Harvesting zooplankton – experiences from Iceland

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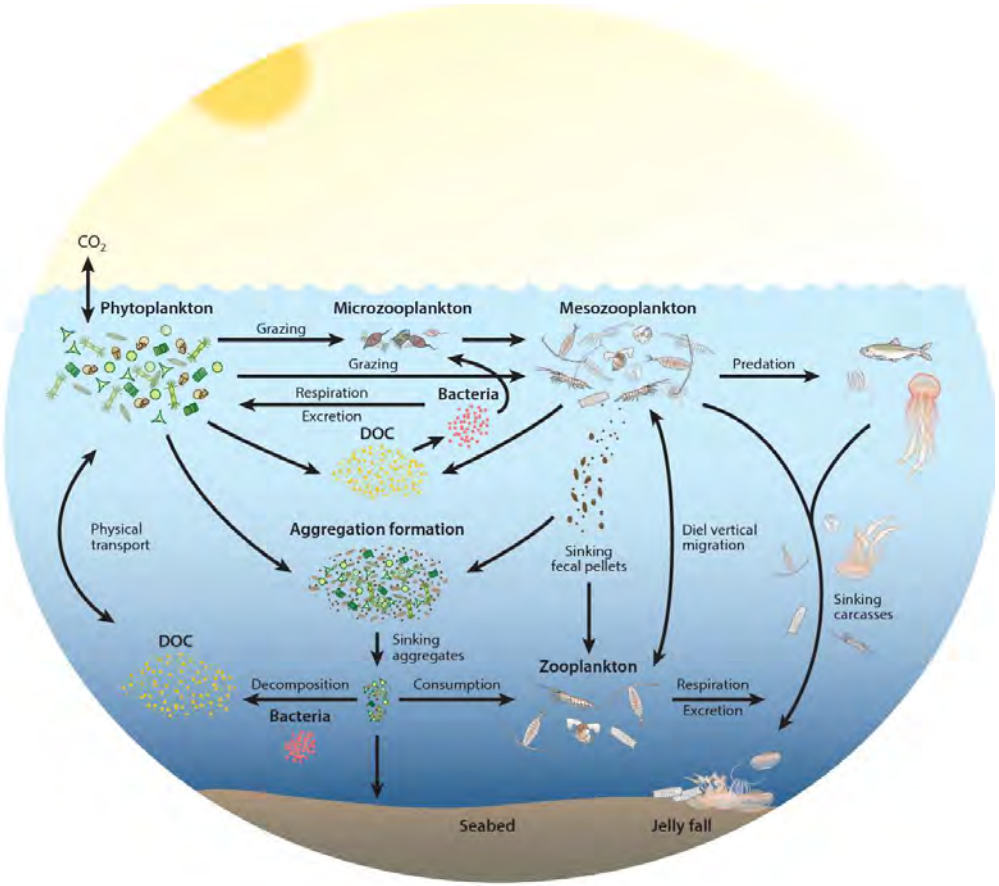
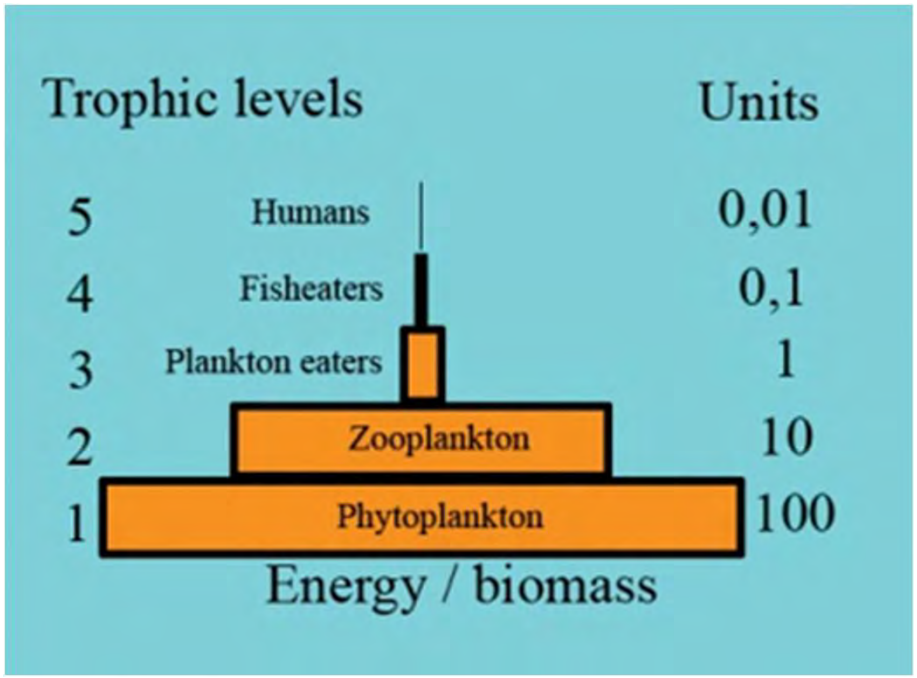
Ecological role of zooplankton



- Conveyors of energy between primary producers and species at higher trophic levels
- Important part in the biological Carbon pump: Conveyors of Carbon from atmosphere to deeper layers
- The ocean interor may store 20 times more organic matter than land
- Most important mesozooplankters: Calanus spp. and krill

Steinberg and Landry (2017)

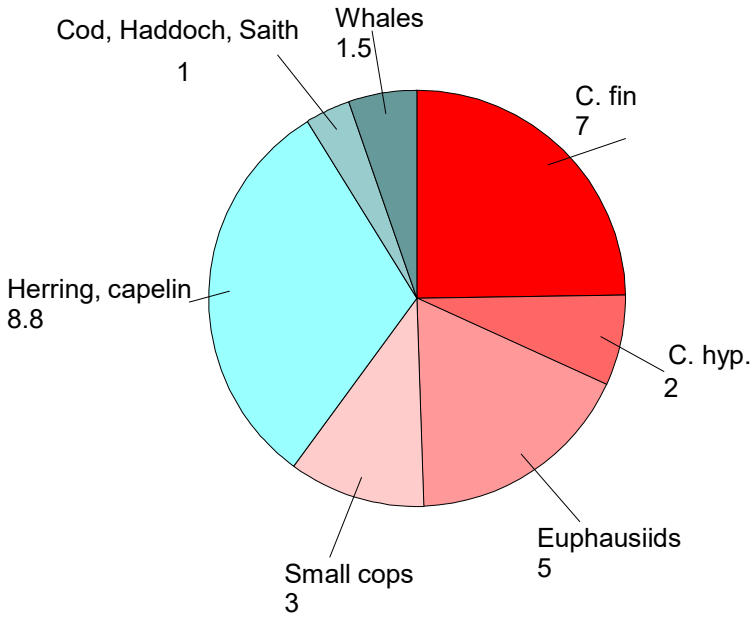
Why harvest on lower trophic levels?



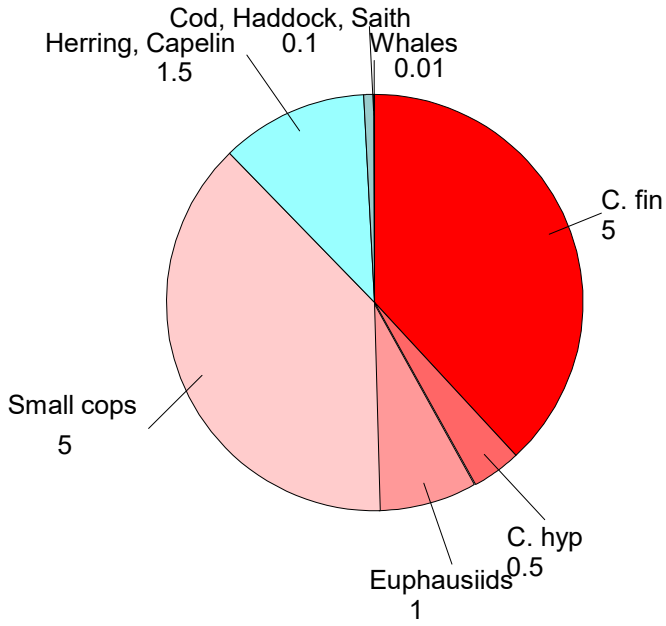
- Each trophic level transfers ~10% of its energy to the level above
- More energy available at the lower trophic levels
- Zooplankton oil is unique (high content of omega-3 FAs as wax esters)
- Pharmaceuticals, ingredient in human food (flavour, health), cosmetic products, food for aquaculture industry
- Total primary production in the oceans similar to that on land (even though the oceans cover ~70% of the globe)
- Only a small part of the food of man derives from the oceans (~2% of calories, 15% of proteins, FAO 2017)
- Most fish stocks fully exploited
- Zooplankton harvesting should be considered

Biomass and production within Icelandic 200 mile Exclusive Economic Zone (EEZ)

Lífmassi (10^6 tonnes WW $year^{-1}$)



Production ($gC\ m^{-2}\ year^{-1}$)



- Zooplankton biomass more than half of the total
- Production of zooplankton far exceeds that of other groups (>80%)

(Astthorsson et al 2007)

Main groups that have the potential of being harvested in Icelandic waters: Calanus and krill

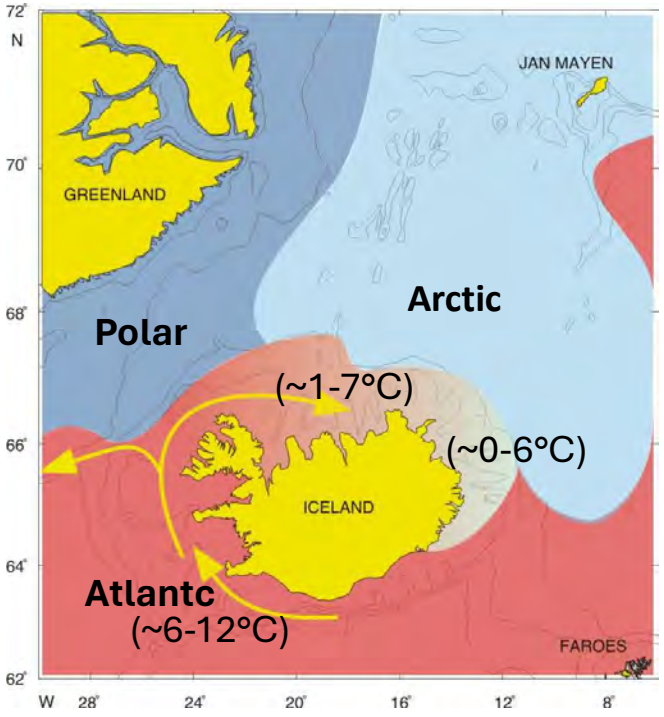
Annual biomass and production within the Icelandic 200 mile Exclusive Economic Zone (Astthorsson et al 2007)

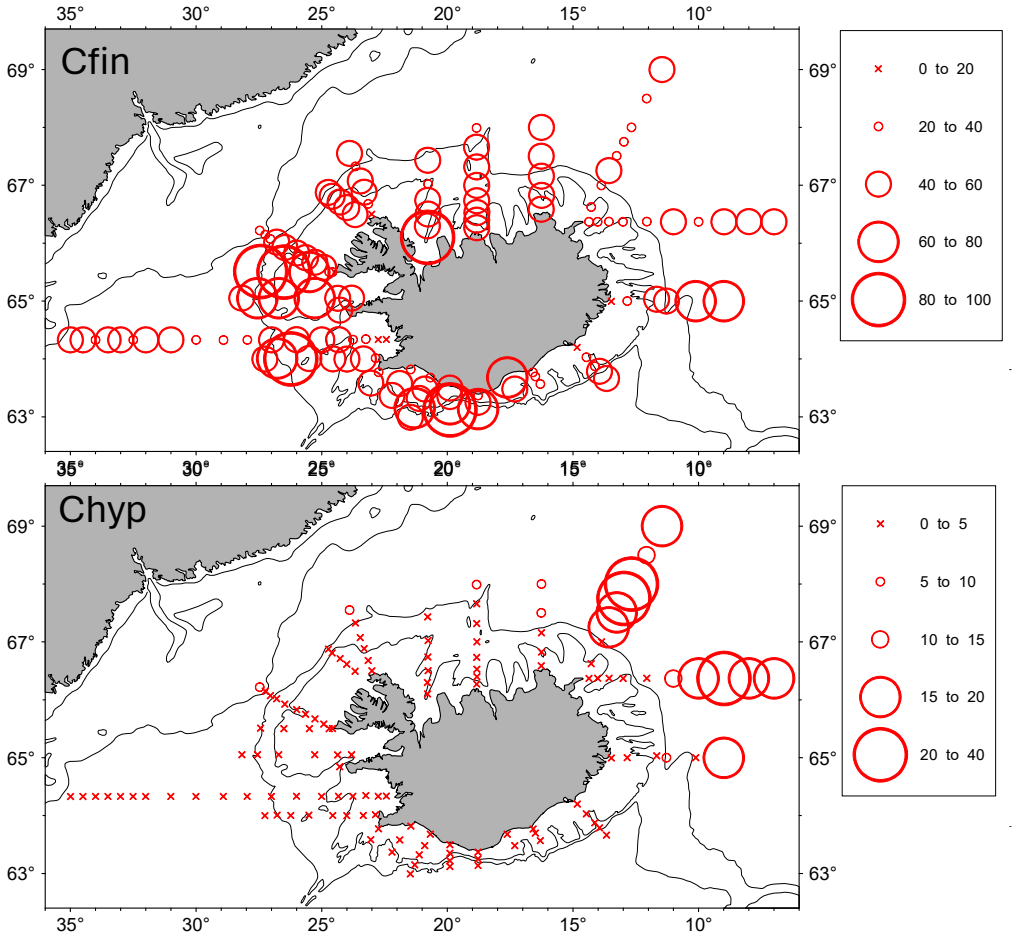
	Biomass WW (10^6 tonnes)	Production WW (10^6 tonnes)
Cfin	7	28
Chyp	2	3
Krill	5	7,5

- Annual production of Cfin ~19 x the yearly catch of all fish species off Iceland (~1.5 x 10^6 tonnes)

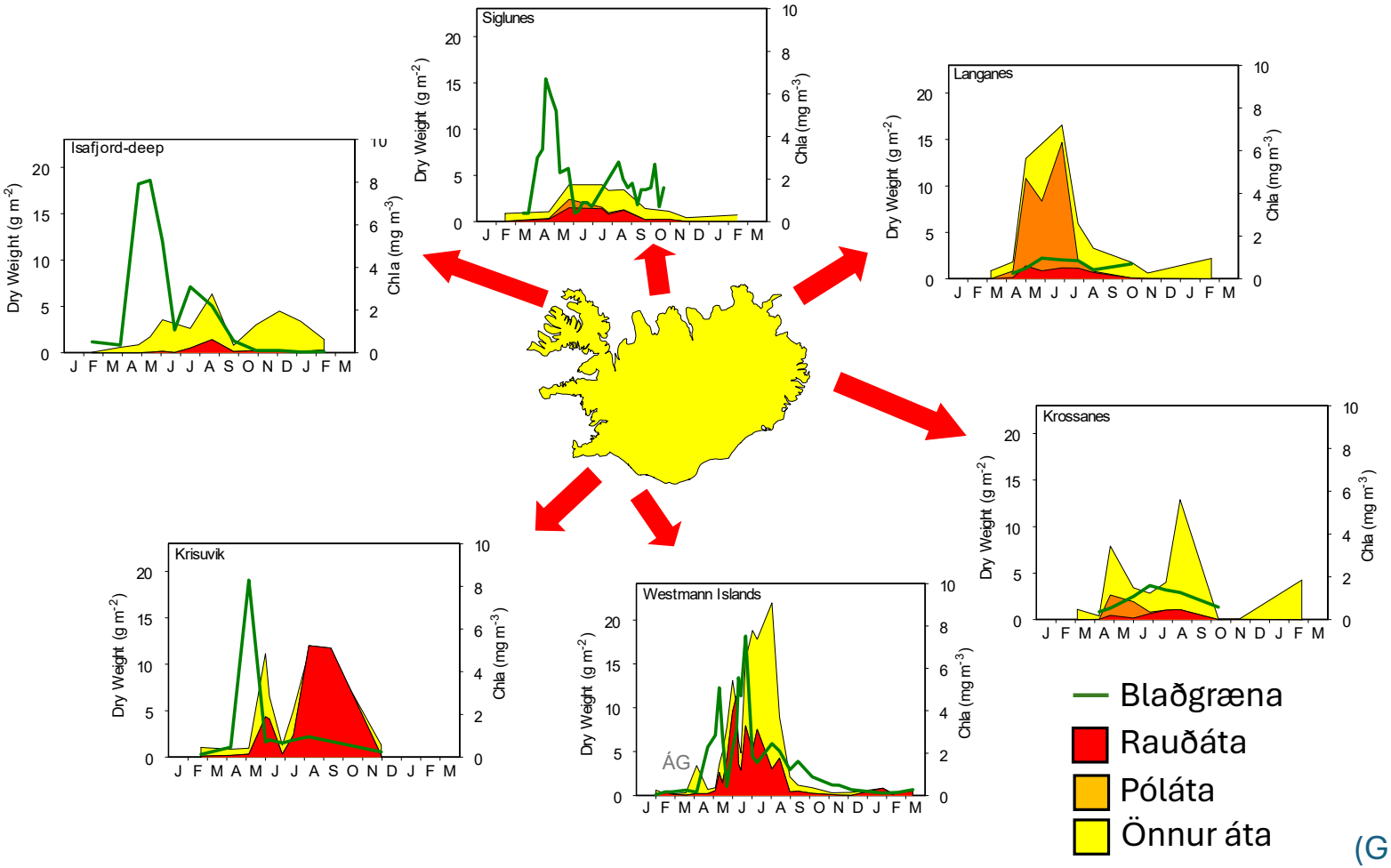
(Astthorsson et al 2007)

Calanus spp.: Environment and distribution



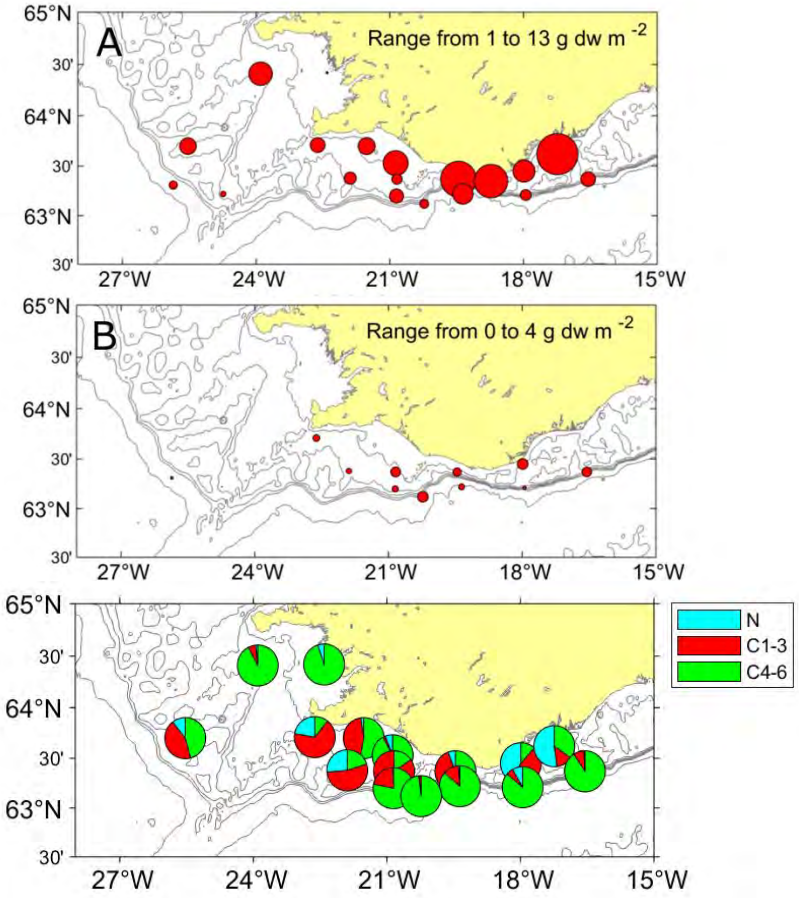


Seasonal abundance in surface waters (0-100 m)



(Gislason et al. 2002)

Exploratory survey for Cfin (June 2012)



Aim

- To explore if Zooca-Calanus methodology to catch Calanus can be used off Iceland

Results

- *Calanus* is harvestable by the methods used by Zooca
- June and July most suitable for harvesting
- Biomass greatest on the shelves
- Most of the stock (>80%) in the upper 50 m
- Older stages (C4-6) generally dominate – spawning still on-going
- By-catch (fish larvae) mainly nearest to the coast
- Importance of monitoring by-catch is emphasized

(Gislason et al 2021)

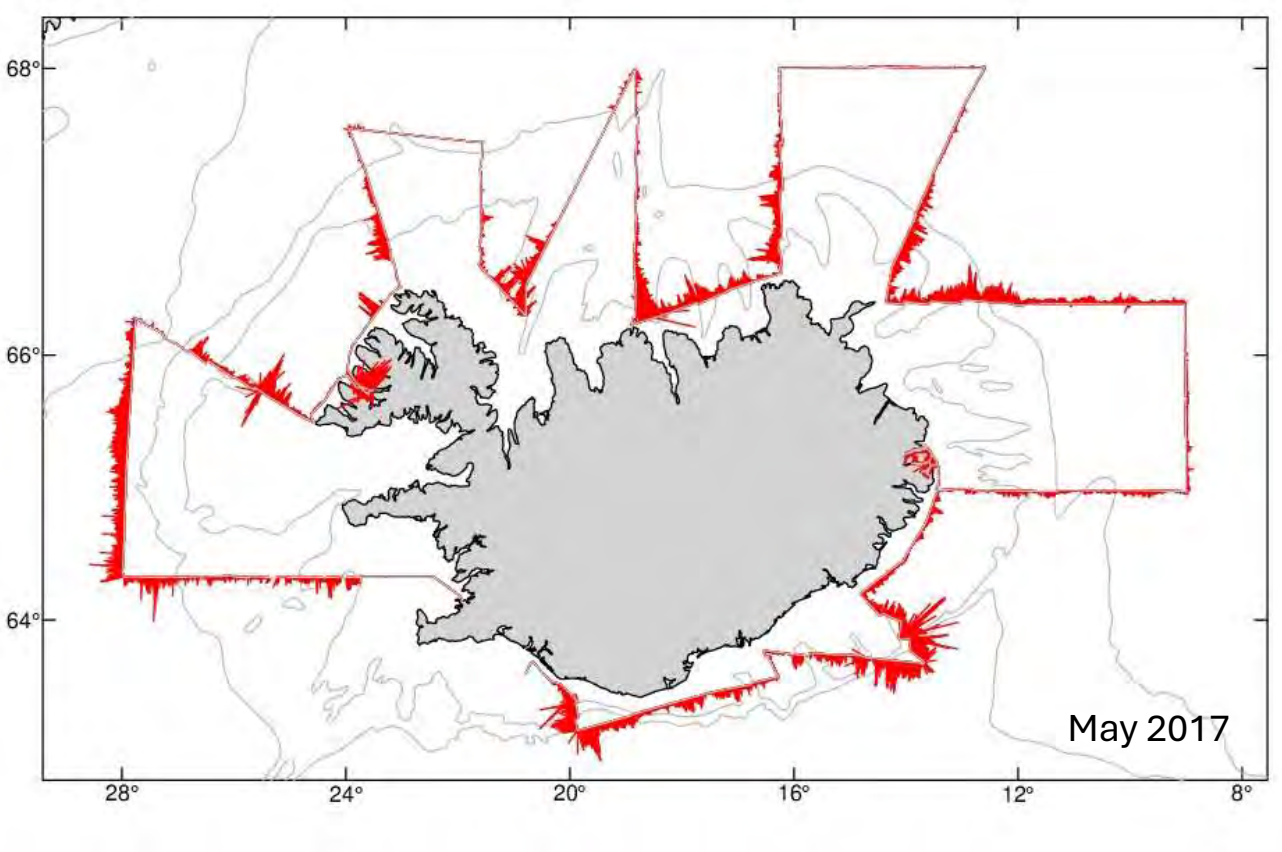
Exploratory survey for Cfin (June 2012)

Allowance to harvest Calanus SW of Iceland (Jan 2013)

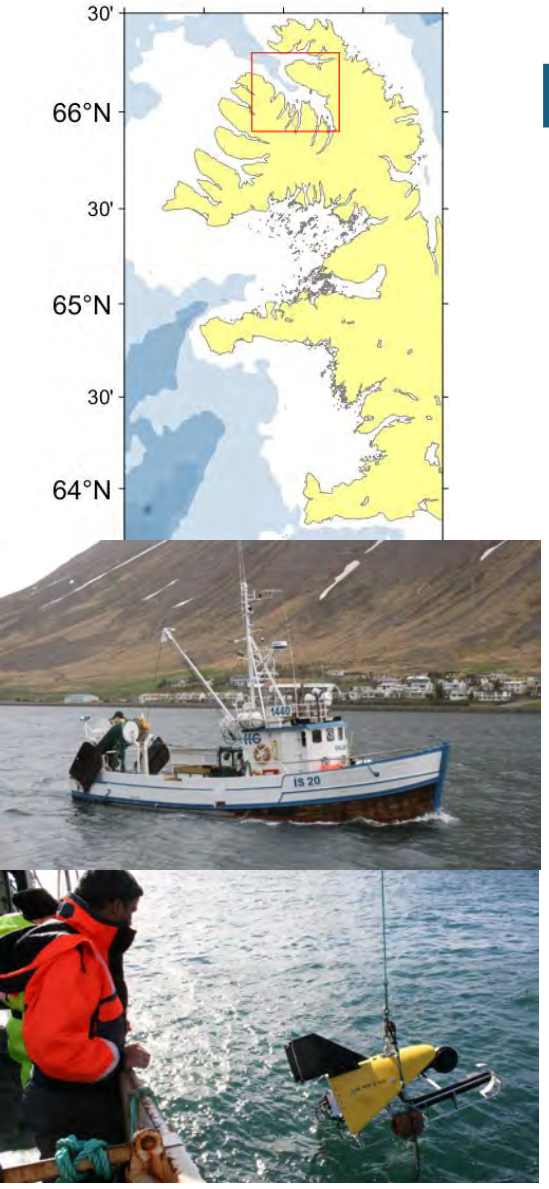
- Applicant: Hraðfrystihúsið Gunnvör Ltd, request for harvesting 300 tons during summer 2013
- MRI assessment (Feb 2013): save to catch 300 tons – adopted by the Ministry
- Arguments and requirements:
  - The mean annual biomass of C. finmarchicus within the Icelandic 200-mile exclusive economic zone ~7 million tons wet weight (Astthorsson et al 2007)
  - More than half of this south and west of Iceland
  - MRI concluded that it would be safe to catch 300 tons south and west of Iceland
  - The areas selected for fishing should be determined in co-operation with MRI
  - Monitoring of by-catch an integrated part of the exercise with skilled observers on board
- The fishery never realized

Krill distribution monitored annually in May

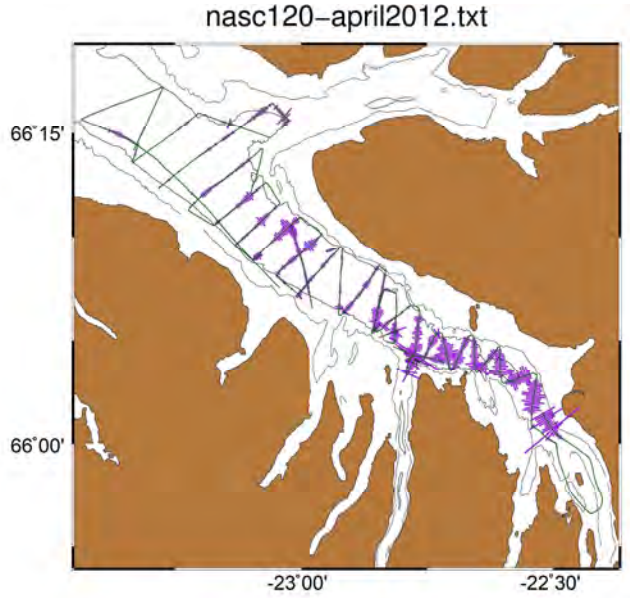
- Most abundant in fjords, over edges and clefts/valleys of the continental shelf
- Four main species:
  - M. norvegica shelf edges
  - T. inermis, shelf
  - T. longicaudata, oceanic
  - T. raschi, fjords

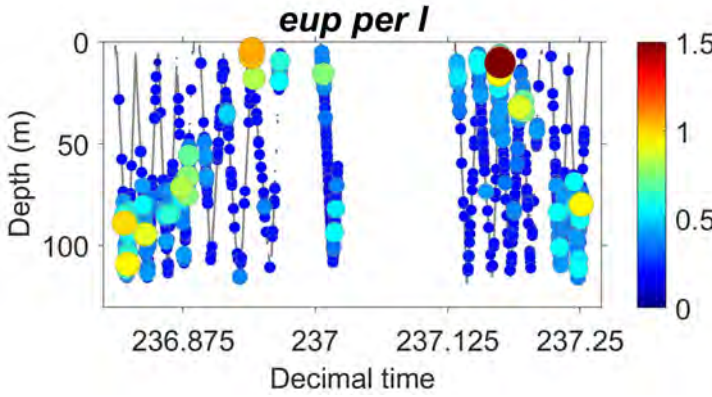


Krill in Ísafjarðardjúp 2011-12



- 5 cruises in August 2011-August 2012
- Acoustics (38, 70, 120, 200 kHz), nets and VPR
- Biology and chemical composition
- *T. raschi* main species
- Highest densities in the middle trough (>100 m)
- Annual mean biomass ~40 thousand tonnes (annual production ~60 thousand tonnes)
- August-September best months for the fishery (lipid- and protein content high and by-catch at minimum)
- Day-time most suitable for fishing (when the krill occur in dense layers relatively deep)





Fishing experiments

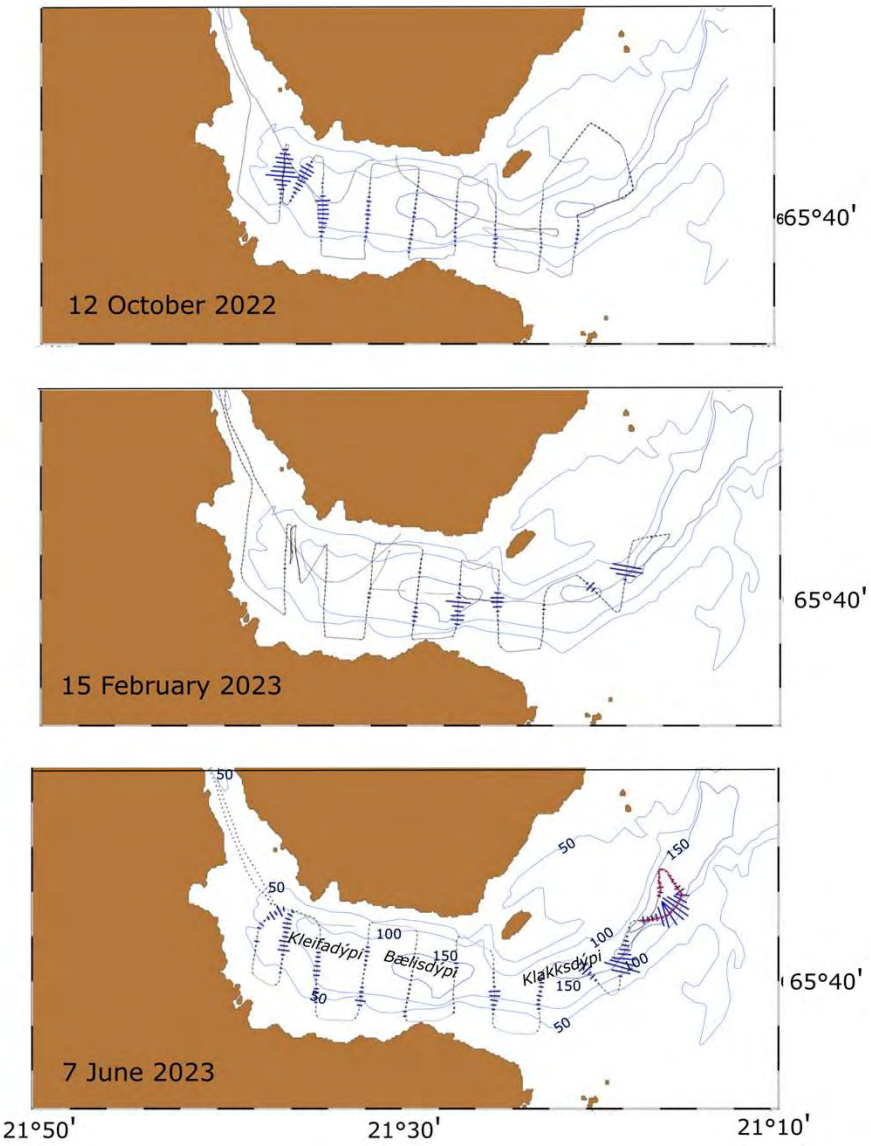
- Krill trawl (Tor-Net, 8 mm mesh size in whole trawl, opening 16 m^2)
- Total catch (8 tows in 2013): ~2 tonnes
- Catches: 104-348 kg/h
- Experiments with processing the catch (drying)

Exploratory fishery of krill in Ísafjarpardjúp using a pumping system (2018)

- Krill pumped up to ship by a special pumping system fitted with lights to attract krill
- Permission to fish for a limited time period (3 weeks, later extended to 2 months)
- Total catch not fixed but MFRI can stop the fishery at any time
- Observers requested to be on board
- Two experiements conducted in July and Sept-Oct 2018
- Krill swarms located by acoustics
- The catch processed on-board into meal and oil
- Total catch for the season (~30 d) ~17 tonnes

Krill surveys in Steingrímsfjörður

- 6 cruises (2021-23)
- Acoustics (38, 70, 120, 200 kHz), nets and VPR
- Biology and ecology
- Highest densities in the middle trough (>100 m)
- Annual mean biomass ~10 thousand tonnes wet weight (annual production ~15 thousand tonnes)



Some thoughts in the end

- New harvesting technology is emerging and other stocks fully utilized => increased interest in harvesting zooplankton
- Adoption of an Icelandic management plan for harvesting is needed
- Precautionary approach:
  - Need better data on stock sizes, production and trophic role
  - How do the stocks respond to fishery?
  - How do predators respond to fishery?
  - What is the by-catch? – effect on affected stocks?
- Is fishing at lower trophic levels bad? cf. fishing down the food web“ (e.g. Pauly et al. 1998, Science)
- Or should we aim at a „balanced“ fishery? „Balanced harvesting over a broad range of species, stocks and size groups would be more ecological correct than a focus on a few large single fish stocks“ (Garcia o.fl. 2012, Science)