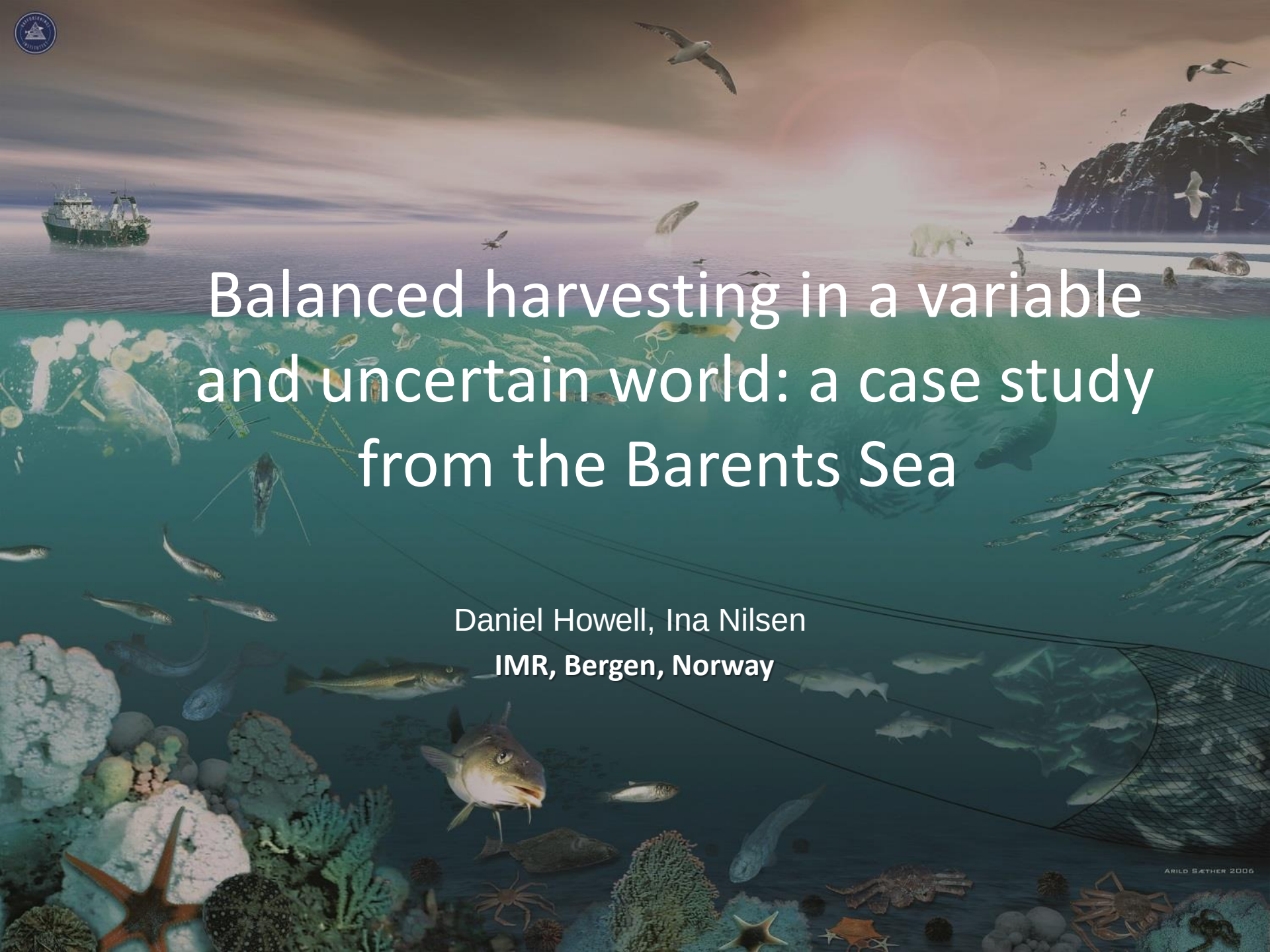

Balanced harvesting in a variable and uncertain world: a case study from the Barents Sea

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Balanced Harvesting

- «Harvest the species in the ocean at a moderate level in proportion to productivity»

- Aims to give increased overall yield with reduced ecosystem impacts
- Less selective pressure than at present
- No discards, everything is targetted, everything is landed

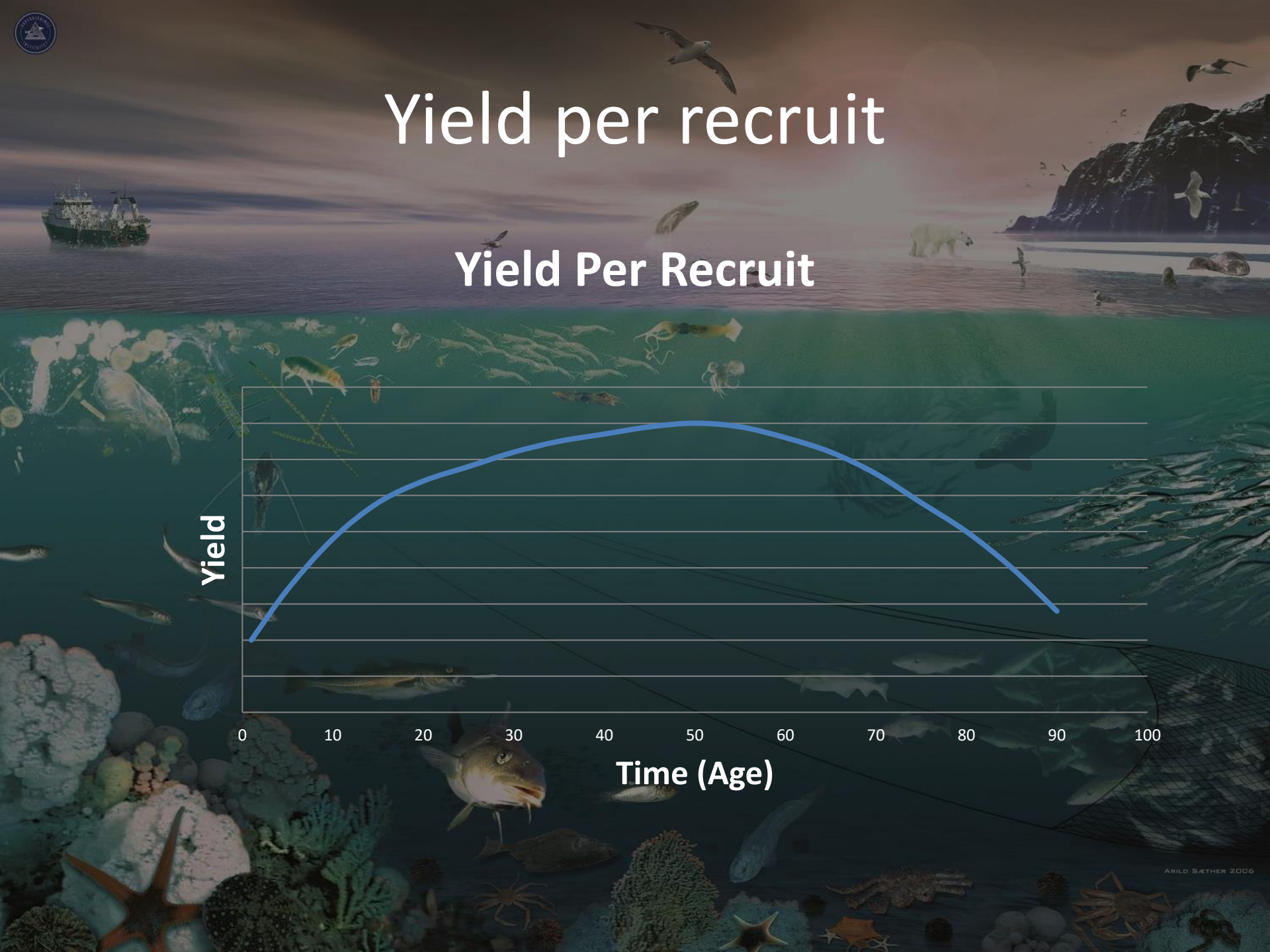
Balanced Harvesting

- Sounds like common sense
- But is actually almost the exact oposite of what we do today
- We direct our fishing
  - Between species
  - Tend to focus on top predators (cod, haddock,…)
  - And by size within species

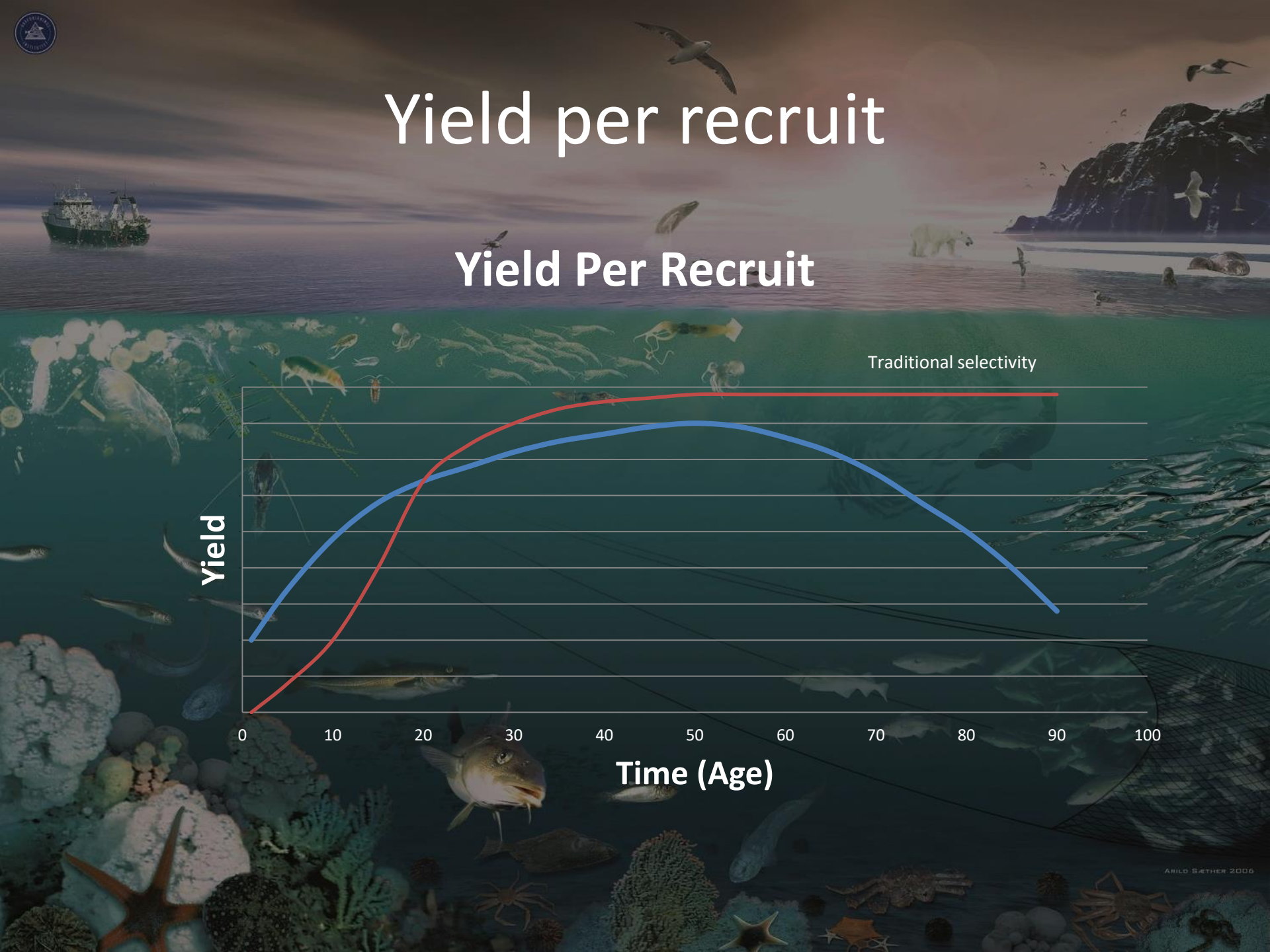
Yield per Recruit

- There is an «optimum» size to catch a fish
- Small fish grow fast
  - More yield if you wait and let them grow
- Large fish grow slowly
  - Lost yield, they are also dying of other causes

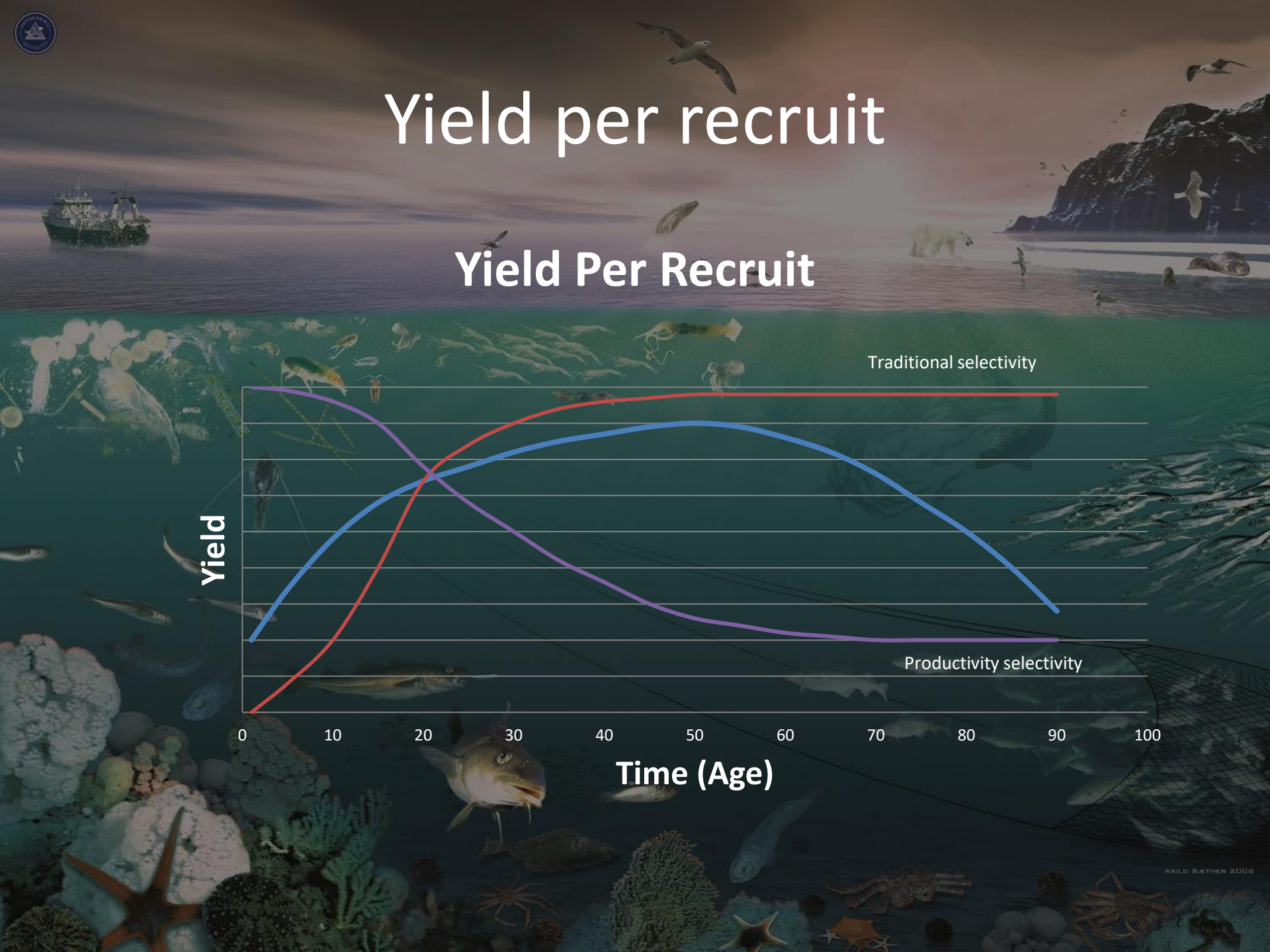
Yield per recruit



Yield per recruit



Yield per recruit



So how can BH give more yield?

- In order for the fish to grow they need to eat
  - To eat other fish
  - Which reduces catches of the prey species
- BH implies lower yields of predator fish
  - Cod, haddock, hake, saithe,…
- And higher yields of forage fish
  - Sandeel, anchovy, sprat, capelin,…
- So higher yields, but maybe not higher value

Could it be implemented?

- Partially
- Some species and sizes are
  - Difficult to harvest
  - Difficult to market
  - Difficult to manage (lack of knowledge)
  - Difficult to forecast (give quotas for)
- But suppose we *could* implement it…

Would it work?

- Maybe

- Never tried in a commercial ocean fishery
- Modelling studies suggest it will give increased yields
  - But they have tended to use simplified models
  - And compare with over-fished systems
- Need to look at specific ecosystems

Features of the Barents Sea

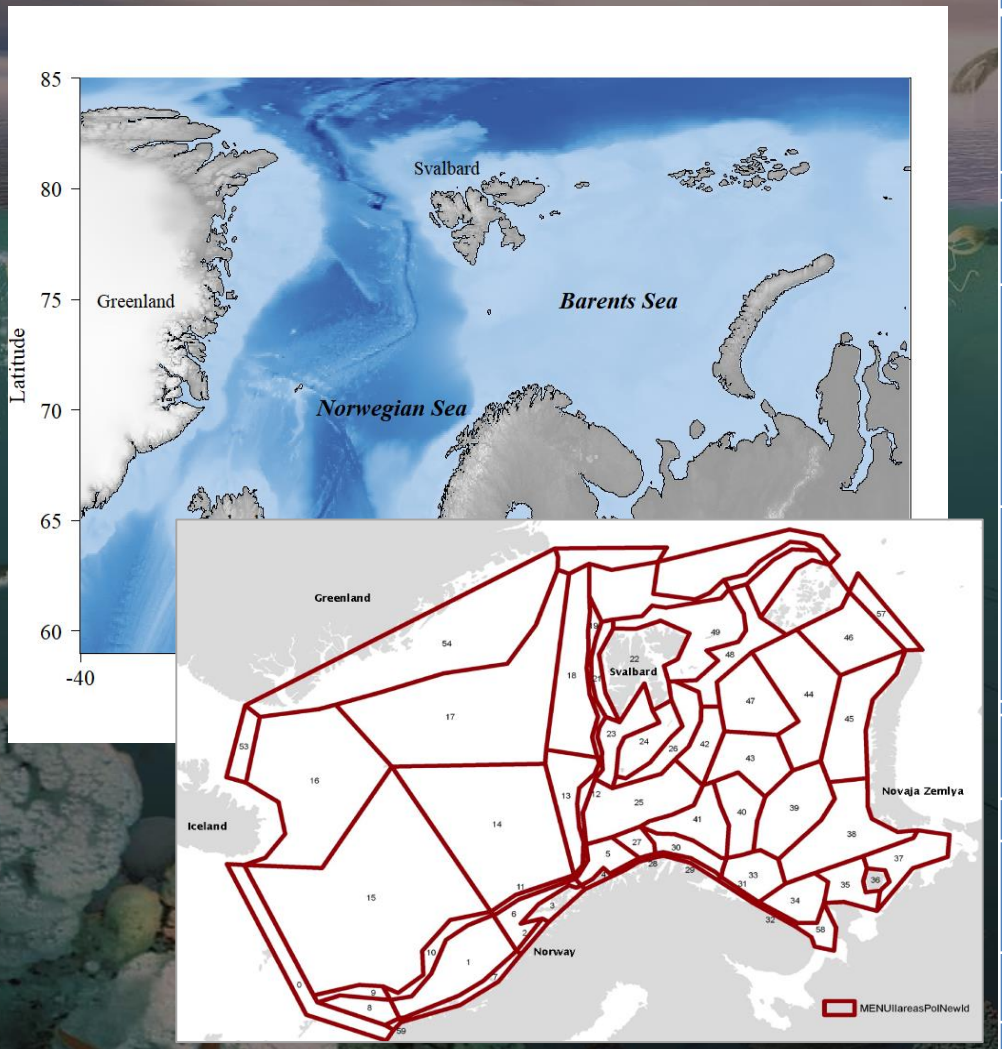
- Every ecosystem is different
- The devil is always in the details
- Fairly well managed system
- HCRs and discard bans for c. 20 years
- High stocks of gadoids
  - Large catches, high value
- Main forage fish is capelin
  - C. 100% spawning mortality

Atlantis model

- Detailed simulation model
  - Spatial and species detail
- Parameterized for the Barents and Norwegian Seas

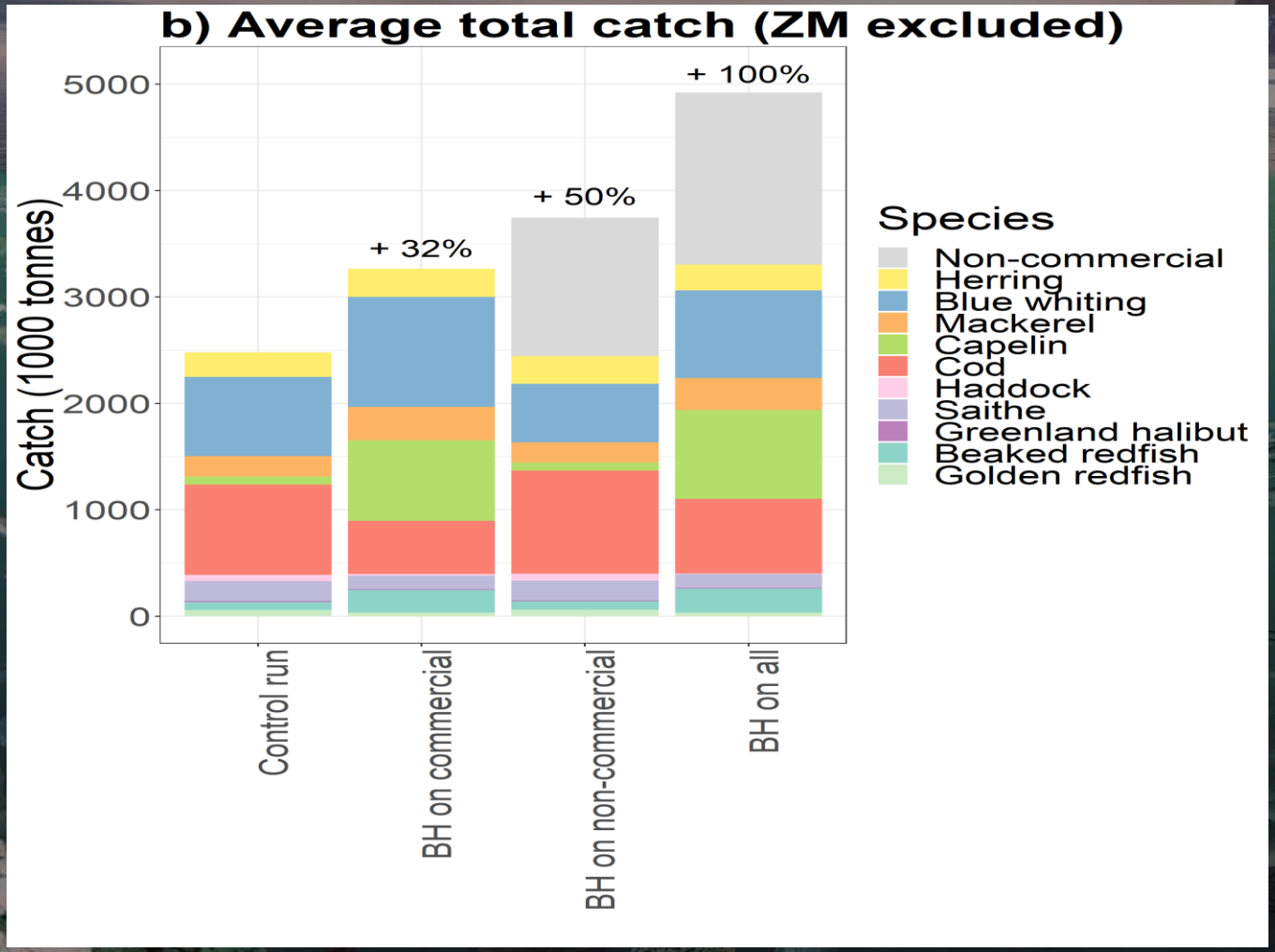
- Used by Ina Nilsen to investigate Balanced Harvesting

Atlantis model



Guild	Species	Abb.	Species included	Year	Distribution
Mammal	Bearded seal	BES		3	BS
	Fin whale	FWH		6	NS+BS
	Harp seal	HAS		4	BS
	Hooded seal	HOS		3	NS
	Humpback whale	HWH		5	NS+BS
	Killer whale	KWH		5	NS
	Minke whale	MWH		5	NS+BS
	Polar bear	POB		2	BS
	Ringed seal	RIS		3	BS
	Sperm whale	SWH		5	NS
Seabird	Arctic seabirds	SBA		2	BS
	Boreal seabirds	SBB		2	NS
Shark	Sharks, other	SHO	Picked dogfish, Porbeagle, Tope shark	3	NS+BS
	Skates and rays	SSK	Arctic skate, starry ray, sailray, longnosed skate, thornback ray, round skate, spinytail skate	2	NS+BS
Demersal fish	Demersal fish, large	DEL	Monkfish, Atlantic halibut, Atlantic wolffish, northern and spotted wolffish	2	NS+BS
	Demersal fish, other	DEO	Ling, Tusk	2	NS+BS
	Flatfish, other	FLA	European plaice, common dab, winter flounder	2	NS+BS
	Greenland halibut	GRH		2	NS+BS
	Haddock	HAD		2	NS+BS
	Long rough dab	LRD		2	NS+BS
	Northeast Arctic cod	NCO		2	NS+BS
	Polar cod	PCO		1	BS
	Redfish	RED	Beaked redfish	4	NS+BS
	Redfish, other	REO	Golden redfish	4	NS+BS
Pelagic fish	Blue whiting	BWH		1	NS+BS
	Capelin	CAP		1	BS
	Mackerel	MAC		2	NS
	Mesopelagic fish	MES	Silvery lightfish, glacier lantern fish	1	NS+BS
	Norwegian Spring Spawning herring	SSH		2	NS
	Pelagic fish, large	PEL	Atlantic salmon	1	NS+BS
	Pelagic fish, small	PES	Lumpfish, Norway pout	1	NS+BS
	Saithe	SAI		2	NS+BS
Squid	Cephalopods	CEP	Gonatus fabricii	-	NS+BS
Filter feeders	Benthic filter feeders	BFF	Selected molluscs, barnacles, moss animals, anemones (Tridonta borealis)	-	NS+BS
	Corals	COR	Lophelia pertusa	-	NS+BS
	Sponges	SPO	Geodia baretti	-	NS+BS
Epibenthos	Prawn	PWN	Pandalus borealis	-	BS
	Red king crab	KCR		-	BS
	Snow crab	SCR		1	BS
Zooplankton	Gelatinous zooplankton	ZG	Aurelia aurita, Cyanea capillata	-	NS+BS
	Large zooplankton	ZL	Thysanoessa inermis	-	NS+BS
	Medium zooplankton	ZM	Parameterized as Calanus finmarchicus	-	NS+BS
	Small zooplankton	ZS	Small copepods, oncaea, pseudocalanus	-	NS+BS
Primary producer	Dinoflagellates	DF		-	NS+BS
	Large phytoplankton	PL	Diatoms	-	NS+BS
	Small phytoplankton	PS	Flagellates	-	NS+BS
Infauna	Detritivore benthos	BD	Selected annelids, echinoderms	-	NS+BS
	Predatory benthos	BC	Echinoderms, sea urchins, annelids and anemones	-	NS+BS
Other	Benthic bacteria	BB		-	NS+BS
	Pelagic bacteria	PB		-	NS+BS
	Carrion	DC		-	NS+BS
	Labile detritus	DL		-	NS+BS
	Refractory detritus	DR		-	NS+BS

Atlantis simulation results



Simulation results

- Less cod catches
- More capelin catches
  - But capelin are not well modelled, so somewhat doubtful
- More catch of non-commercial species
  - Not all of which may be practical to catch

- **Main gain from non-commercial species**

Conclusions

- Balanced Harvesting promises increased yield and reduced ecosystem impacts
  - Although may reduce value
- But everything is ecosystem specific
- In the Barents Sea it looks as if the main gains come from unexploited species
  - Which doesn't need Balanced Harvesting
- Otherwise the benefits are limited

Conclusions

- We are moving, step by step, to a more ecosystem view of fisheries
- Balanced Harvesting is part of this discussion
  - But there is no magic bullet
- The basics remain the same
  - Fish within natural limits
  - Respond to natural variation
  - Minimize discards
  - Don’t overfish

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