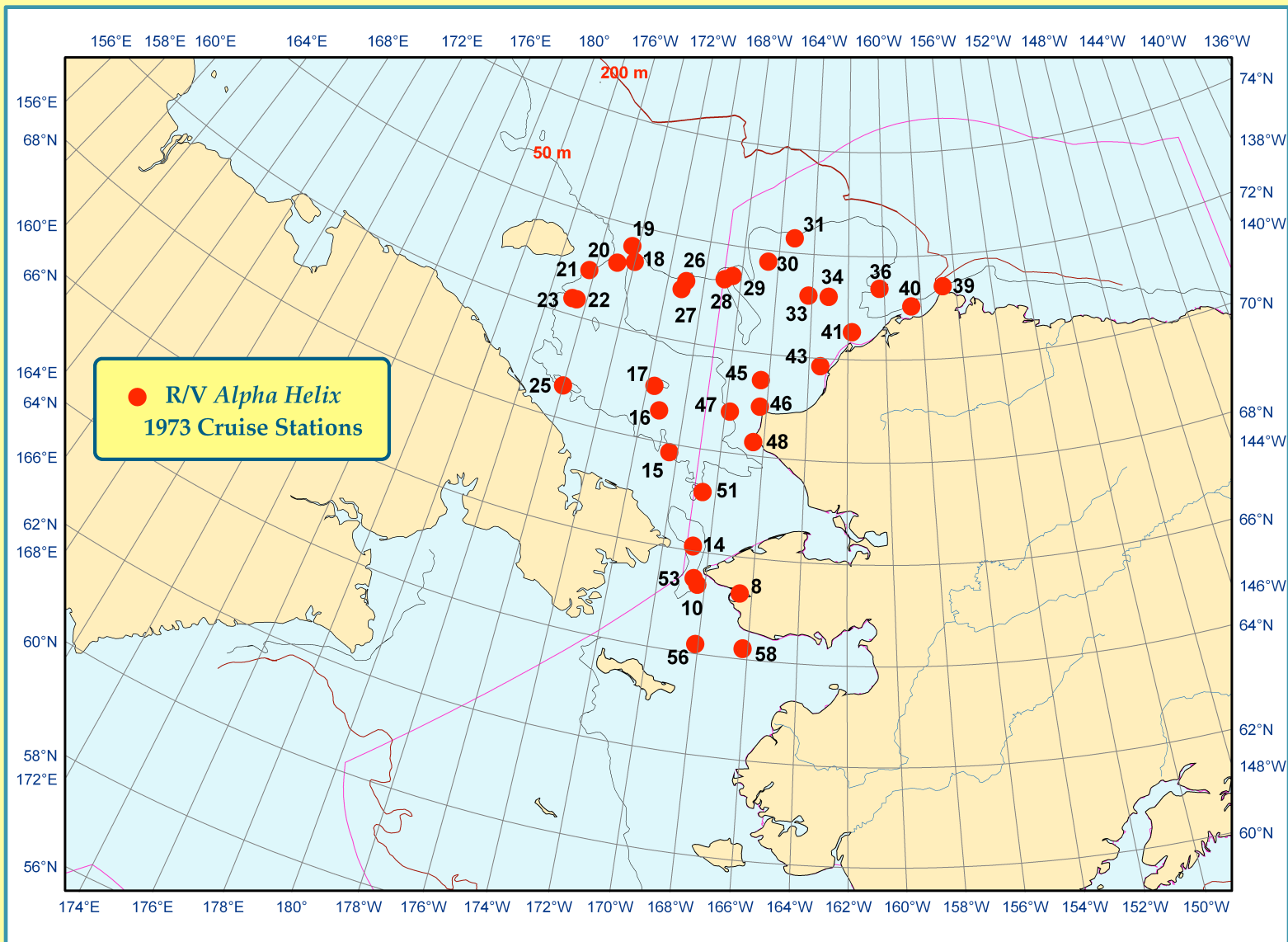
NOAA, NMFS, 1976, NE Bering and SE Chukchi Sea

University of Alaska Fairbanks, 1989–1991; NE Chukchi Sea

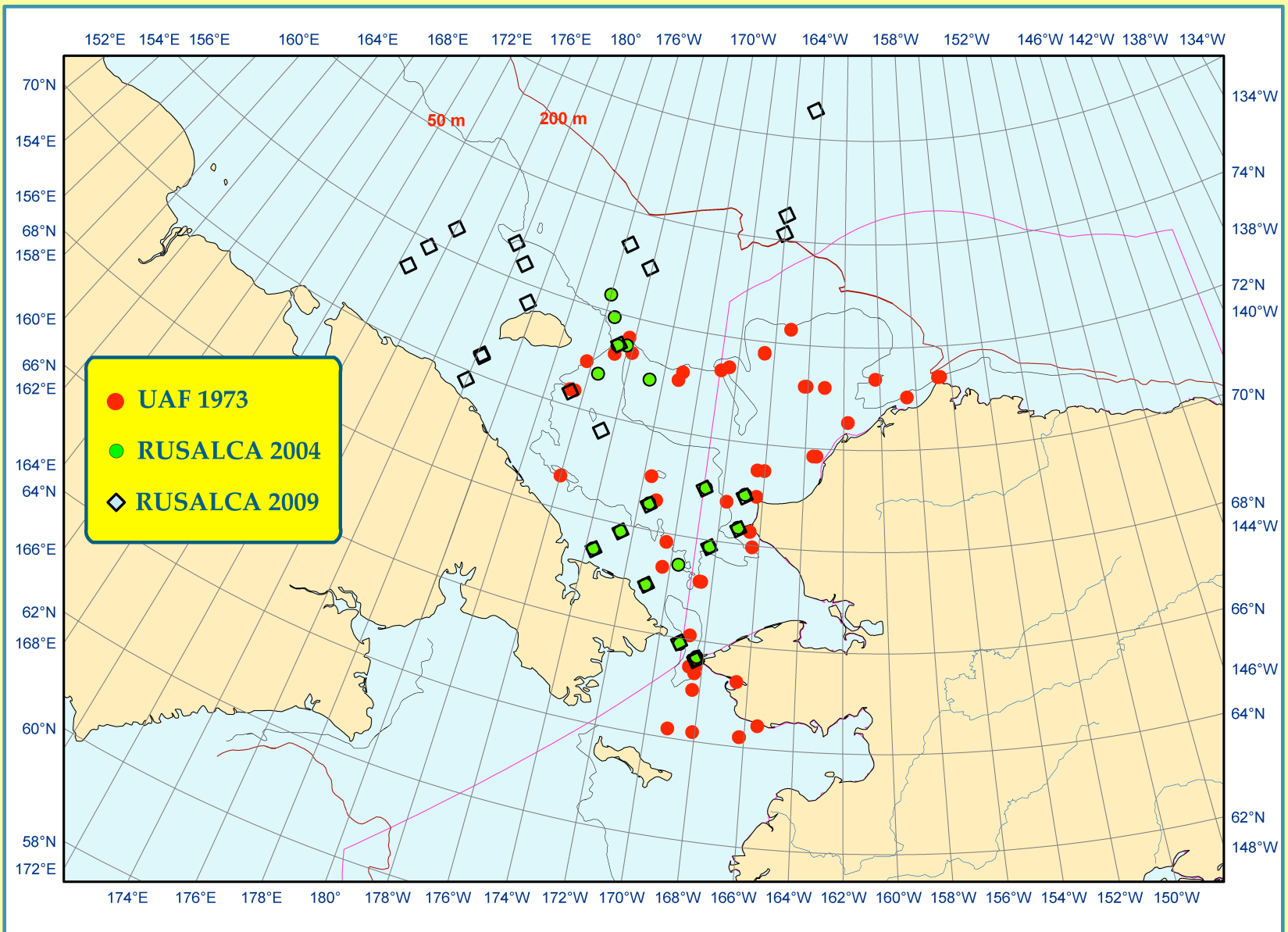
Hokkaido University Faculty of Fisheries, 1990–1992, E Chukchi Sea

Only one investigation since 1946 (Andriashev 1952), except for RUSALCA 2004 and 2009, has sampled fishes by bottom trawling in Russian as well as American waters of the Chukchi Sea:

University of Alaska Museum, 1973



Otter trawl stations, Aug–Sep 1973, R/V Alpha Helix, James E. Morrow, University of Alaska Museum



UAF 1973, RUSALCA 2004 & 2009

Most Recent Pacific-Arctic Collections Studied

2004, Chukchi Sea, RUSALCA, RV *Professor Khromov*; C.W. Mecklenburg, D.L. Stein, B.A. Sheiko on board

2006, northeastern Bering Sea near Bering Strait, Norton Sound Economic Development Corporation, biennial bottom trawl survey (frozen specimens sent to us for identification and archiving)

2007, eastern Chukchi Sea; NOAA, NMFS, surface trawl; UAF/Norcross-Holladay beam trawl; C.W. Mecklenburg on board conducting RUSALCA-ArcOD barcode study; vessel *Oscar Dyson*

2007 and 2008, eastern Chukchi Sea, Hokkaido University IPY project; UAF/Norcross-Holladay beam trawl; vessel *Oshoro Maru* (frozen)

2009, Chukchi Sea, Chukchi Borderland, East Siberian Sea; RUSALCA; RV *Professor Khromov*; C.W. Mecklenburg, N.V. Chernova, and Norcross-Holladay teams on board

Other, smaller collections – e.g., frozen fish sent by NOAA, E. Logerwell PI, Beaufort Sea, 2008

Metadata report and 2nd edition of database

http://www.arcodiv.org/Database/Fish_datasets.html

The 3rd edition, which will include the RUSALCA 2009 voucher specimen records, is planned to be available online at the ArcOD site in spring or early summer 2011. We are updating the nomenclature and making numerous small corrections to the existing database, as well as adding more historical and recent records.

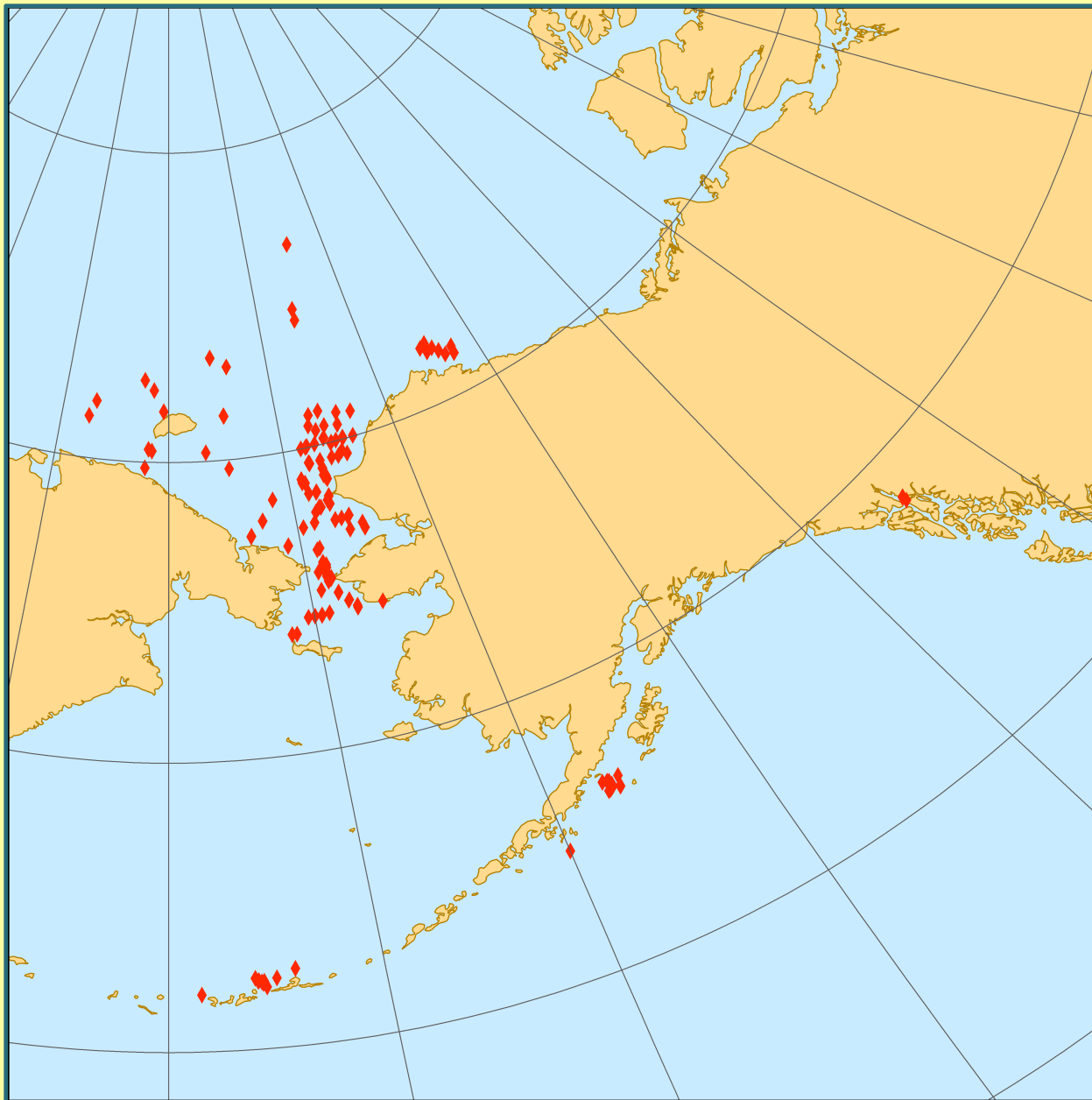
RUSALCA

2009:

“Barcoding” Project

DNA sequencing by the Barcode of Life project uses a standard region of the mitochondrial cytochrome c oxidase 1 gene (CO1). The statistical analysis discriminates among species, and has been proved useful for a wide variety of organisms from insects, fishes, and birds to mammals, and even macroalgae.

Purpose: to help identify species and resolve taxonomic problems. Too often, morphology is not enough.

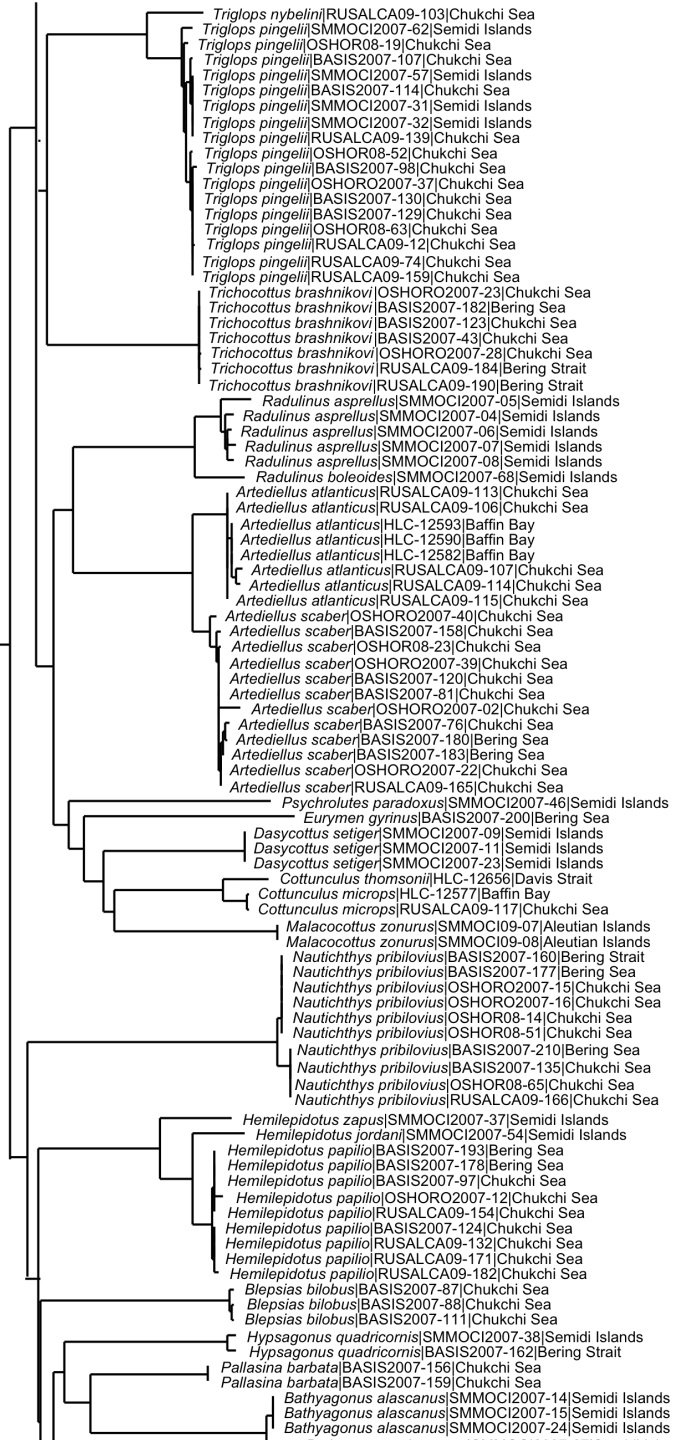


RUSALCA–ArcOD fish barcode project (Pacific-Arctic):

**Muscle tissue samples
were collected from fishes
caught during cruises and
other sampling in 2007–
2009**

**Locations from Chukchi
and Beaufort Seas to
Aleutian Islands and
Gulf of Alaska**

**Samples were analyzed at
University of Guelph,
Canada, by Marine
Barcode of Life program**

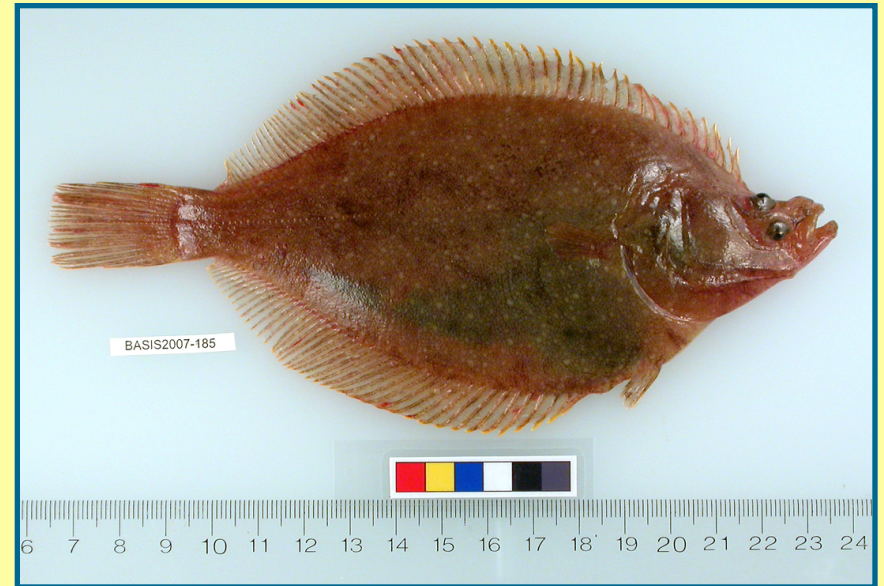


RUSALCA–ArcOD fish barcode project (Pacific-Arctic):

691 tissue samples, including 192 from RUSALCA 2009, were submitted

684 (99%) were successfully sequenced

Sequences were grouped by statistical “neighbor-joining” in clades (groups) representing 106 species



Both = *Limanda proboscidea* (Longhead Dab)



29 mm



31-32 mm



37-42 mm



70-81 mm



97 mm

Sculpin juveniles – What species are they? Bering Strait and Chukchi Sea



(Alcoholic specimen collected in 1890,
colors have faded)

Microcottus sellaris
Brightbelly Sculpin

Could they be this species?



NE Chukchi Sea, 2007, 37–42 mm



Bering Strait, RUSALCA 2009, 97 mm



NE Chukchi Sea, 2007, 70–81 mm



Bristol Bay, 1890, 110 mm

Although the juveniles look like *M. sellaris*,
they are not this species

Large, rounded, spiny
scales behind pectoral fin



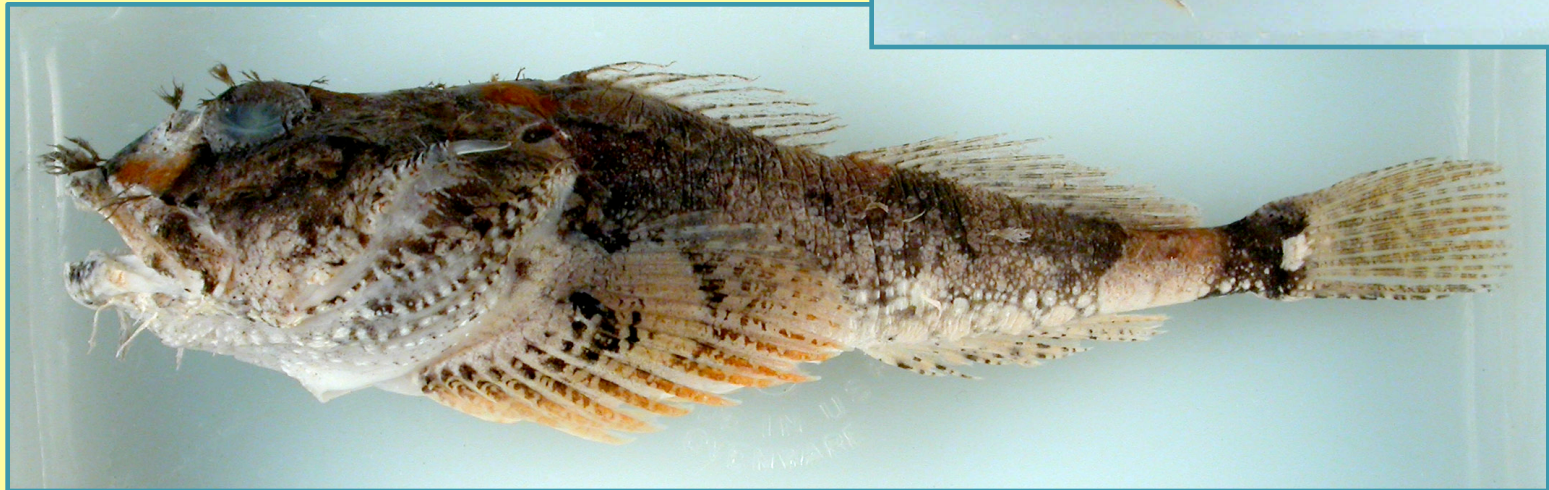
109 mm RUSALCA 2009

Trichocottus brashnikovi
Hairhead Sculpin




164 mm TL, NE Bering Sea, 2006

Trichocottus brashnikovi
Hairhead Sculpin



Trichocottus brashnikovi
Hairhead Sculpin

Outline of Presentation:

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- 2) Arctic Marine Fish Museum Specimens evaluation & database
- 3) DNA sequencing (“barcoding”) Arctic fishes
-  **4) Taxonomic solutions, distribution patterns, & change**
- 5) Fishes caught in the Chukchi Borderland, 2009

Results from the 3 lines of investigation insofar as they contribute to topic number 4 have been reviewed and synthesized in a recent paper (Mecklenburg, Møller & Steinke 2010), which we illustrate with more examples in the rest of this presentation than could be accommodated in the paper.

Biodiversity of Arctic Marine Fishes: Taxonomy and Zoogeography

(Marine Biodiversity, 2010)

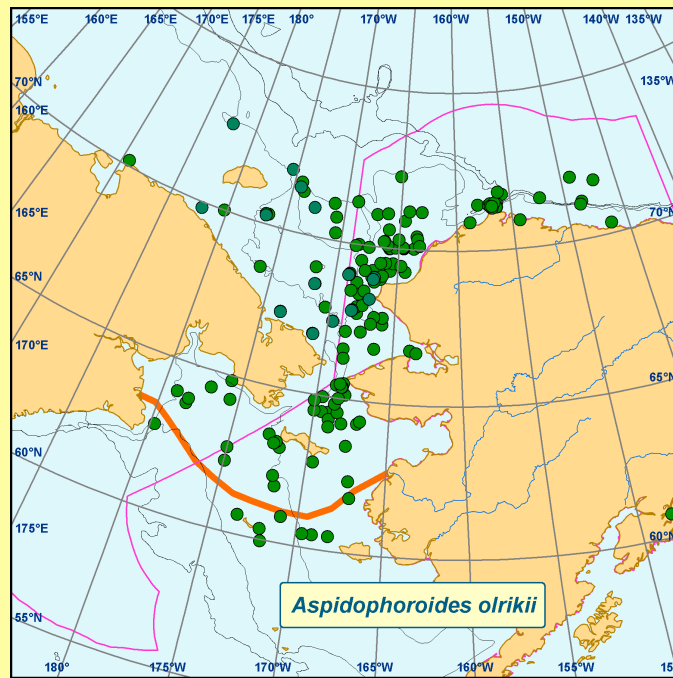
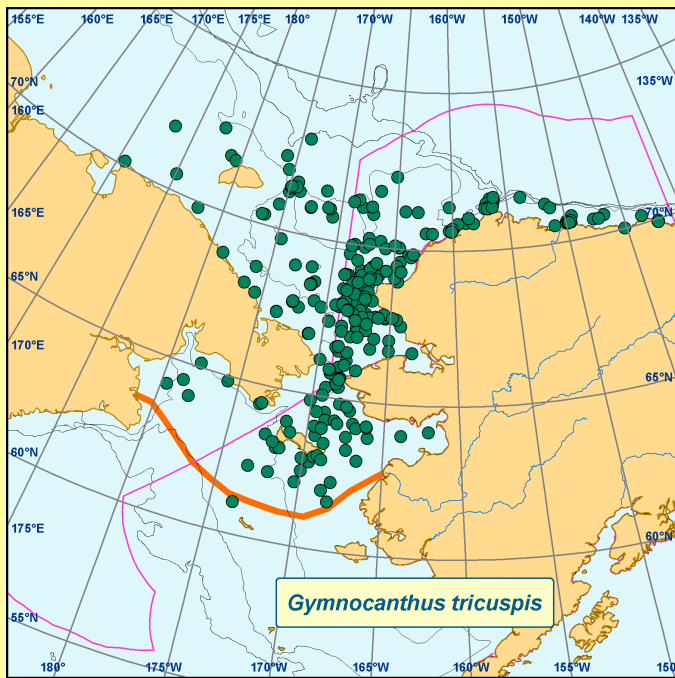
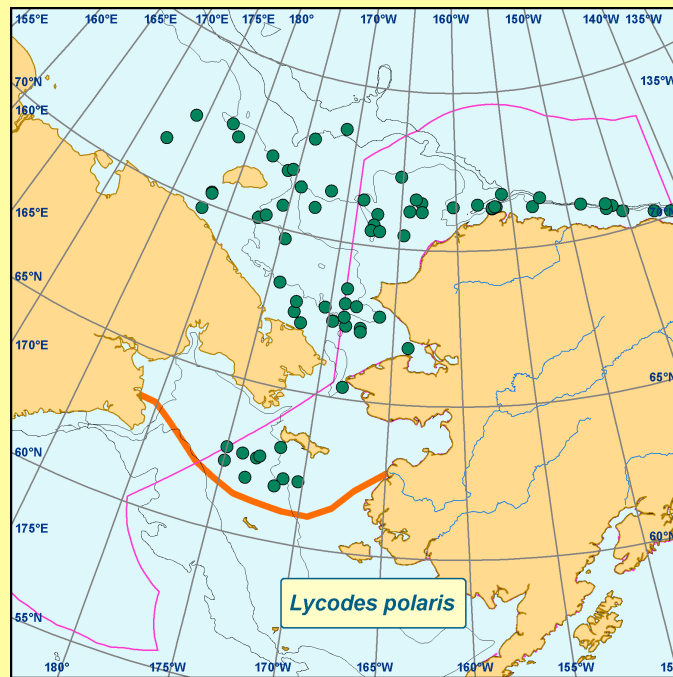
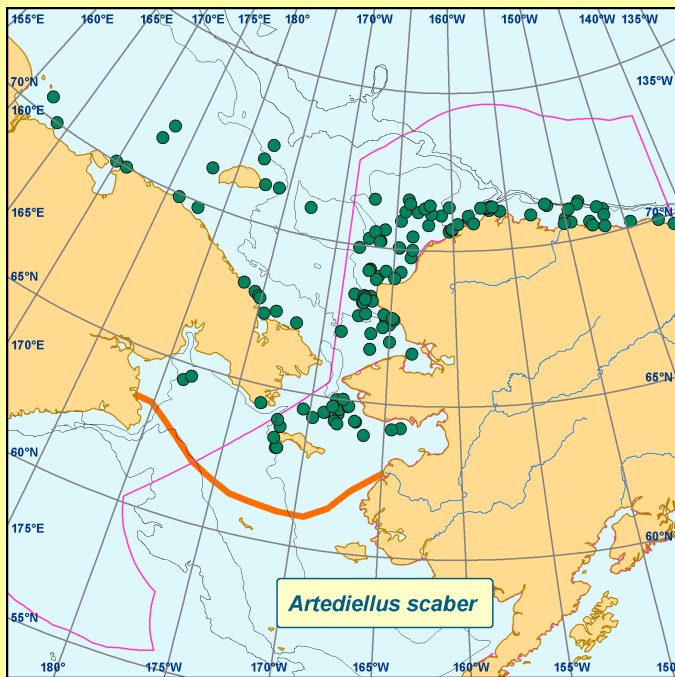
- **Catherine W. Mecklenburg**, Research Associate, California Academy of Sciences, San Francisco; Private Consultant, Point Stephens Research, Auke Bay, Alaska
- **Peter R. Møller**, Head of Vertebrate Zoology and Curator of Fishes, Natural History Museum of Denmark, University of Copenhagen
- **Dirk Steinke**, Lead Scientist, Barcoding of Marine Life, Biodiversity Institute of Ontario, University of Guelph, Ontario, Canada

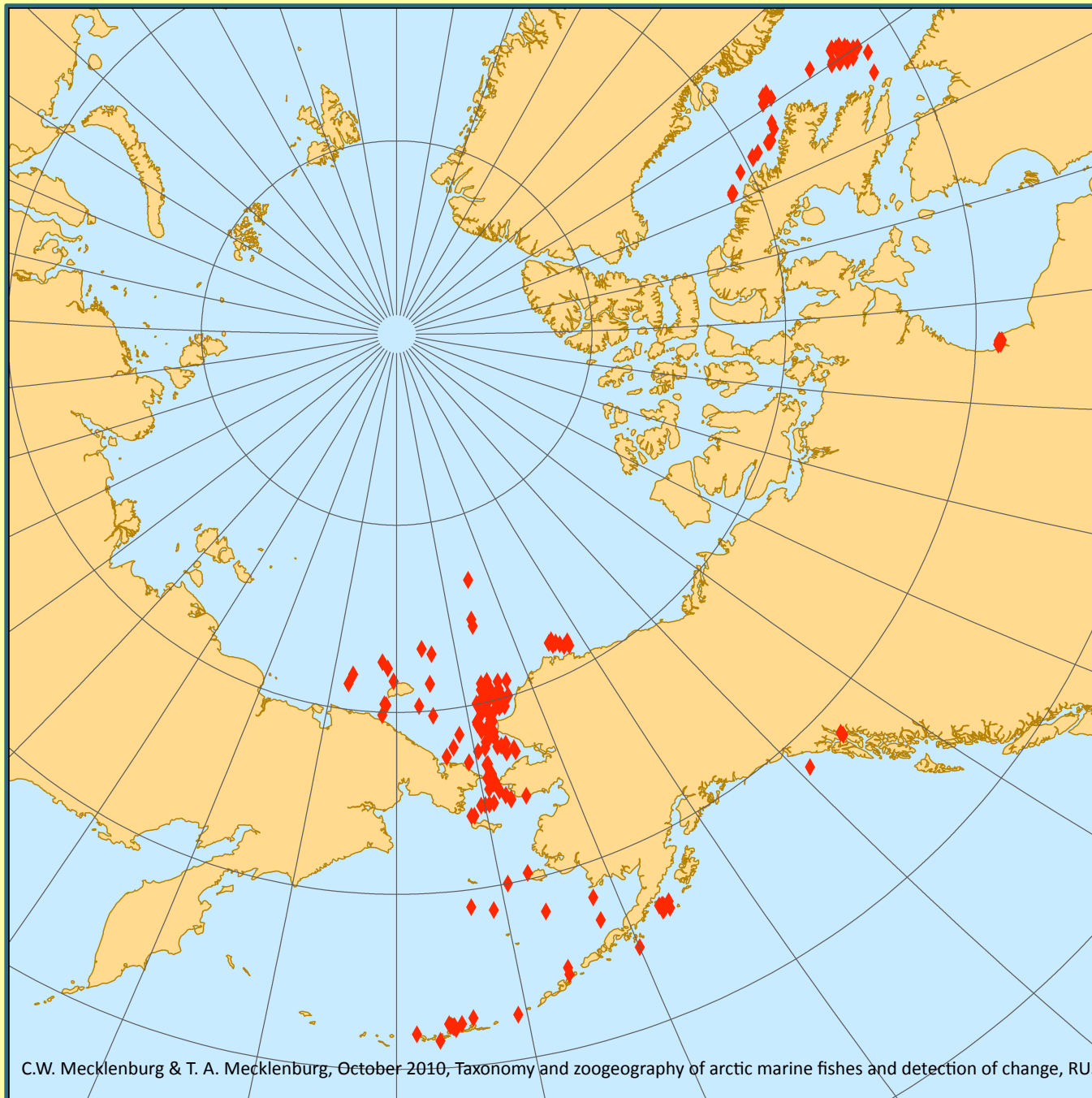


C.W. Mecklenburg & T. A. Mecklenburg, October 2010, Taxonomy and zoogeography of arctic marine fishes and detection of change, RUSALCA 2009 Postcruise Workshop, Montenegro



Arctic Marine Ichthyofaunal Region





Samples from NW Atlantic barcoding projects were added to our Pacific-Arctic samples: Baffin Bay and Davis Strait, and Hudson Bay

Increased number of sequences for “pan-Arctic” analysis to 880 from 684



Saddled Eelpout
Lycodes mucosus

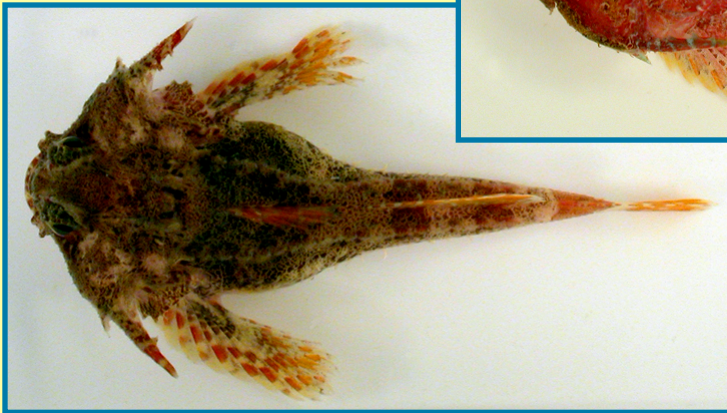


Estuarine Eelpout
Lycodes turneri

Leister Sculpin
Enophrys lucasi



Sturgeon Poacher
Podothecus accipenserinus



Antlered Sculpin
Enophrys diceraus



Veteran Poacher
Podothecus veterenus

Similar in appearance but genetically different



Gymnelus species
Eelpouts

Some species
“complexes” may not
be so complex

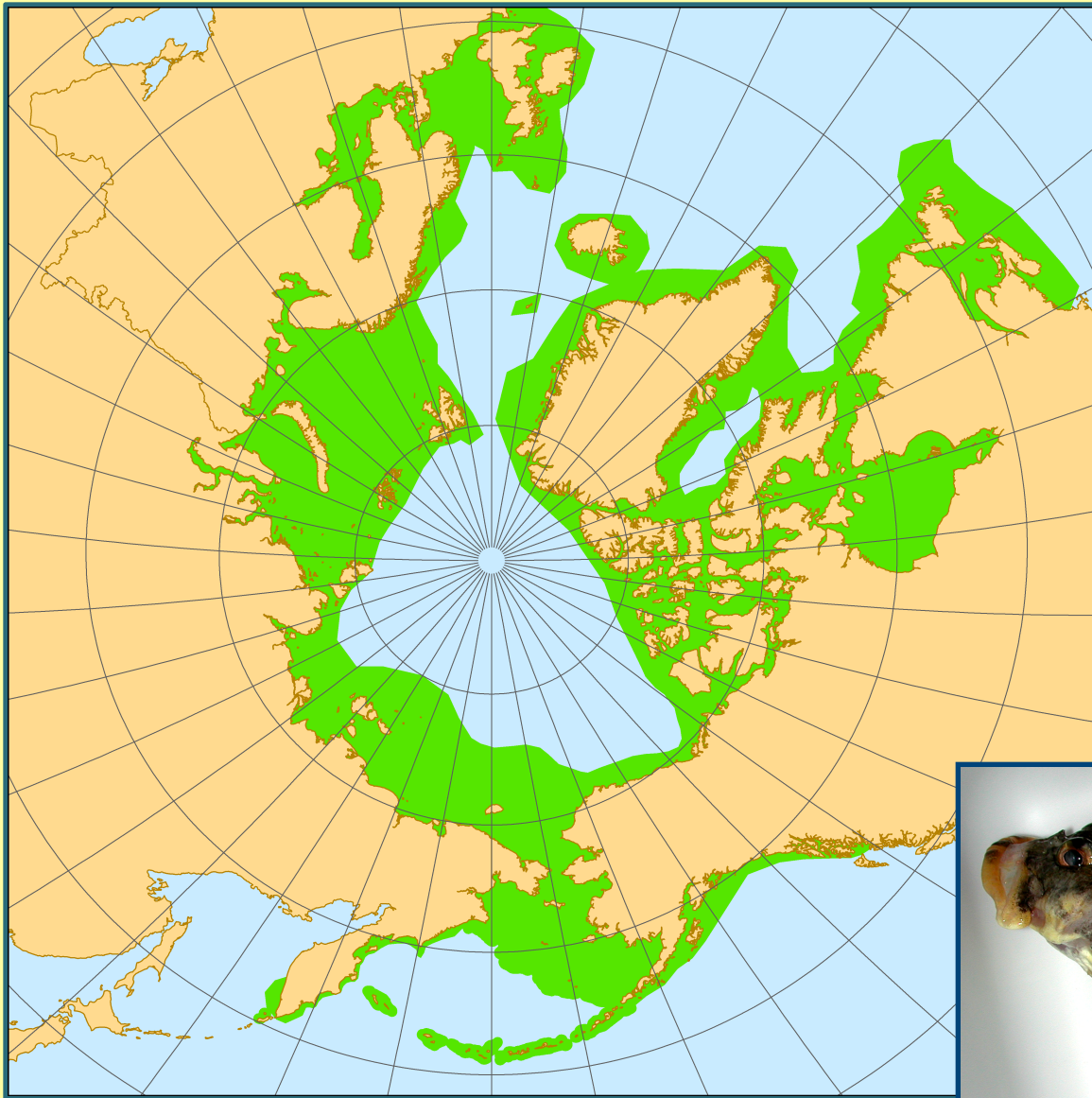


Liparis species
Snailfishes



Myoxocephalus scorpius
Shorthorn Sculpin





*Myoxocephalus
scorpius*
Shorthorn Sculpin

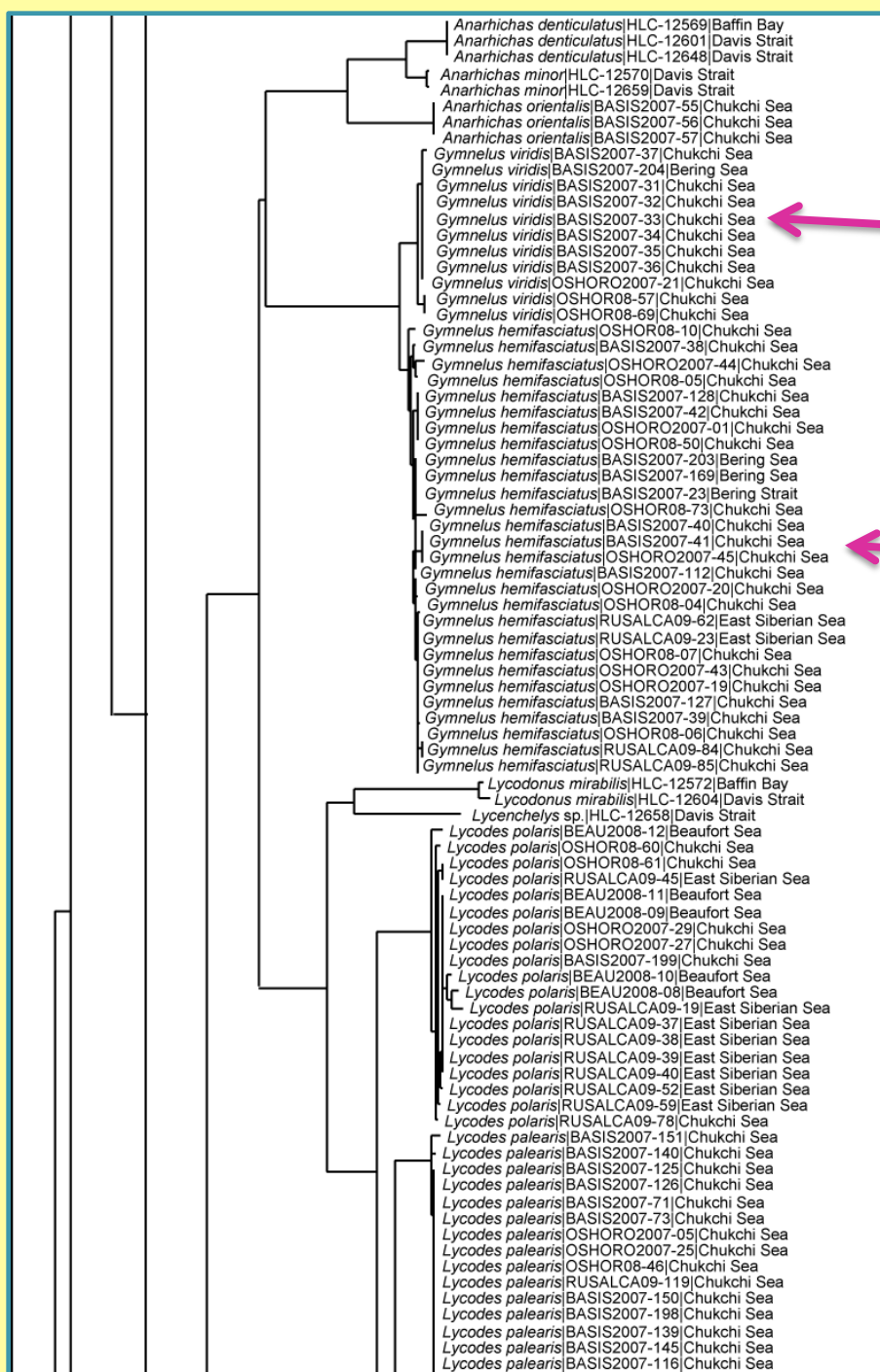
Barcodes from the Baltic Sea
to the Bering Sea are identical.





Gymnelus species

Only two species are in this photo.



Gymnelus viridis
Fish Doctor

G. hemifasciatus
Halfbarred Pout

CO1 sequences indicate each is only one species, not a complex of species as recently proposed. We (Mecklenburg, Møller, & Steinke 2010) use the original species names and the earlier descriptions and classification (Anderson 1982).

The small divergence between the 2 clades indicates these are probably young species.



Male
174 mm



Female
172 mm

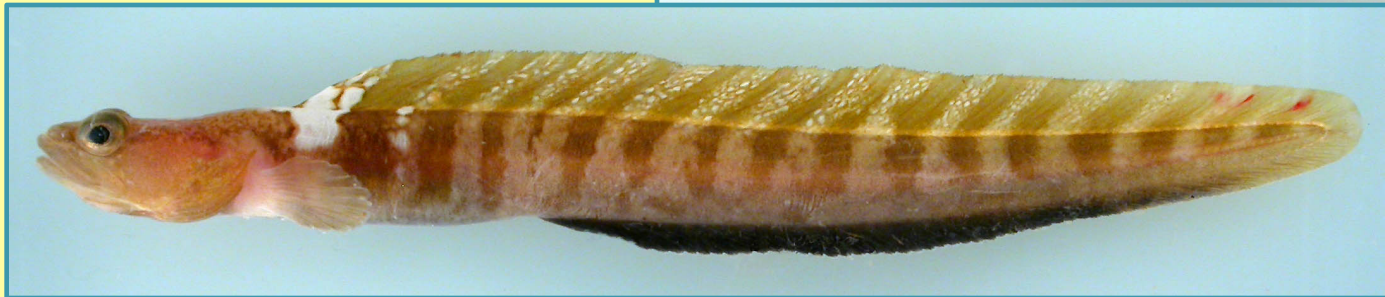
Gymnelus viridis
Fish Doctor



159 mm



72 mm

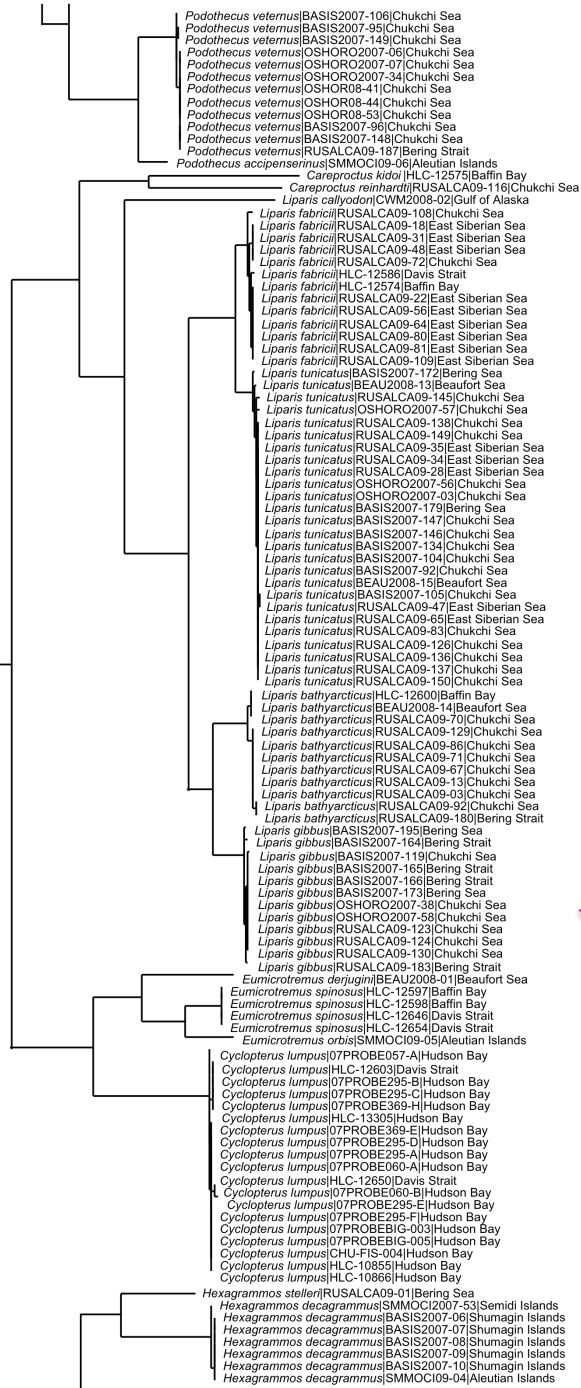


Male
128 mm



Female
101 mm

Gymnelus hemifasciatus Halfbarred Pout

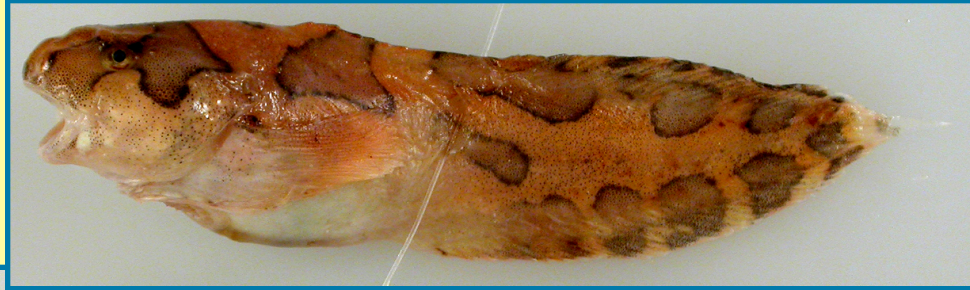
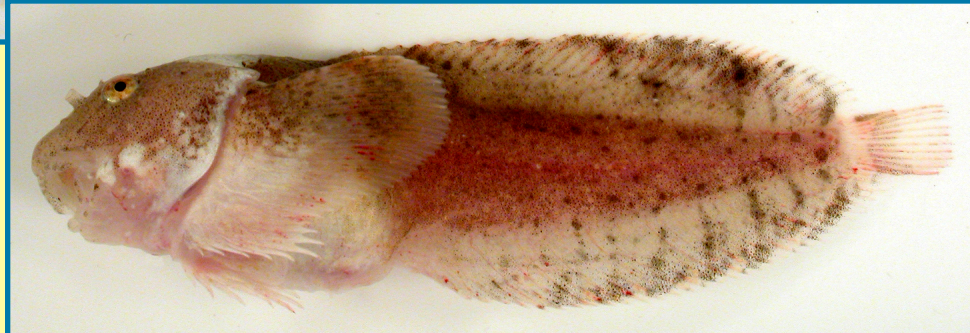


Liparis fabricii
Gelatinous Seasnail

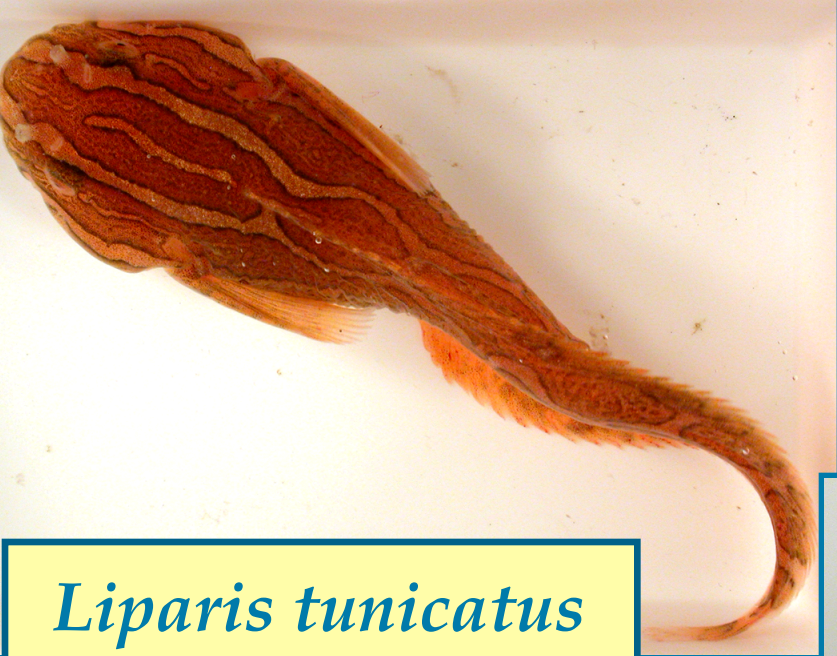
Liparis tunicatus
Kelp Snailfish

Liparis bathyarticus
Arctic Seasnail

Liparis gibbus
Variegated Snailfish



RUSALCA 2004 Professor Khromov



Liparis tunicatus
Kelp Snailfish
= All one species



94 mm, RUSALCA 2004

Liparis fabricii
Gelatinous Seasnail



130 mm, RUSALCA 2009

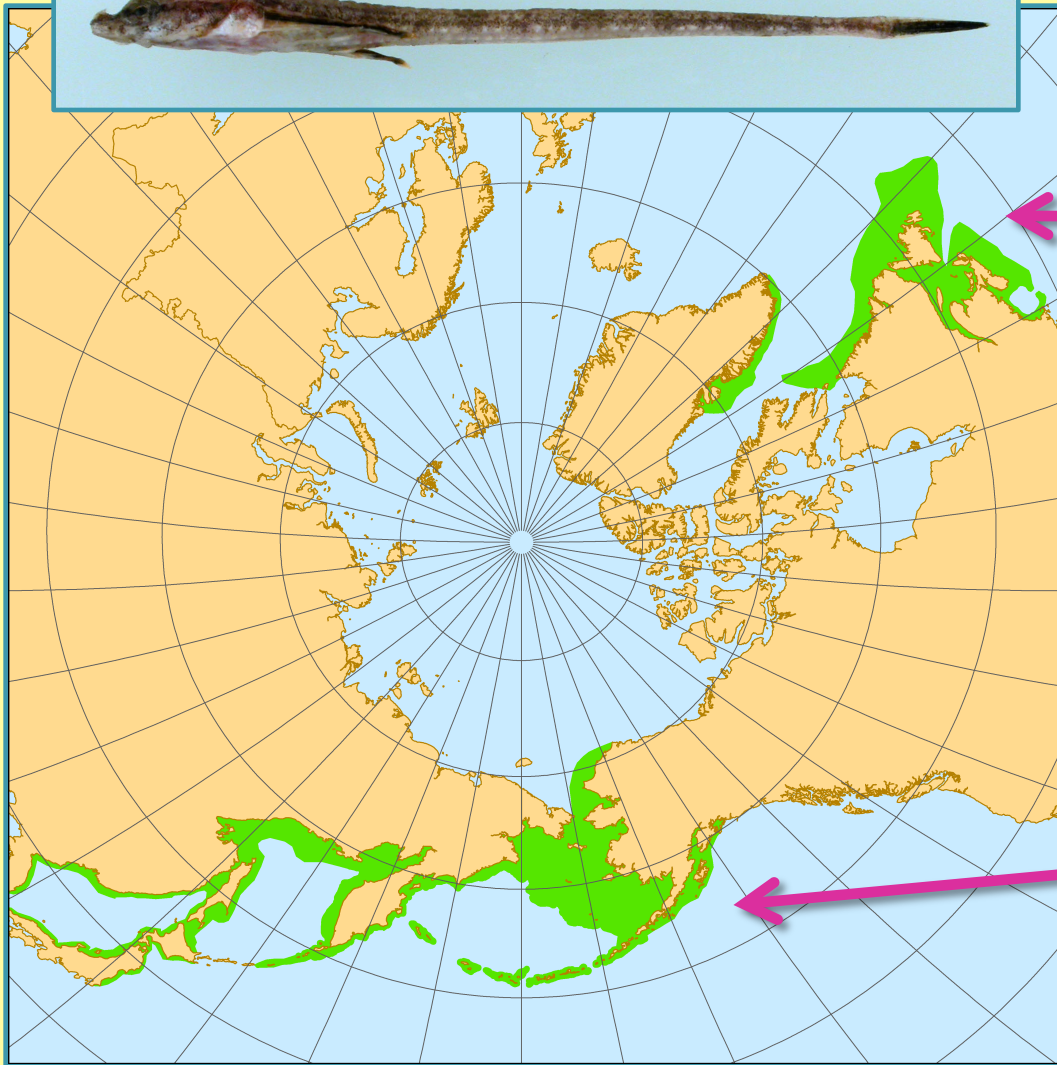


Liparis gibbus
Variegated Snailfish



Liparis bathyarcticus
Arctic Seasnail

Very close in appearance, but they are genetically different.



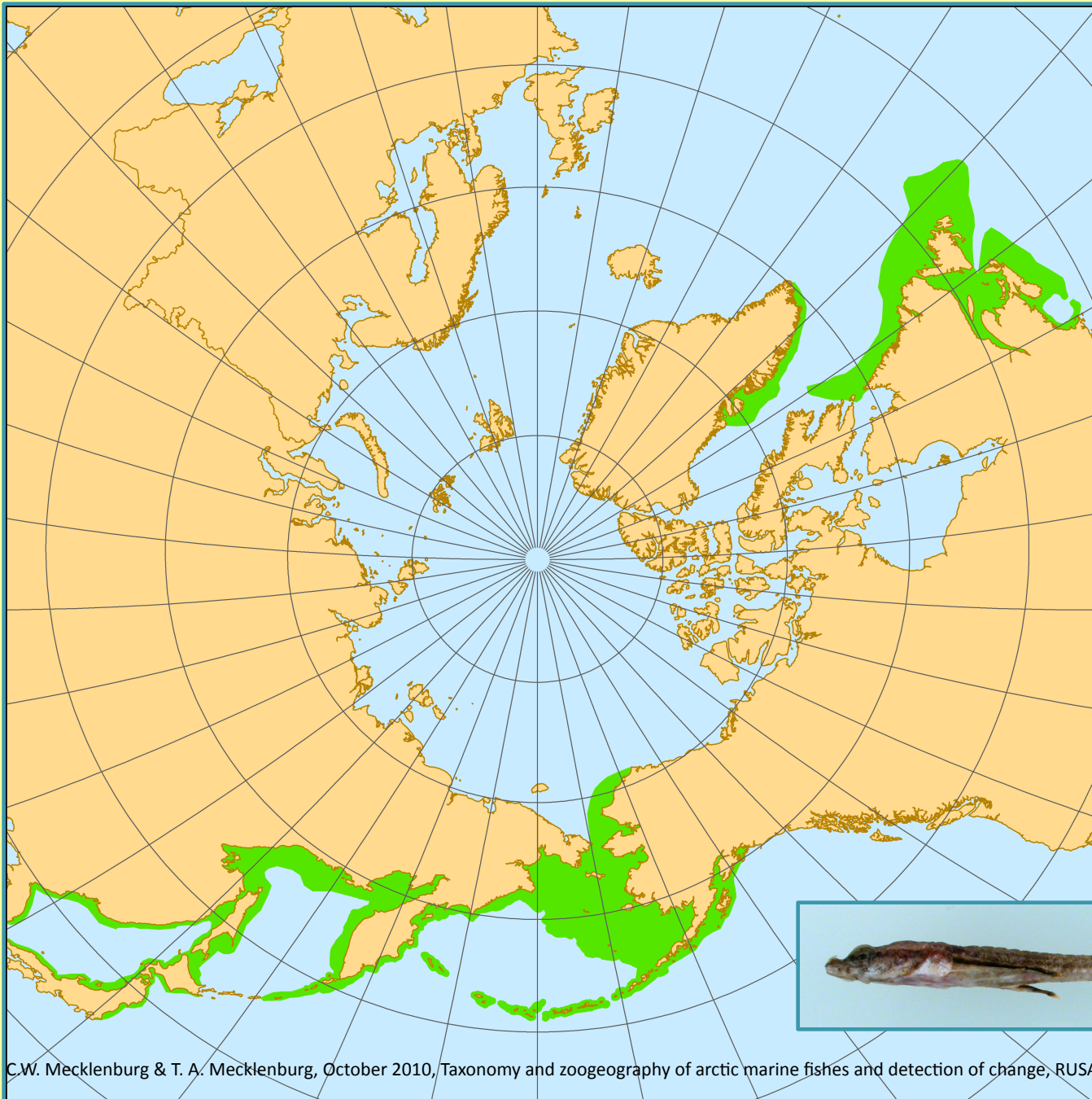
*Aspidophoroides
monopterygius*

Alligatorfish
(Bloch 1786)

*Aspidophoroides
bartoni*

Aleutian Alligatorfish
(Gilbert 1896)

For some species, barcoding confirmed the identity of Pacific and Atlantic populations that evidently have no intervening populations. Previously, in such situations, the two populations were assumed to be different species and given different names.



*Aspidophoroides
monopterygius*
Alligatorfish

Amphiboreal:
species
distributed in
Pacific and
Atlantic but not
in between





Male

Icelus sp.



Female



Male

Icelus spatula



Female

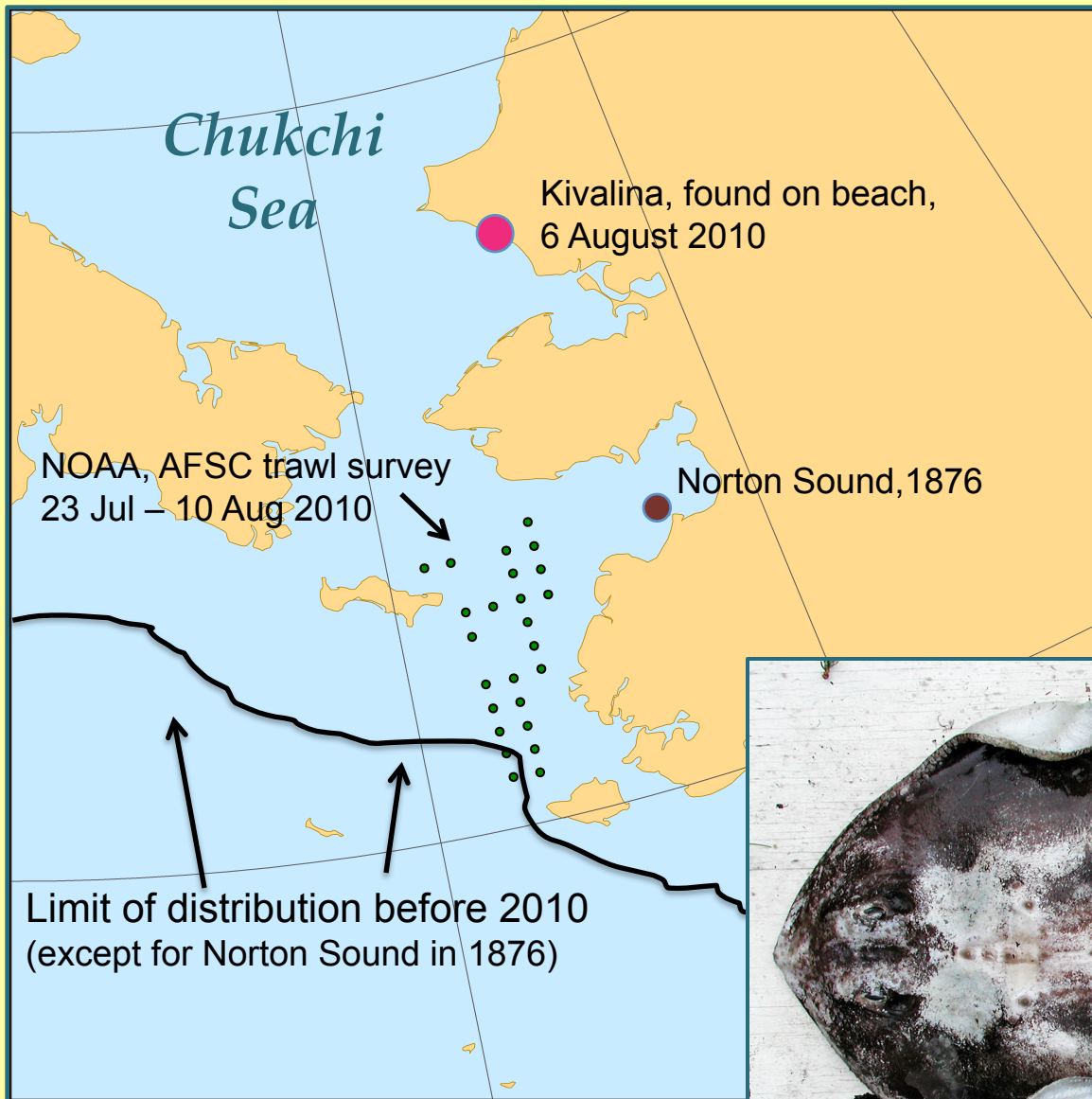
What species are new to the Arctic?

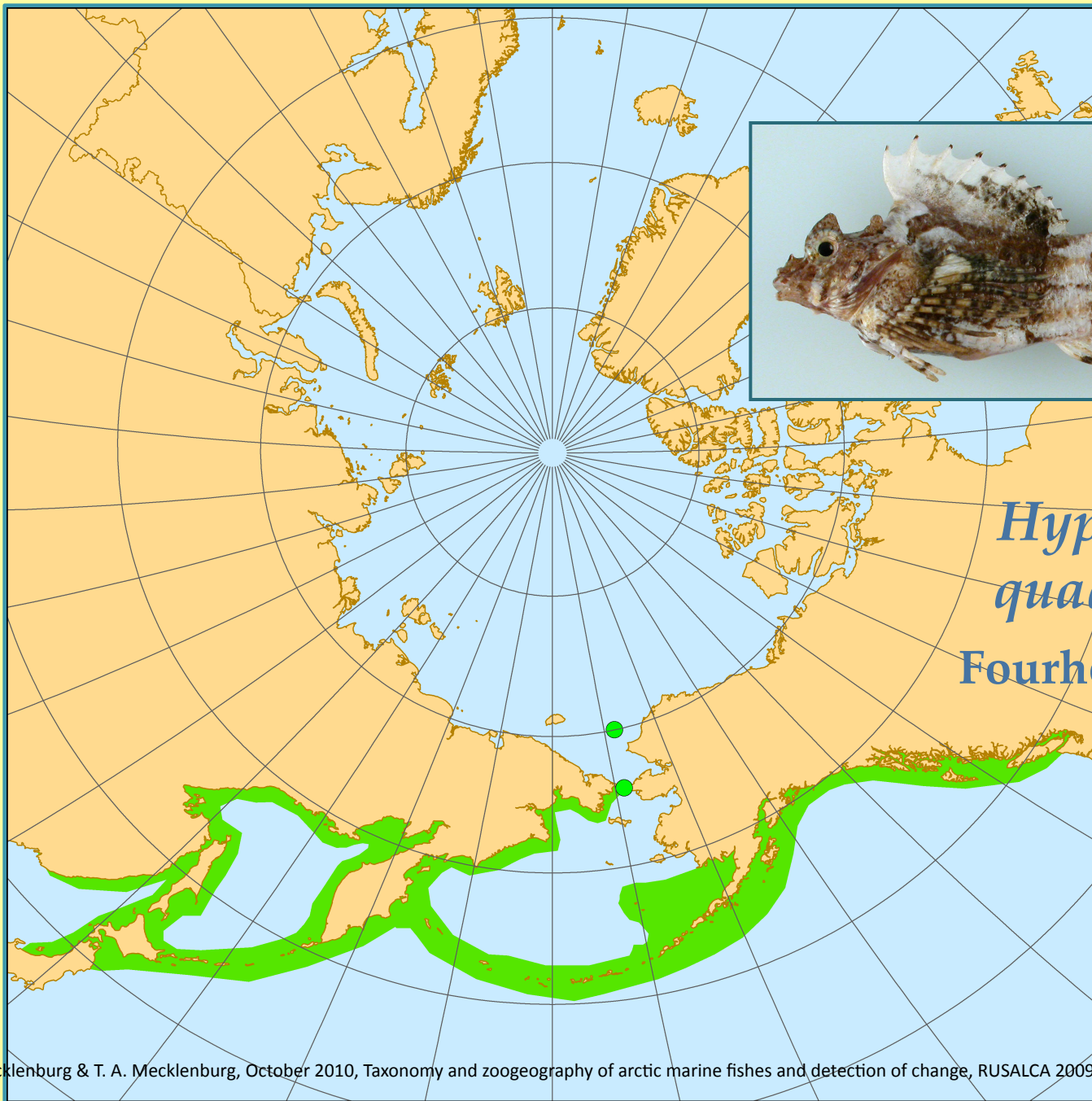
Bathyraja parmifera Alaska Skate

Kivalina — First record of occurrence in the Chukchi Sea

Skate center of distribution has moved north about 90 km since 1982 (Mueter & Litzow 2008).

Biomass and abundance have increased nearly fourfold since 1975 (Hoff 2006).



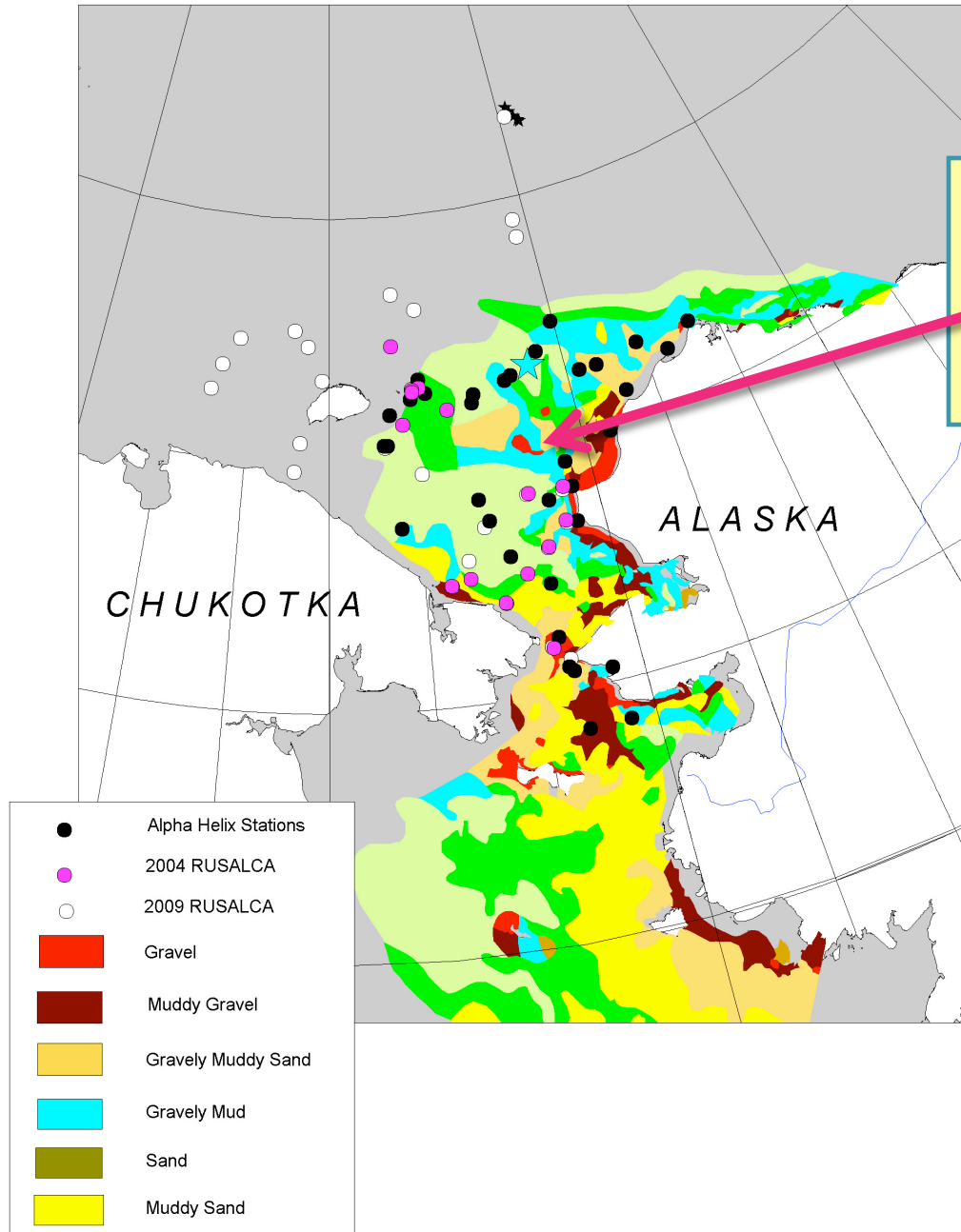


*Hypsagonus
quadricornis*
Fourhorn Poacher

Green dot in
Chukchi Sea is
from Oshoro Maru
cruise in 2007

Gap in distribution
in eastern Bering
Sea is a problem.

Sediments of the Bering and Chukchi Sea (Otter Trawl Stations Superimposed)



Hypsagonus quadricornis
Fourhorn Poacher

Preferred
substrate =
gravel

Map by Kathy Crane,
NOAA, Arctic Research
Program



Poor swimmer.
Walks, using
stiff, finger-like
pectoral, pelvic,
and anal fin
rays and up-
and-down tail
motions for
propulsion
(Jensen 2007)

*Hypsagonus
quadricornis*
Fourhorn Poacher

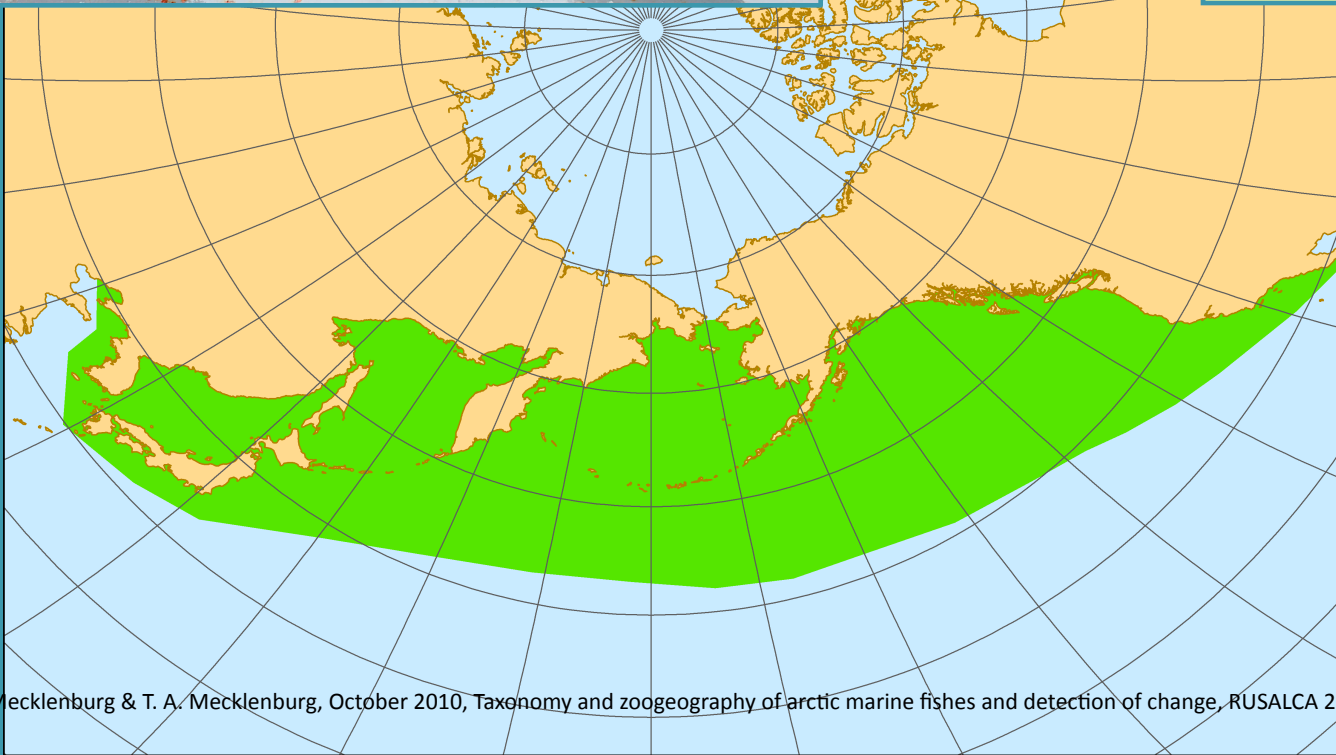




MS Busby / NOAA / AFSC

A well-known pelagic species caught by surface trawl.

Lamna ditropis Salmon Shark



2007: Caught at Bering Strait. Adult male. This is the first adequately documented catch north of the southern Bering Sea. Previously, range to Bering Strait was doubted by some authors.



Zaprora silenus Prowfish

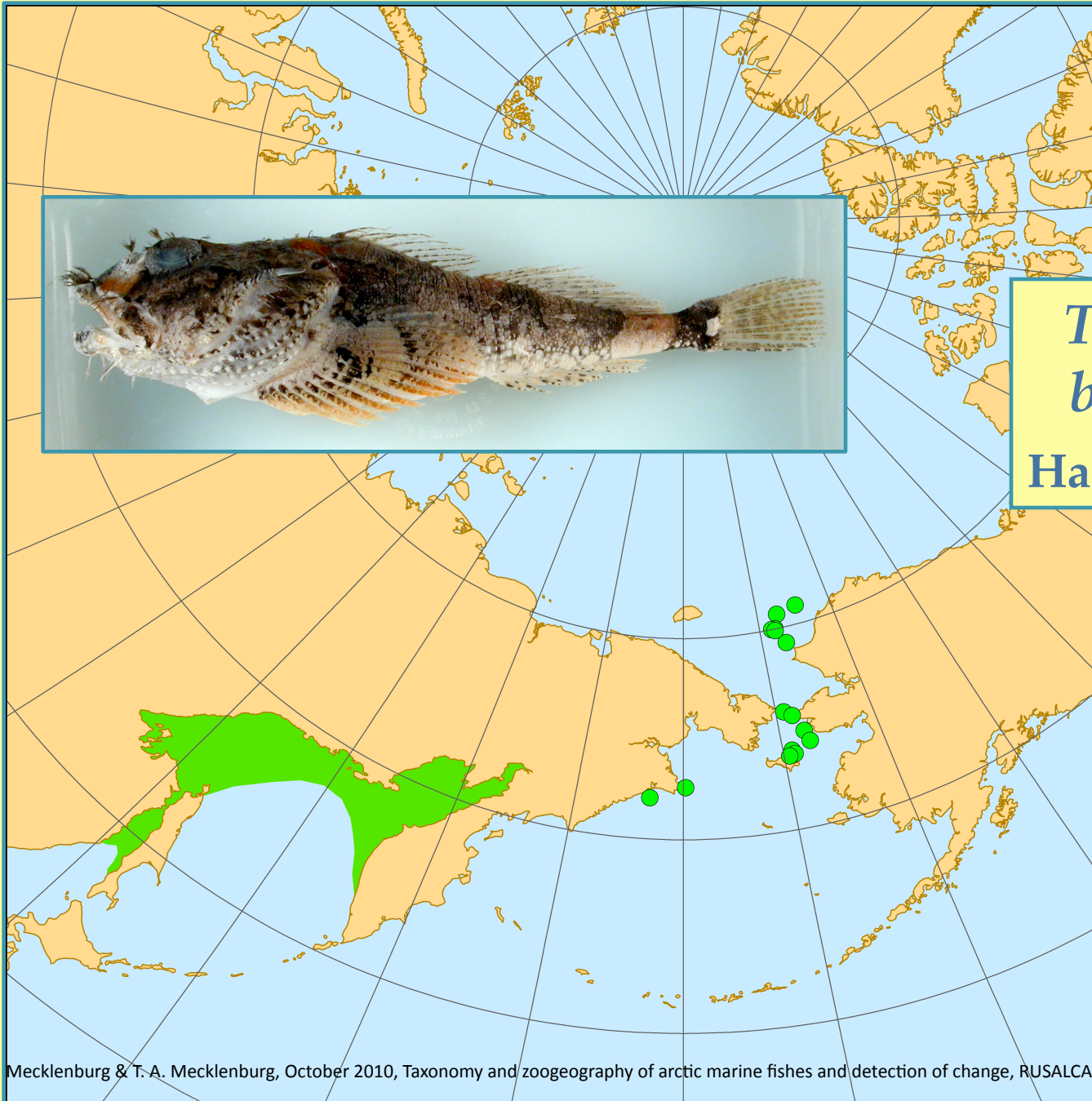
Found in Chukchi Sea for first time in 2007, by surface trawl. However, surface trawling has been rare in the Chukchi. Our bottom trawls would not have picked it up.

Adults are benthopelagic, live deep, near the bottom; juveniles stay near the surface.

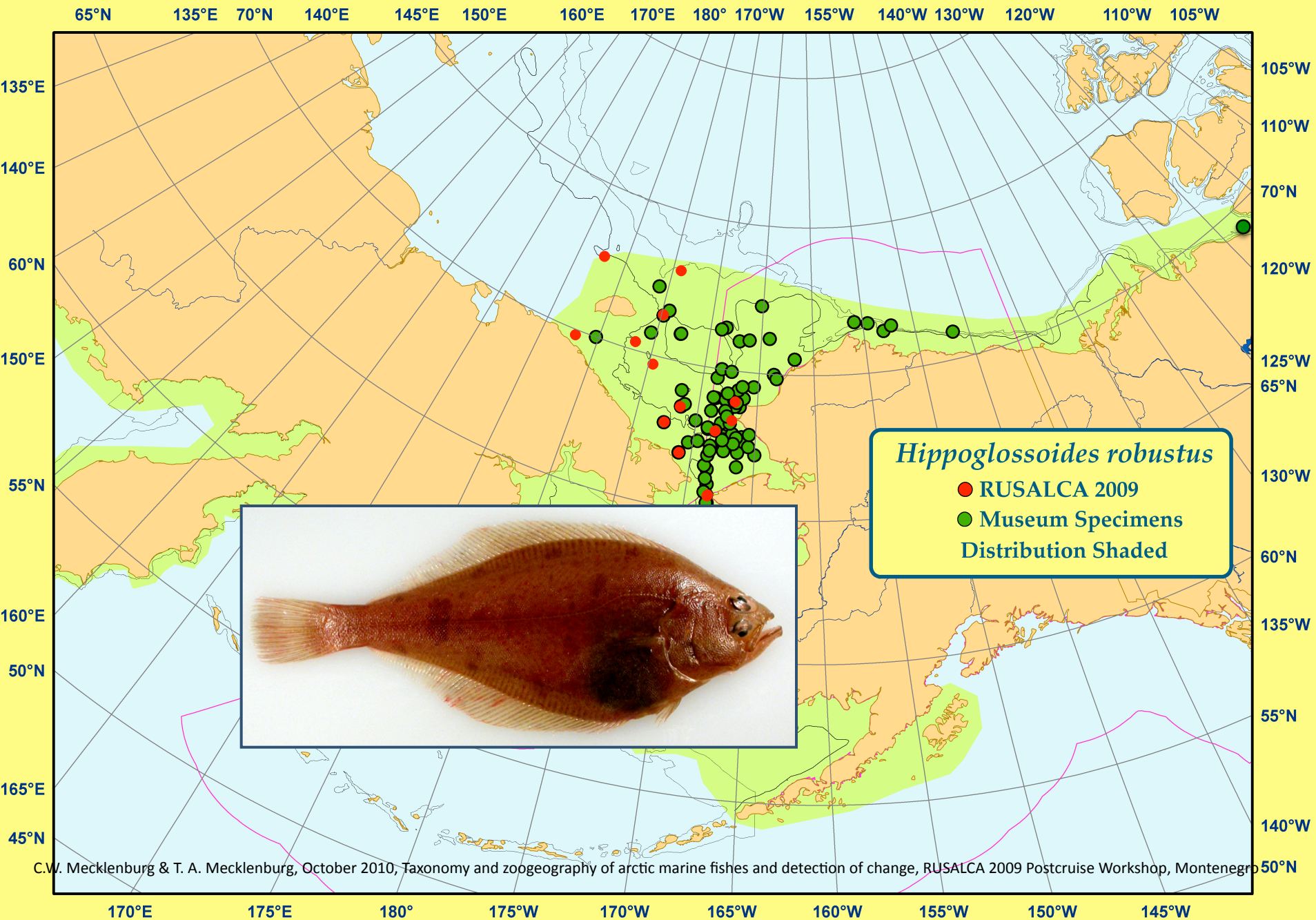
Northern Bering and Chukchi are not deep enough for the adults. If the juveniles are new to the Arctic, will they cross the shelf to settle in the deep slope waters of the Arctic, or die?



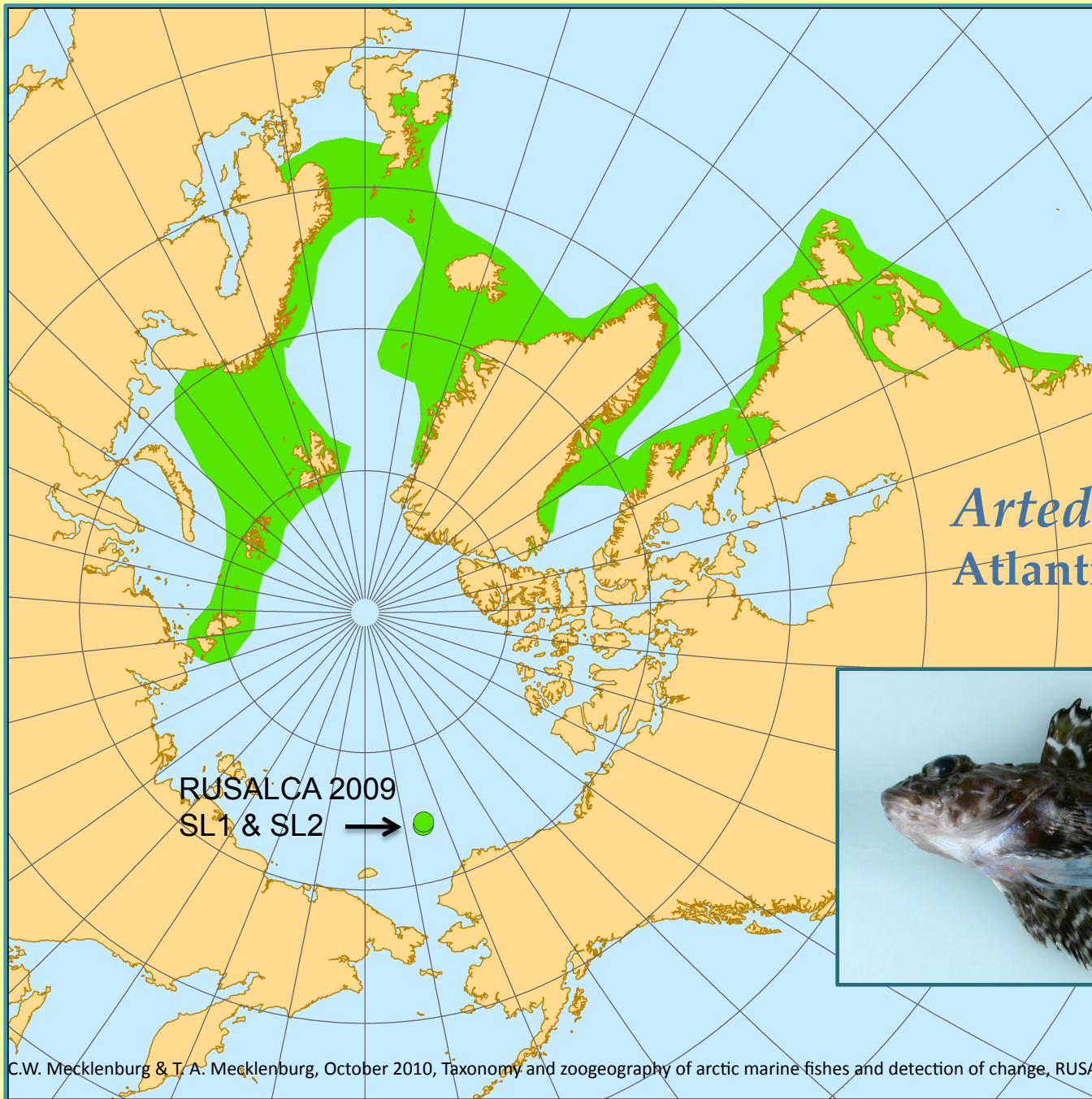
*Trichocottus
brashnikovi*
Hairhead Sculpin



Population in Seas of Japan and Okhotsk but nothing in Bering and Chukchi until 1973. Do the new finds in Bering and Chukchi indicate expansion into the Arctic? Or have they been there all along but misidentified? (See slides 26–31.)



C.W. Mecklenburg & T. A. Mecklenburg, October 2010, Taxonomy and zoogeography of arctic marine fishes and detection of change, RUSALCA 2009 Postcruise Workshop, Montenegro



Artediellus atlanticus
Atlantic Hookear Sculpin





Chukchi Sea coast near
Barrow, Alaska, November
2008 — found on the ice

*Anarhichas
denticulatus*
Northern Wolffish

First records from Pacific-Arctic

Most common in NW Atlantic



Beaufort Sea at Kaktovik,
Alaska, October 2008 —
washed up on the beach



RUSALCA 2009:

Fishes from the Chukchi Borderland

This part of the RUSALCA 2009 workshop fish presentation will be provided on the RUSALCA website at a later date. Analysis of the Chukchi Borderland collection is nearing completion and manuscripts are in progress.

