What we have learned about change in the distribution of fishes from the RUSALCA mission.
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RUSALCA Fish Diversity Assessments

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Biodiversity of Arctic Marine Fishes: Taxonomy and Zoogeography

(Marine Biodiversity, Published)

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Biodiversity of arctic marine fishes: taxonomy and zoogeography

Catherine W. Mecklenburg · Peter Rask Møller · Dirk Steinke

Abstract Taxonomic and distributional information on each fish species found in arctic marine waters is reviewed, and a list of families and species with commentary on distributional records is presented. The list incorporates results from examination of museum collections of arctic marine fishes dating back to the 1830s. It also incorporates results from DNA barcoding, used to complement morphological characters in evaluating problematic taxa and to assist in identification of specimens collected in recent expeditions. Barcoding results are depicted in a neighbor-joining tree of 880 COI (cytochrome c oxidase I gene) sequences distributed among 165 species from the arctic region and adjacent waters, and discussed in the family reviews. Using our definition of the arctic region, we count 242 species with documented presence, if 12 species that likely are synonyms are excluded. The 242 species are distributed among 45 families.

Six families in Cottocidae with 72 species and five Zoarceidae with 55 species account for more than 30% of the 242 species. Sequence variability in the barcoding region permits discrimination of all species. The average sequence variation within species was 0.2% (range 0.1–1.2%), while the average genetic distance between congener was 4.7% (range 3.7–13.3%). The COI sequences support taxonomic separation of some species, such as Ophiodon elongatus and O. noltei and Liparis bathyuricicus and L. gibbus; and synonymy of others, like Myoxocephalus scorpius and Gymnocephalus kenaqutschus and G. horni. They sometimes revealed the presence of additional species that were not entirely expected, such as undescribed species of Liparis in the western Gulf of Alaska, most likely a new species and an unidentified fish species of the I. spalata complex with populations in the eastern Gulf of Alaska and the northern Bering and Chukchi Seas which could be a new species of a species in synonymy.

Reviewing distribution, we found that for 24 species barcoding patterns assigned by authors underestimates historical presence in the arctic region, and for 12 species they overestimate presence. For instance, Hippoglossoides robustus is considered as an arctic-boreal species rather than predominantly boreal and Artedius australis as predominantly arctic rather than predominantly boreal. Species with arctic, predominantly arctic, or arctic-boreal distributions composed 41% of the 242 species in the region, and predominantly boreal, boreal, and widely distributed species composed 59%. For unique continental shelf species, such as the primarily amphihaline Euphausiidae species and Leptoceras mariae, distributions appear to reflect changes, including recent Arctic sea ice reestablishment of continuous ranges, but zoogeographers believe they have been going on since the end of the last glacial period.
Collection localities for samples in the Arctic fish DNA barcode database (C.W. Mecklenburg, PI)

1,214 tissue samples
188 species
Synonyms, supported by new data:
Arctogadus borisovi Drjagin, 1932 = Arctogadus glacialis (Peters, 1872)
Aspidophoroides bartoni Gilbert, 1896 = Aspidophoroides monopterygius (Bloch, 1786)
Careproctus dubius Zugmayer, 1911 = Careproctus reinhardtii (Krøyer, 1862)
Cottus groenlandicus Cuvier, 1829 = Myxocephalus scorpius (Linnaeus, 1758)
Eumicrotremus eggvinii Koefoed, 1956 = Eumicrotremus spinosus (Fabricius, 1776)
Gadus callarias marisalbi Derjugin, 1920 = Gadus macrocephalus Tilesius, 1810
Gadus ogac Richardson, 1836 = Gadus macrocephalus Tilesius, 1810
Gymnelus barsukovi Chernova, 1999 = Gymnelus viridis (Fabricius, 1780)
Gymnelus bilabrus Andriashev, 1937 = Gymnelus viridis (Fabricius, 1780)
Gymnelus knipowitschi Chernova, 1999 = Gymnelus hemifasciatus Andriashev, 1937
Gymnelus platycephalus Chernova, 1999 = Gymnelus hemifasciatus Andriashev, 1937
Liparis liparis bathyarcticus Parr, 1931 = Liparis bathyarcticus Parr, 1931
Lycodes vahli gracilis Sars, 1867 = Lycodes gracilis Sars, 1867
Lycodes vahli vahli Reinhardt, 1831 = Lycodes vahli Reinhardt, 1831
Lycodonus ophidium (Jensen, 1902) = Lycodonus flagellicauda (Jensen, 1902)
Myxocephalus scorpius groenlandicus (Cuvier, 1829) = Myxocephalus scorpius (Linnaeus, 1758)
Myxocephalus verrucosus Bean, 1881 = Myxocephalus scorpius (Linnaeus, 1758)
Myxine limosa Girard, 1859 = Myxine glutinosa Linnaeus, 1758
Melletes papilio Bean, 1880 = Hemilepidotus papilio (Bean, 1880)
Theragra chalcogramma (Pallas, 1814) = Gadus chalcogrammus Pallas, 1814
Theragra finnmarchica Koefoed, 1956 = Gadus chalcogrammus Pallas, 1814
Triglopsis quadricornis (Linnaeus, 1758) = Myxocephalus quadricornis (Linnaeus, 1758)
Ulcina olrikii (Lütken, 1877) = Aspidophoroides olrikii Lütken, 1877
Relationships needing further study:

*Cottunculus konstantinovi* Myagkov, 1991 = *Cottunculus microps* Collett, 1875?
*Cottunculus sadko* Essipov, 1937 = *Cottunculus microps* Collett, 1875?
*Gymnelus andersoni* Chernova, 1998 = *Gymnelus retrodorsalis* Le Danois, 1913?
*Gymnelus esipovi* Chernova, 1999 = *Gymnelus retrodorsalis* Le Danois, 1913?
*Gymnelus obscurus* Chernova, 2000 = *Gymnelus viridis* (Fabricius, 1780)?
*Gymnelus taeniatu*s Chernova, 2005 = *Gymnelus retrodorsalis* Le Danois, 1913?
*Liparis bristolensis* (Burke, 1912) = *Liparis tunicatus* Reinhardt, 1836?
*Liparis marmoratus* Schmidt, 1950 (in part?) = *Liparis tunicatus* Reinhardt, 1836?
*Lycodes rossi* Malmgren, 1865 = *Lycodes reticulatus* Reinhardt, 1835?
Fish species in Arctic Region (n = 242 species)

- Arctic: 41%
- Boreal: 59%

Fish species in Chukchi Sea (n = 78 species)

- Arctic: 40%
- Boreal: 60%
Marine fish species in the Chukchi Sea

1939

Boreal 54%
Arctic 46%

2011

Boreal 60%
Arctic 40%
RUSALCA Bottom Trawl Stations in Chukchi Borderland

- Chukchi Cap: 588 m
- Slope Sta 1: 370 m
- Slope Sta 2: 236 m

Locations include:
- Wrangel I.
- Bering Strait

Years covered: 2004, 2009
The TUNU-Programme: Euro-Arctic Marine Fishes – diversity and adaptation (TEAM-Fish) addresses biodiversity and ecological issues for conservation and reliable assessments of the marine fishes native to Euro-Arctic waters.

Workshop Purpose: The TEAM-Fish Workshop I was the first step towards a collaboration between ongoing and prospective research on Arctic marine fishes in the Euro-Arctic sector and the Far East through the RUSALCA programme (see abstract 1).

Workshop funding: Fram Centre
Workshop convener: Jørgen S. Christiansen, University of Tromsø, Norway

Selected abstracts

1. Catherine W. Mecklenburg, California Academy of Sciences, USA
Russian–American Long-term Census of the Arctic (RUSALCA): Atlantic fishes in the Chukchi Borderland
With the retreat of the Arctic sea ice in September 2009, the RUSALCA (Russian–American Long-Term Census of the Arctic) expedition reached north to the Chukchi Borderland, a region of complex seafloor topography that has barely been explored. It had rarely been sampled for fishes, and never by trawling from a ship. One tow of a small bottom trawl net at three sites at depths of 227–588 m was accomplished. We caught 12 species distributed among seven families (Gadidae, Cottidae, Psychrolutidae, Liparidae, Stichaeidae, Zoaridae, Pleuronectidae) and four orders (Gadiformes, Scorpaeniformes, Perciformes, Pleuronectiformes). These include the first record of Lycodes adolfi from the western Arctic, the first record of Arctedielius atlanticus between the western Laptev Sea and Baffin Bay, and rare records of Careproctus reinhardtii, Cottunculus microps, Triglops nybelini, and Lycodes seminudus from the Pacific
Russian–American Long-term Census of the Arctic (RUSALCA), 2009: Atlantic Fishes in the Chukchi Borderland

TEAM-Fish Workshop
University of Tromsø
Tromsø, Norway
7 November 2011

Presentation by C.W. Mecklenburg
Maps by T.A. Mecklenburg
Strong outflow of Pacific Water through Bering Strait
Atlantic Water circulation in the Arctic, 200–800 m
Classification of Species Taken by Otter Bottom Trawl in Chukchi Borderland, 2009

Gadiformes
- Gadidae (cods)
  - *Arctogadus glacialis*
  - *Boreogadus saida*
  - *Gadus chalcogrammus*

Scorpaeniformes
- Cottidae (sculpins)
  - *Artediellus atlanticus*
  - *Triglops nybelini*
- Psychrolutidae (fathead sculpins)
  - *Cottunculus microps*

Perciformes
- Stichaeidae (pricklebacks)
  - *Leptoclinus maculatus*
- Zoarcidae (eelpouts)
  - *Lycodes adolfi*
  - *Lycodes seminudus*

Liparidae (snailfishes)
- *Careproctus reinhardtii*
- *Liparis fabricii*

Pleuronectiformes
- Pleuronectidae (flounders)
  - *Reinhardtius hippoglossoides*

Species = 12
Families = 7
Orders = 4
6 species collected in the Chukchi Borderland are also found on the continental shelf

- **Leptoclinus maculatus**
  - Daubed Shanny
- **Liparis fabricii**
  - Gelatinous Seasnail
- **Reinhardtius hippoglossoides**
  - Greenland Halibut
- **Boreogadus saida**
  - Arctic Cod
- **Arctogadus glacialis**
  - Polar Cod
- **Gadus chalcogrammus**
  - Walleye Pollock
*Reinhardtius hippoclossoides*

**Greenland Halibut**

- **arctic–boreal**
- Pacific & Atlantic

**437 mm TL**

- Chukchi Borderland: 1 at 365–370 m
- Overall depth range: 14–2,000 m
- Demersal, benthopelagic

(amphi-Arctic, amphiboreal)
Gadus chalcogrammus
Walleye Pollock

Norway pollock

Chukchi Borderland:
1 at 365–370 m

Overall depth range:
Surface to 1,200 m
Demersal & pelagic

predominantly boreal Pacific
(amphi-Arctic)

392 mm TL
The other 6 species were found only in the Chukchi Borderland.
Atlantic Water circulation in the Arctic, 200–800 m
Careproctus reinhardtii
Sea Tadpole

Arctic species, mainly Atlantic, possibly circumpolar

RUSALCA 2009: 1 at 365–370 m (SL1)

Overall depth range: 100–1,840 m?
(Identification problem)
Benthic

170 mm TL
**Cottunculus microps**

**Polar Sculpin**

- **Chukchi Borderland:** 1 at 365–370 m
- **Overall depth range:** 159–1,450 m
- **Benthic**

**135 mm TL**

*arctic–boreal, mainly Atlantic, possibly circumpolar*
Artediellus atlanticus
Atlantic Hookear Sculpin

Chukchi Borderland:
5 at 227–236 m
2 at 365–370 m

Overall known depth range:
11–1,366 m
Benthic

arctic–boreal, mainly Atlantic, possibly circumpolar

142 mm TL
Lycodes adolfi
Adolf’s Eelpout

Nielsen & Fosså 1993

Chukchi Borderland: 4 at 580–588 m

Overall depth range: 386–1,880 m

Benthic

arctic, mainly Atlantic, probably circumpolar
Fishes of the Arctic Ocean and Adjacent Seas

A distributional atlas and identification guide to the Arctic marine ichthyofauna
DNA sequences (barcodes) indicate 4 distinct species of Liparis are present

- **Liparis fabricii**
  Gelatinous Seasnail

- **Liparis tunicatus**
  Kelp Snailfish

- **Liparis bathyarcticus**
  Arctic Seasnail

- **Liparis gibbus**
  Variegated Snailfish
Very close in appearance, yet they are genetically different.

*Liparis gibbus*
Variegated Snailfish

*Liparis bathyarcticus*
Arctic Seasnail
The Most Active Collaborators So Far

**Russia:**
- Oleg V. Karamushko, Murmansk Marine Biological Institute
- Boris A. Sheiko, Zoological Institute, St. Petersburg

**Norway:**
- Ingvar Byrkjedal, Bergen Museum
- Jørgen S. Christiansen, University of Tromsø
- Arve Lynghammar, University of Tromsø
- Camilla Ottesen Meyer, University of Tromsø

**Denmark:**
- Peter R. Møller, Zoological Museum, University of Copenhagen

**Canada:**
- Dirk Steinke, Barcode of Life, University of Guelph
- Danny Kent, Vancouver Aquarium

**U.S.:**
- Brenda A. Holladay, University of Alaska Fairbanks
- Milton Love, University of California, Santa Barbara
- T. Anthony Mecklenburg, Point Stephens Research, Alaska
**Family: Agonidae — Poachers**

**Aspidophoroides olrikii**

- Head large, more than 20% of body length
- Body robust
- One dorsal fin
- Short barbel on posterior end of maxillae
- Less than 35 lateral line plates
- One row of plates above lateral line
- Mature males have white blotch on posterior portion of dorsal fin

- Most likely to be confused with alligatorfish *Aspidophoroides monopterygius*. One of the most reliable distinguishing features is the relatively large head and robust body of *A. olrikii*.
- Chalky white or pini marks appearing on the back or head of some individuals are highly variable in presence, shape and location and not helpful for identification.
- In small juveniles the distal portion of each pectoral fin is black, but this is also the case in *A. monopterygius*.

**Arctic alligatorfish**

- 77 mm female
- 54 mm juvenile male
- 74–77 mm: UAM 5813, northeastern Chukchi Sea, barcode ID OSHOS8-56
- 54 mm male: UAM 5727, northeastern Chukchi Sea, barcode ID OSHOS8-38
- 74–77 mm: PIR 442, northeastern Bering Sea, 2006
- 39 mm: UAM 1873, northeastern Chukchi Sea, 2007

By C.W. Mecklenburg

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Guide to Marine Fishes of the Northern Bering, Chukchi & Beaufort Seas
Mecklenburg et al., DRAFT — Do not duplicate or distribute. Rev 25 Jan 2012
Agonidae — Poachers

*Aspidophoroides olrkii* Lütken, 1877  Arctic alligatorfish

French name: poisson-alligator arctique
Norwegian name: arktisk pamerulke
Russian name: (ledovitomorskaya lisitchka)

**Distribution:** Predominantly Arctic, nearly circumpolar; southern Barents Sea and White Sea eastward to west Greenland, southward to northern Bering Sea and the Newfoundland banks.

**Habitat:** Benthic, found at depths of 7–520 m, usually < 100 m; temperatures mostly below 0°C; salinity 33–35‰; mostly on muddy and muddy-sandy substrate.

**Identifying features:** Brownish to greenish brown on back and upper sides fading to white below; three darker saddle bands or blotches and dark band around base of caudal fin, dorsal fin blackish; anal and pelvic fins white; caudal fin blackish brown with white area in center and white along margin. Posterior area of dorsal fin chalky white in males. Bands are darker and more distinct in juveniles. Body elongate and robust; mouth terminal; head broad, large, more than 20% of standard length.

**One dorsal fin** (the first is absent), with 5–7 rays, opposite anal fin with 5–7 rays. Plates on body and top of head flat, without spines or keels; suprapteral row of plates absent, leaving one row of plates above lateral line row; single row of plates along midline of breast. Nasal spine (paired) present, nearly indiscernible to well developed. **Short barbel on posterior end of maxilla.** Small juveniles (about 40 mm or less) differ from the adults by having pectoral fins with a narrow blackish band in the middle and broad blackish distal portion, spine-like keels on the plates, a projecting lower jaw, and the anus situated farther posteriorly.

**Life history:** Females spawn 110–250 eggs about 1.7 mm diameter on the seafloor (Andriashev 1986). Up to 250 well developed eggs as well as numerous smaller eggs have been observed present in ovaries (Frost and Lowry 1993). **Adults attain 89 mm total length** (Andriashev 1961). Largest of 140 *A. olrkii* taken in bottom trawls in the Chukchi Sea in 1973, 2004, and 2009 was 76 mm.

**Diet:** Small benthic invertebrates including gammarid amphipods, polychaete and nemertine worms, and ostracods. Eaten by halibuts (*Hippoglossus*) and other bottom fishes.

**Relative abundance in arctic region:** The most abundant poacher in bottom trawl surveys of the Chukchi and Beaufort Seas, where this species has ranked 5–12th in abundance by number of fish caught in research sampling (e.g., Frost and Lowry 1983, Mecklenburg et al. 2007, and unpublished catch records from 1973 and 2009 cruises). Uncommon to rare in northern boreal (subarctic) waters. In the Gulf of St. Lawrence was found at only 3% of the stations (Noëcres et al. 2010). In the Bering Sea, rare south of St. Matthew Island, only one or two records (Mecklenburg et al. 2011).
**Family: Agonidae — Poachers**

*Aspidophoroides oikiki* Lütken, 1877  *Arctic alligatorfish*

**French name:** poisson-alligator arctique  
**Norwegian name:** schnittipanenlue  
**Russian name:** lodo-guselnaya lisitsa

**Distribution:** Predominantly Arctic, nearly circumpolar: southern Barents Sea and White Sea eastward to west Greenland, southward to northern Bering Sea and the Newfoundland Banks.

**Habitat:** Benthic, found at depths of 7–220 m, usually < 130 m; temperatures mostly below 6°C; saline 33–35‰; mostly on muddy and muddy-sandy substrates.

**Identifying features:** Brownish to greenish brown on back and upper sides fading to white below; three darker saddle bands or blotches and dark band around base of caudal fin; dorsal fin blackish; anal and pelvic fins white; caudal fin blackish brown with white areas in center and white along margin. Posterior area of dorsal fin chalky white in males. Bands are darker and more distinct in juveniles. Body elongate and robust; mouth terminal; head broad, large, more than 20% of standard length.

**Life history:** Females spawn 110–250 eggs about 1.7 mm diameter on the seafloor (Andriashev 1998). Up to 266 well-developed eggs as well as numerous smaller eggs have been observed present in caves (Troft and Lowry 1903). *Adults attain 89 mm total length* (Andriashev 1964). Largest of 143 *A. oikiki* taken in bottom trawls in the Chukchi Sea in 1973, 1994, and 2009 was 76 mm.

**Diet:** Small benthic invertebrates including gammarid amphipods, polychaetes and nemertine worms, and ostracods. Eaten by halibut (*Hippoglossus*) and other bottom fishes.

**Relative abundance in arctic region:** The most abundant poacher in bottom trawl surveys of the Chukchi and Beaufort Seas, where this species has ranked 5–17th in abundance by number of fish caught in research sampling (e.g., Frost and Lowry 1983, Mecklenburg et al. 2007, and unpublished catch records from 1993 and 2009 cruises). Uncommon to rare in northern Barents (subarctic) waters. In the Gulf of St. Lawrence was found at only 3% of the stations (Neustroev et al. 2010). In the Bering Sea, rare south of St. Matthew Island, only one or two records (Mecklenburg et al. 2013).

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**Aspidophoroides oikiki**

- **7 mm female:** IAM 1881, northeastern Chukchi Sea, substrate ID DSH-008-56  
- **54 mm male:** IAM 3791, northeastern Chukchi Sea, substrate ID DSH-008-36  
- **76–77 mm:** PSR 462, northeastern Bering Sea, 2005  
- **39 mm:** IAM 1887, northeastern Chukchi Sea, 2007

*All by C. W. Mecklenburg*

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**Arctic alligatorfish**

- **77 mm female**
- **54 mm juvenile male**
- **39 mm juvenile male**

*Guide to Marine Fishes of the Northern Bering, Chukchi & Beaufort Seas*  
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26 January 2012

**Taxonomic status:** Not currently identified as problematic. *Aspidophoroides gantneri* Bean, 1885 was described as a separate new species from Alaska but was later shown to be the same as *A. otrikii* (Rendahl 1931). Classified for a time in *Ulna*, this species was recently returned to *Aspidophoroides* (Mecklenburg et al. 2011).

Collection localities for barcoded specimens from the northern Bering Sea, the East Siberian, Chukchi and Beaufort Seas are given in Appendix X.

**Taxonomic Serial Number:** 692156

**Commercial significance:** Not commercially fished.

**Notes on Distribution:** Not known from the Canadian high Arctic archipelago, northern Baffin Bay, east Greenland to Norwegian Sea and northern Barents Sea (Mecklenburg et al. 2011). In bottom trawl surveys of the Barents Sea during 2004–2009, was found only in the eastern part off Novaya Zemlya (Wienerroither et al. 2011). The presence of a single record (UAM 1171, confirmed by CWM) indicates a disjunct population in Prince William Sound, northern Gulf of Alaska, perhaps a relic of former colder times (Mecklenburg et al. 2011).

**Notes on Habitat:** To 250 m in the Canadian Arctic at Bathurst Inlet, 400 m in the Beaufort Sea off Alaska (Frost and Lowry 1983), 200–300 m in Barents Sea (Andriashev 1986). The extreme depth of 520 m is from the Kara Sea (Andriashev 1986). At temperatures of 2–3°C in the White Sea and western Greenland (Andriashev 1986). At salinities of 23–28‰ in East Siberian and White Seas (Andriashev 1986). At ~1.7°C and salinity of 33.32 to 7.9°C and salinity of 31.30 in the Chukchi Sea in 2004 (Mecklenburg et al. 2007); in 2009, ______.

**Selected References:**

- Frost and Lowry 1983; Mecklenburg et al. 2002:552; Mecklenburg et al. 2007; Mecklenburg et al. 2011:Suppl. 5 page 29-30; Nozères et al. 2010. See also:
  - Kanayama T (1991) Taxonomy and phylogeny of the family Agonidae (Pisces: Scorpaeniformes). Mem Fac Fish Hokkaido Univ 38(1.2)
RUSALCA 2012: Fish Diversity & Otter Trawling

Cruise objectives for 2012 are the same as for 2009, slightly modified:

1) Deploy the otter trawl at selected stations sampled in 2009, omitting those that were nonproductive in terms of species diversity, and trawl twice rather than once at some other stations.

2) Document the catch by preserving examples of each species caught and archiving them in the PIs’ museums’ permanent fish collections (CAS, UAM, ZIN).

3) Obtain tissue samples for DNA sequencing. Analyses in addition to barcoding will be conducted. All tissue-sampled fishes need to be photographed and archived to provide proper documentation.

4) Collect specimens for taxonomic research. Natalia and I need specimens for study of morphological characters, not just for archiving as species identification vouchers.

5) Photograph live and fresh specimens to fill remaining gaps in the atlas & guide. There are still a lot of gaps.