# Kelp forest recovery in previous sea urchin barrens; rebuilding of ecosystem functioning

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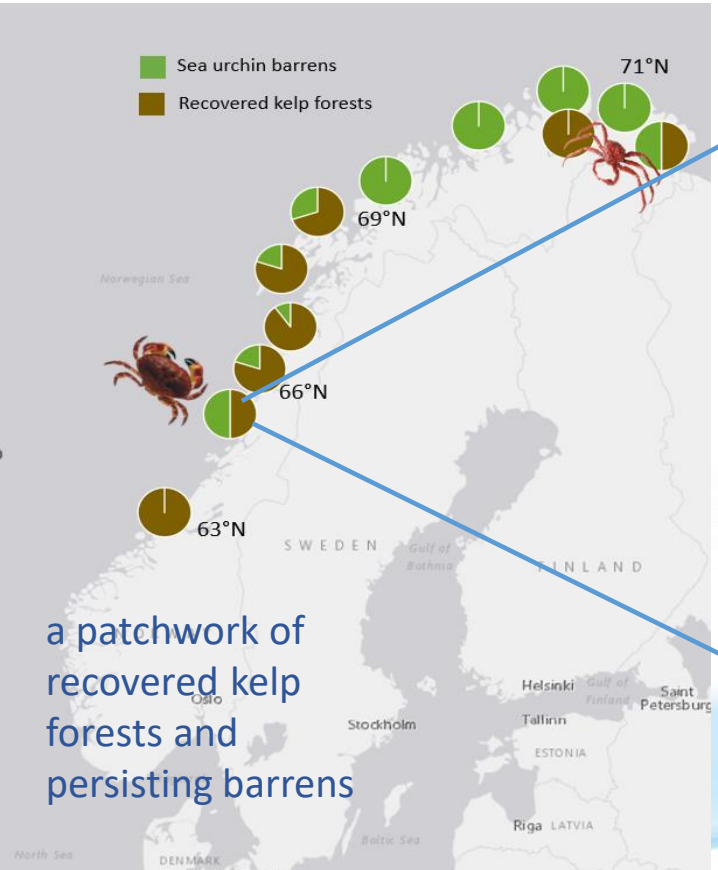
# Ocean warming causes kelp recovery in Norway

Still extent barrens in northern Norway (since 1970s), but some kelp forests are in recovery due to ocean warming in the south (-urchins/+ predator crabs) and caused by the invasive red king crab in the north

# The climate-change related kelp recovery provides an excellent opportunity to study the transition from barrens to kelp forests




a patchwork of recovered kelp forests and persisting barrens

We have studied **structure** and **functioning** of barrens and recovered kelp forests, north of Vega, Norway

# Questions

- **How do barrens and recovered kelp forest ecosystem differ** with respect to species diversity, community structure and functional diversity?
- Does a **recovered sugar kelp** (*Saccharina latissima*) forest represent **a fully recovered ecosystem** – or does it need time to rebuild its naturally occurring diversity and functioning?

- We know that the long-lived tangle kelp (*Laminaria hyperborea*) needs time to recover its climax ecosystem diversity and functioning (from studying recovery in kelp trawled areas), however, **sugar kelp is more short-lived and opportunistic**. Hence it could be that a newly recovered sugar kelp forest function like an intact sugar kelp forest.

# Overview of surveys

**Kelp and sea urchin density** (scuba diving)

At 1, 5 and 10 m depth; 10 repl. at the 3 barren sites, and 6 repl. at kelp recovered sites. Frame size: 0.5x0.5 m.

**Invertebrate fauna communities** (scuba diving)

Fauna traps (4 repl) placed within 3 barren sites and 3 recovered kelp forest sites

**Sugar kelp assosiated fauna** (scuba diving)

3 kelp plants from 3 recovered kelp forests, in 2014 and 2017, (sieved at 250µ)

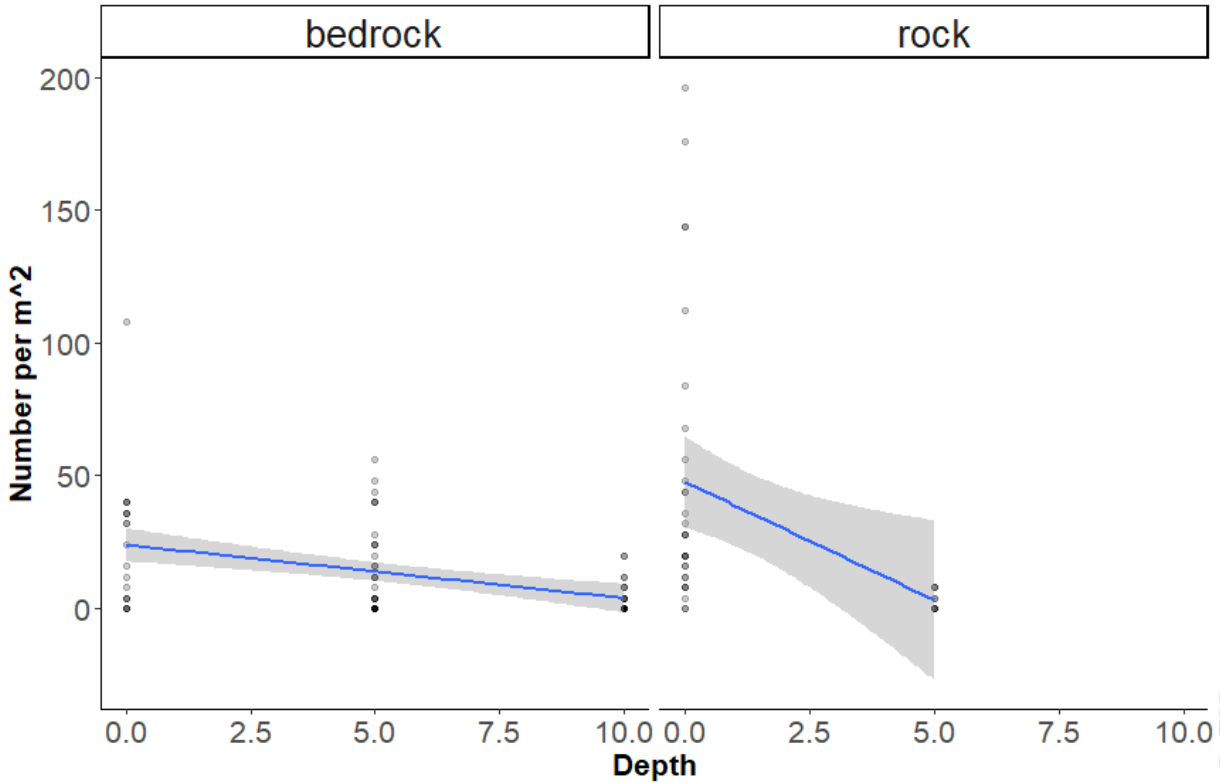
**Fish and scavenger species**

Three types of gill nets, 1 repl. in 3 barrens and 3 recovered kelp forests in 2015

**Cod diet**

Cod stomach analysis – 34 and 26 stomaches from cod caught in kelp forest and barrens resp.

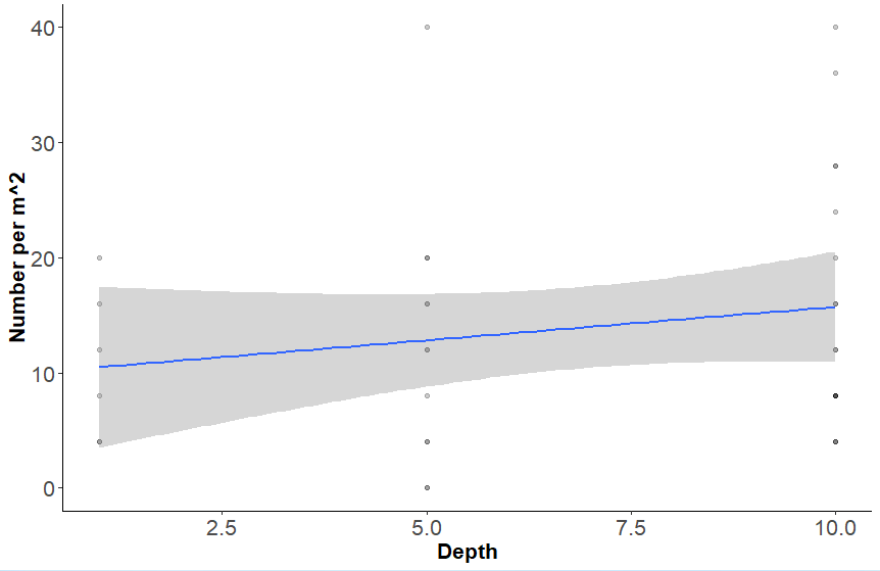
# Sea urchin density varies with depth and substrate



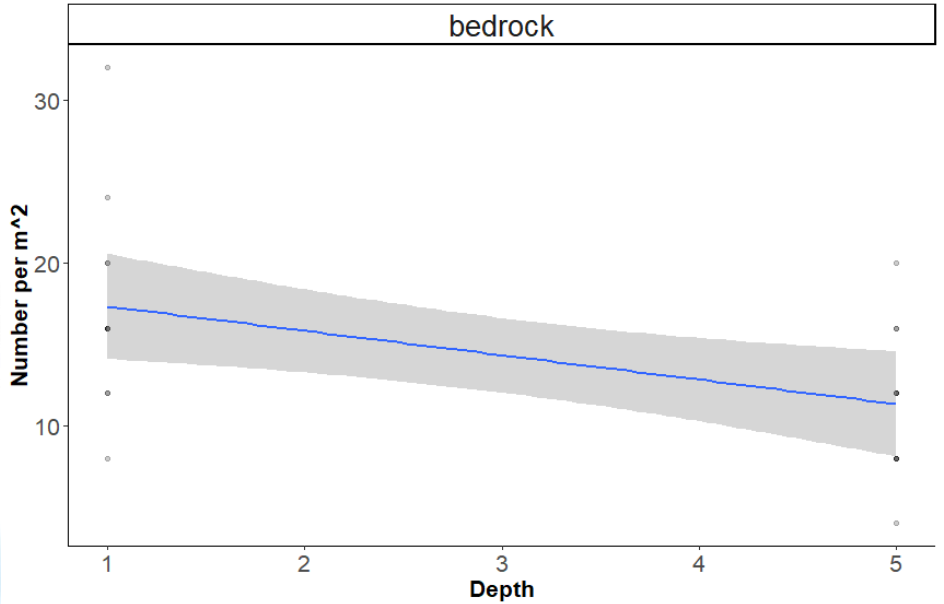

10 replicates at barrens, and 6 replicates at kelp sites, 0,5 x 0,5 m frames

# Kelp recovery varies with depth, and kelp species

Recovery (abundance) of sugarkelp increases with depth, and occur on both bedrock and rocks




Tangle kelp only recover in the shallow part (0-5 m), and on bedrock. Abundance decreases with depth

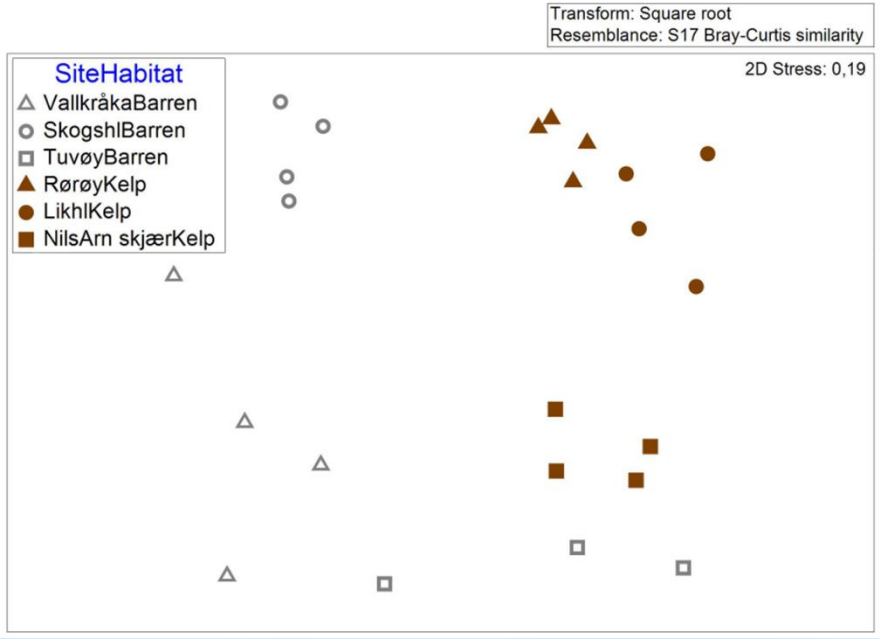


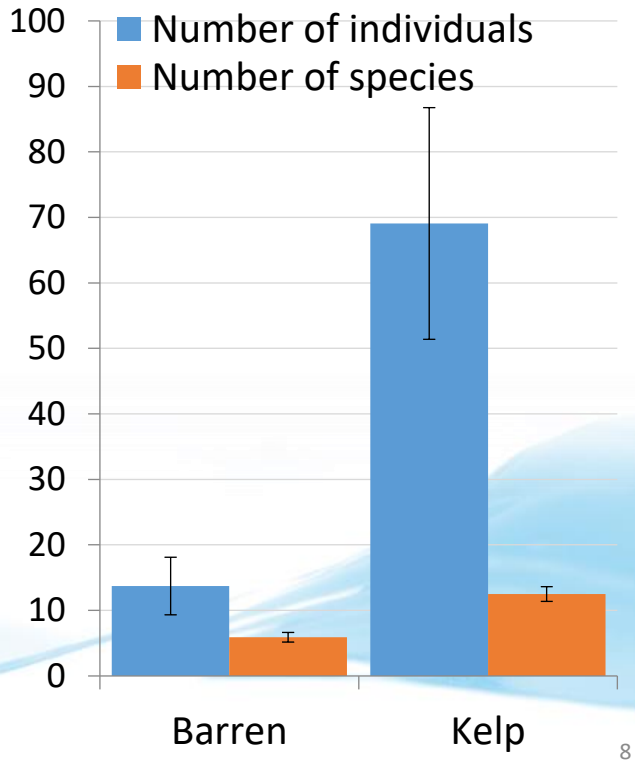
# Higher abundance and diversity of invertebrate fauna in the recovered kelp forest

Based on fauna traps, 4 repl. per site

Community structure: sign. differences between sites.

The impact of habitat type varies among sites.




Significantly **higher diversity (2X)** and **abundance (7X)** of fauna in the kelp forests

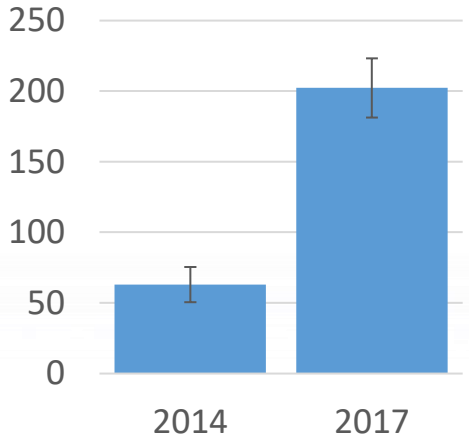
# Sugar kelp associated fauna, increased abundance and diversity over time

**Abundance** increased from about 7 000 to 22 000 individuals per $m^2$

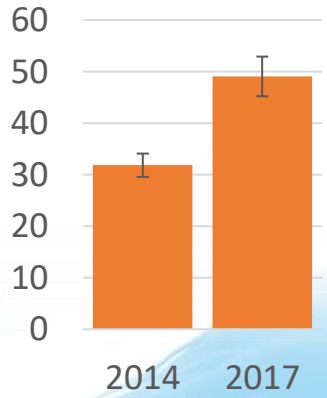
Average **number of species** increased from 30 to 50.

**Total number of species**: 117

Abundance, no. individuals per $m^2$ of sugar kelp leaf areas



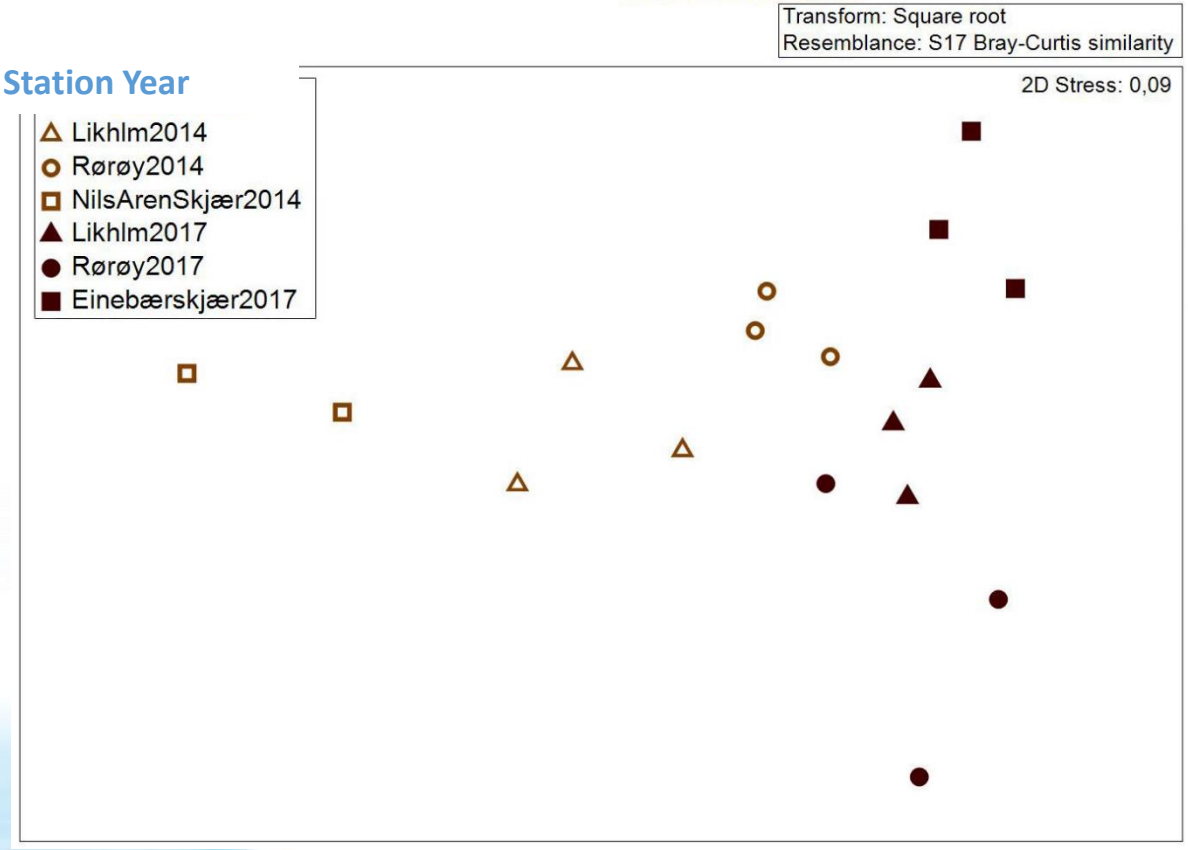

Number of species per sugar kelp plant



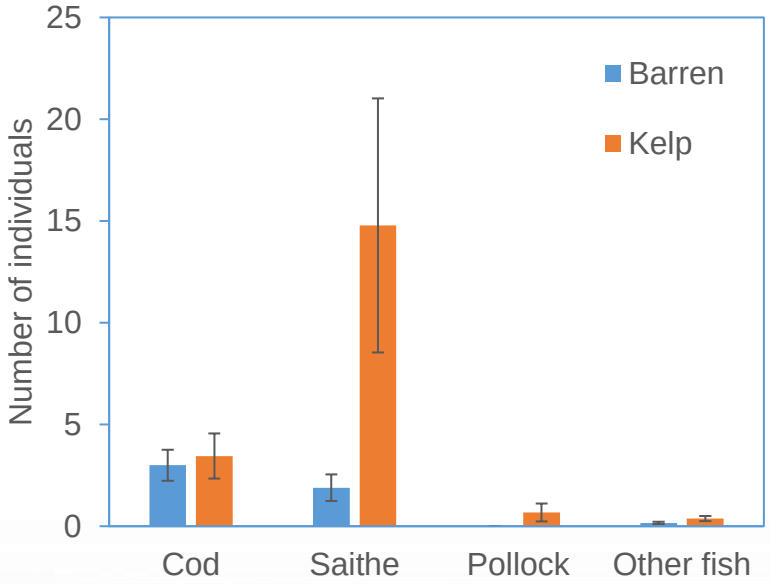
# Sugar kelp associated fauna community structure changed from 2014 to 2017

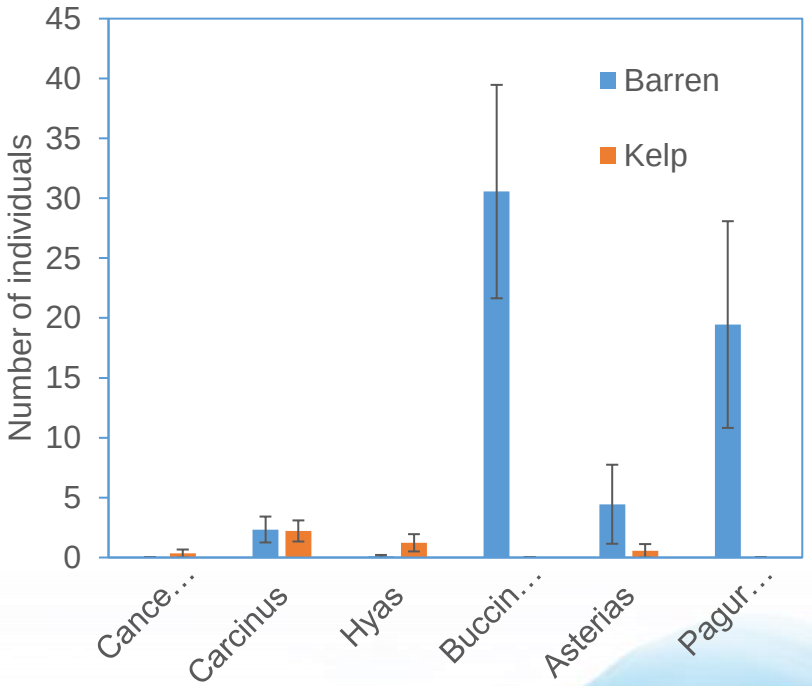
Sign. differences between sites.

The impact of year varies among sites.



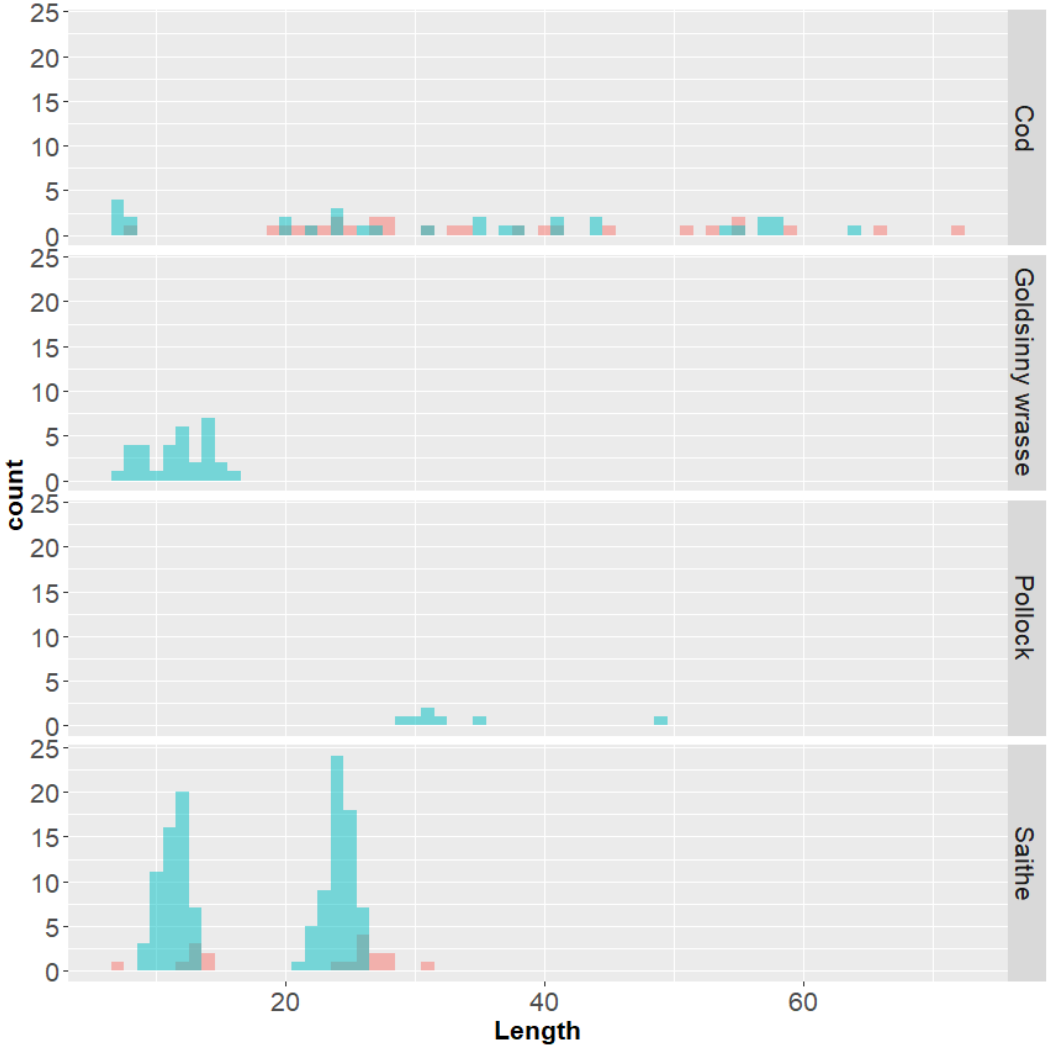
# Fish and scavengers




3X more fish individuals in kelp forests than at barrens (wolf fish, halibut and sculpin – were only found in the kelp forests). Also, more crabs in the kelp forest (except for *Carcinus maenas*)

The barrens were dominated by scavengers: *Buccinum undatum*, *Pagurus spp.,* and *Asterias rubens*, in addition to the green sea urchins




# Kelp forests are more important as nursery and habitat for fish, than the barrens

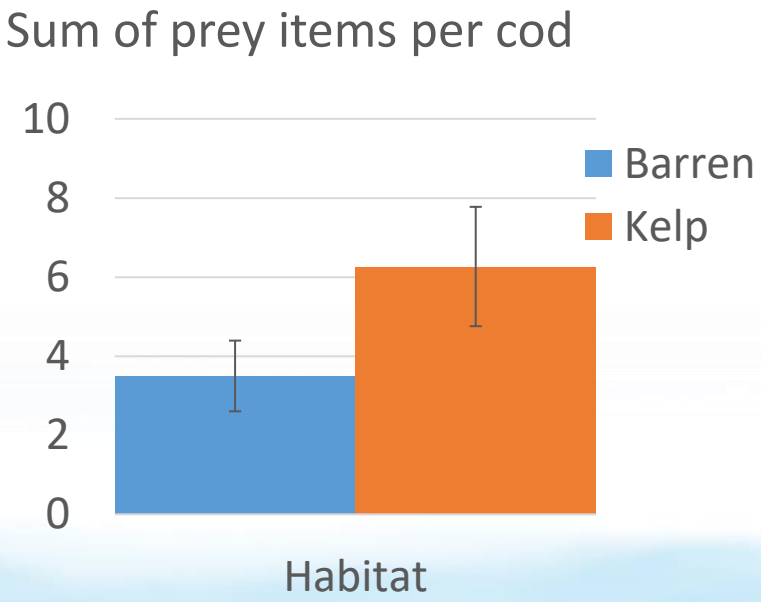
- more juvenile saithe and cod in the kelp forest

There were more fish species in the kelp forest, and higher numbers of individuals of several of the species.

**5 of the 14 fish species were only found in the kelp forests**

Habitat
Barren
Kelp

# Cod: a varied diet but seem to avoid sea urchins, even at the barrens



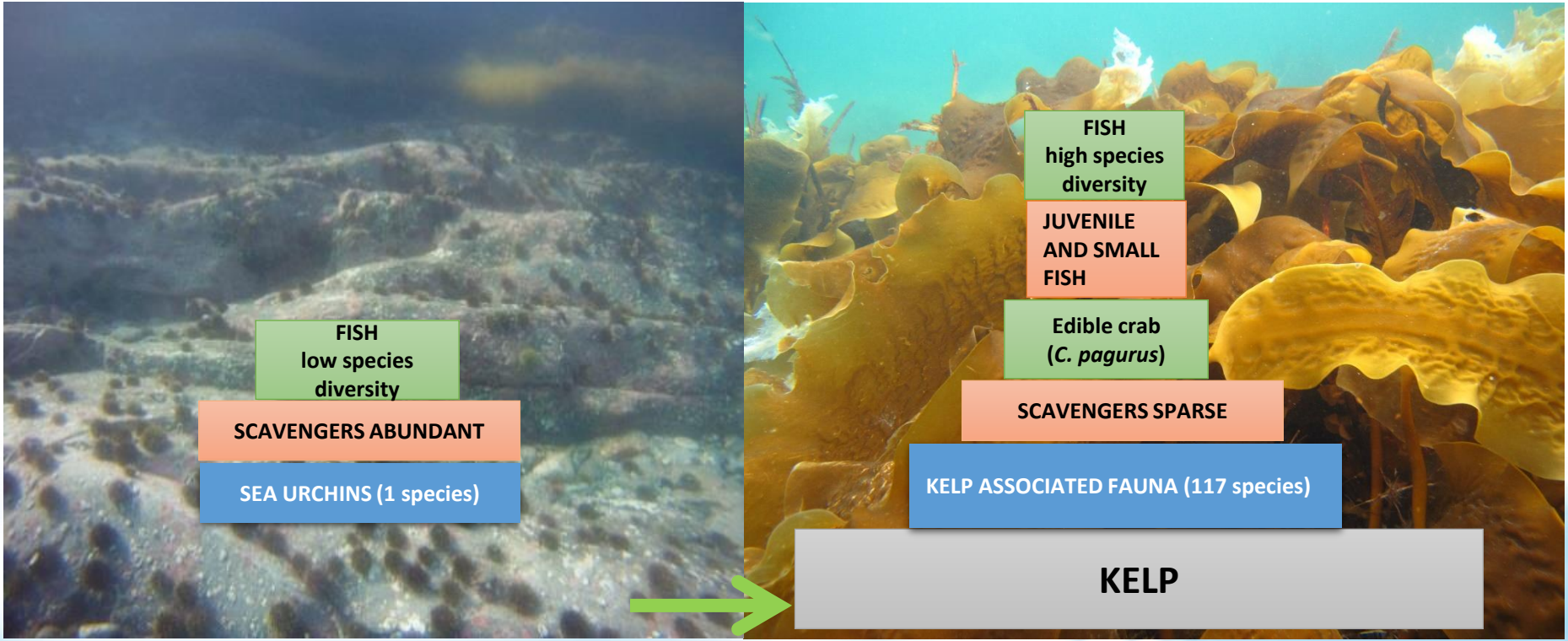

More prey items per cod caught in kelp (6) compared to barrens (3.5). On average about 2 prey item species per cod, in both habitats.

Also, more prey species in cod from kelp forests (33), and 19 species on barrens

No traces of sea urchins in the diet.

Sample size: 34 cod from kelp and 26 from barrens

# Major changes in ecocystem structure and functioning with recovery of kelp



# Conclusions

- We have got more knowledge on how barrens and the recovered sugar kelp forests differ with respect to both species diversity, community structure and functional diversity
- The results suggests that the recovered sugar kelp forests do need time to rebuild its naturally occurring diversity and functioning, but we lack baseline data for non-grazed sugar kelp communities in northern Norway


Thanks a lot for your attention!