



A Cascade of Warming Impacts Brings Bluefin Tuna to Greenland Waters



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Acknowledgements

Greenland fishery control authorities

EURO-BASIN
 BASIN SCALE ANALYSIS, SYNTHESIS AND INTEGRATION



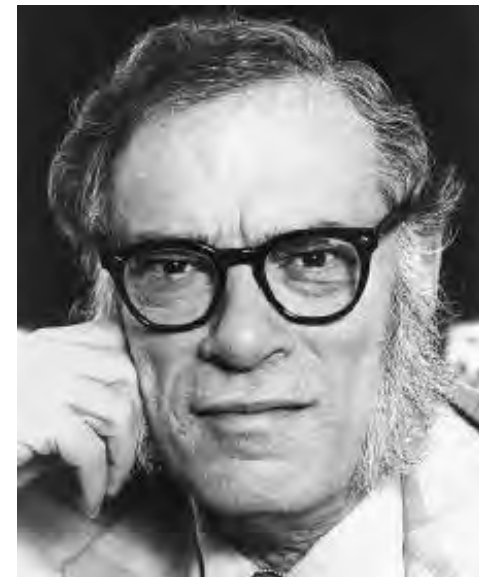
The research leading to these results has received funding from the European Union 7th Framework Programme (FP7 2007-2013) under grant agreement numbers 308299 (NACLIM project) and 264933 (Euro-Basin project).



The most exciting phrase to hear in science,
the one that heralds new discoveries, is not
'Eureka!' but *'That's funny...'*



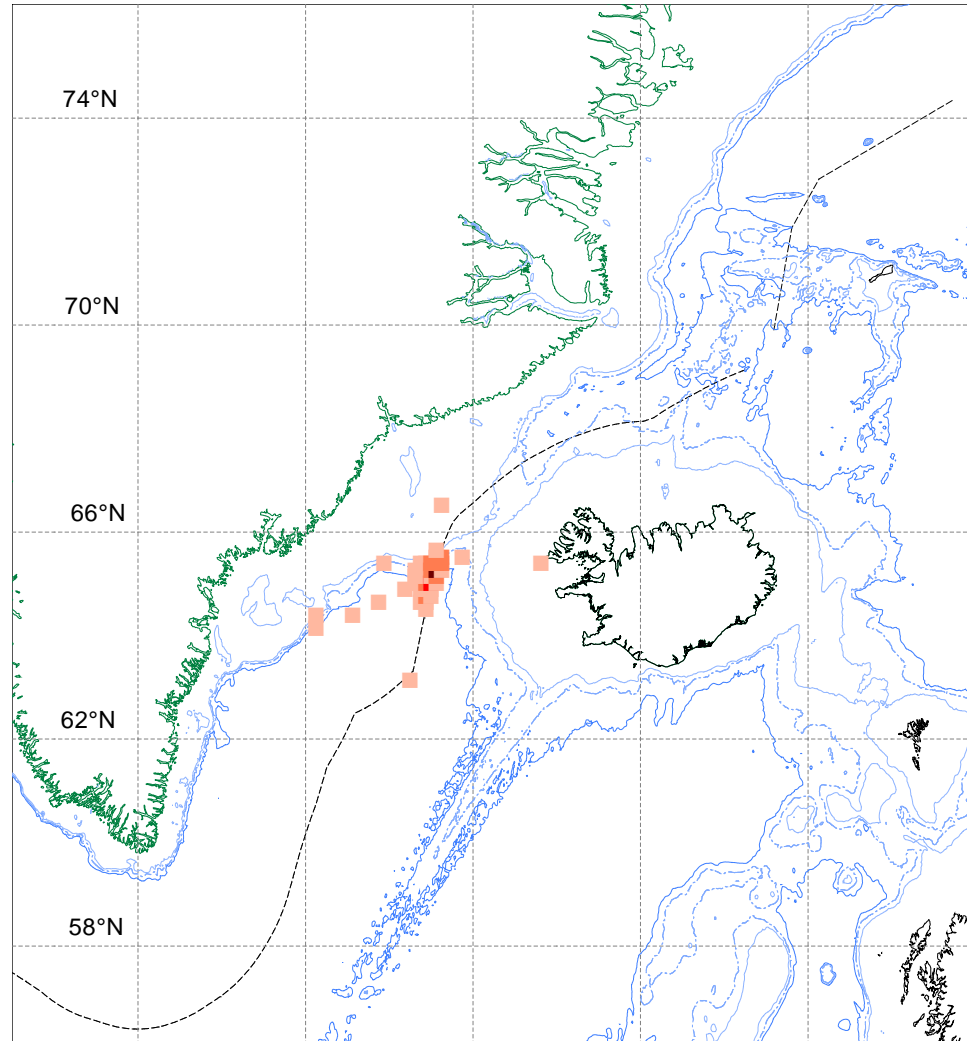
- Isaac Asimov



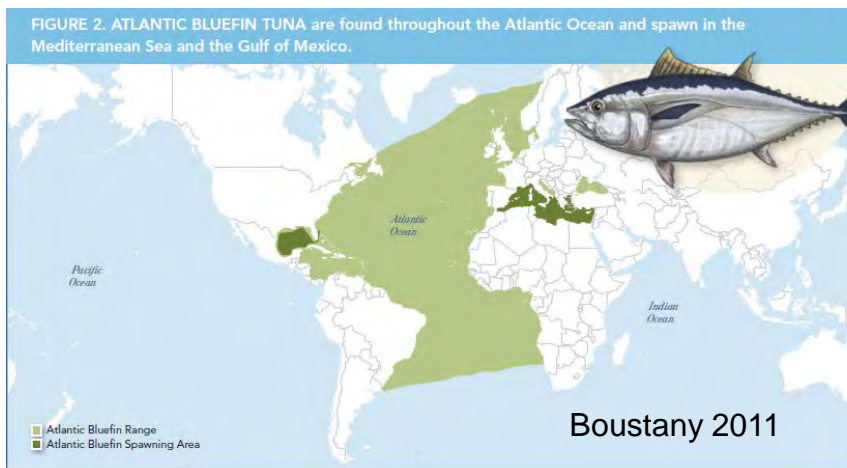
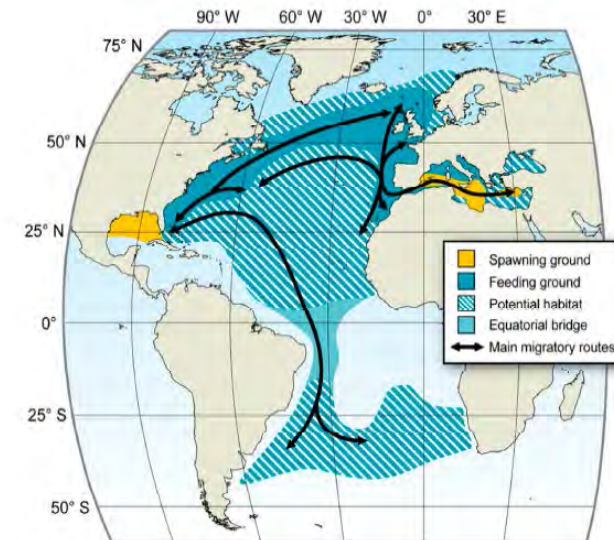




Exploratory Fishery for Mackerel in East Greenland 2012



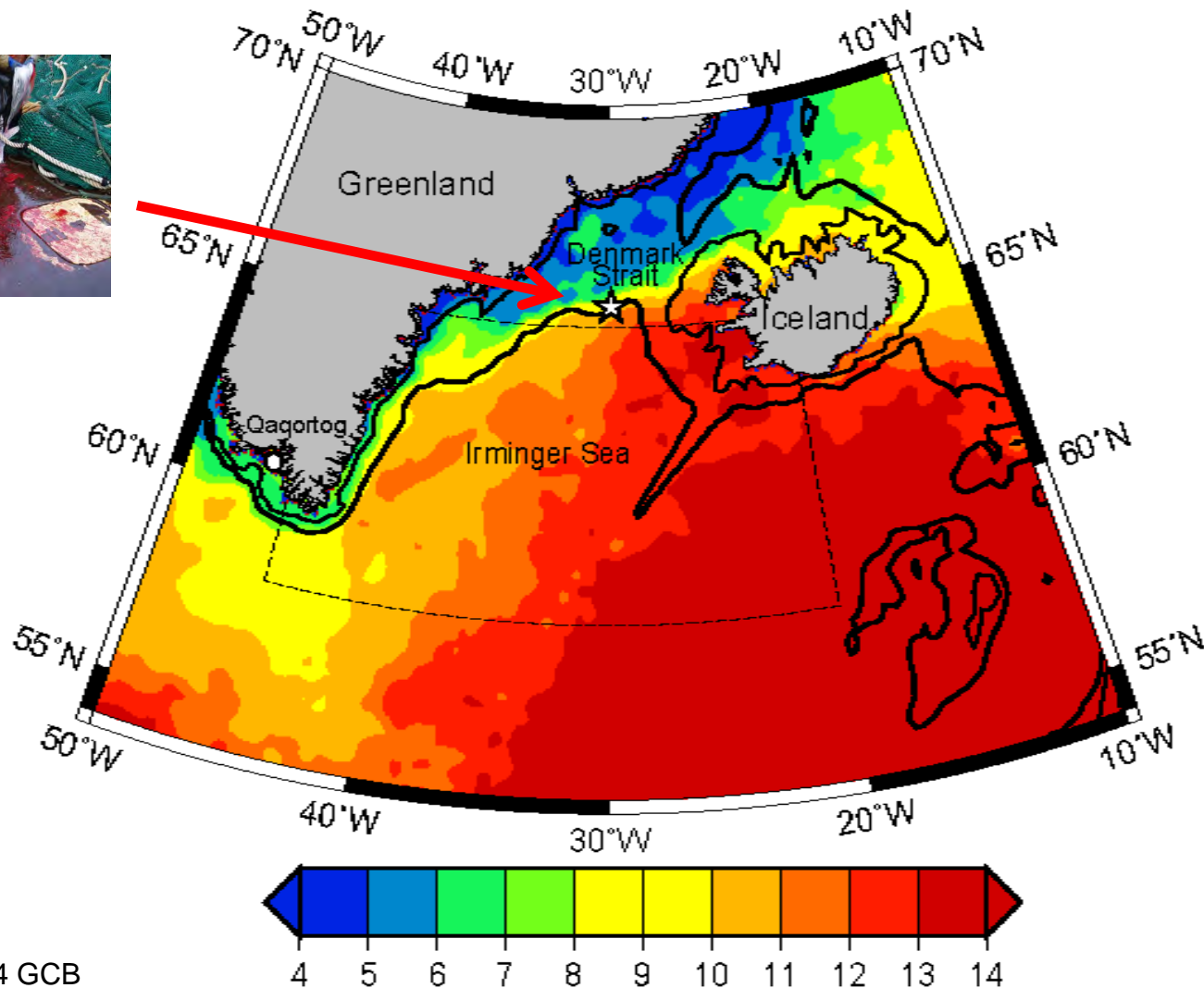
Distribution Range of Bluefin Tuna



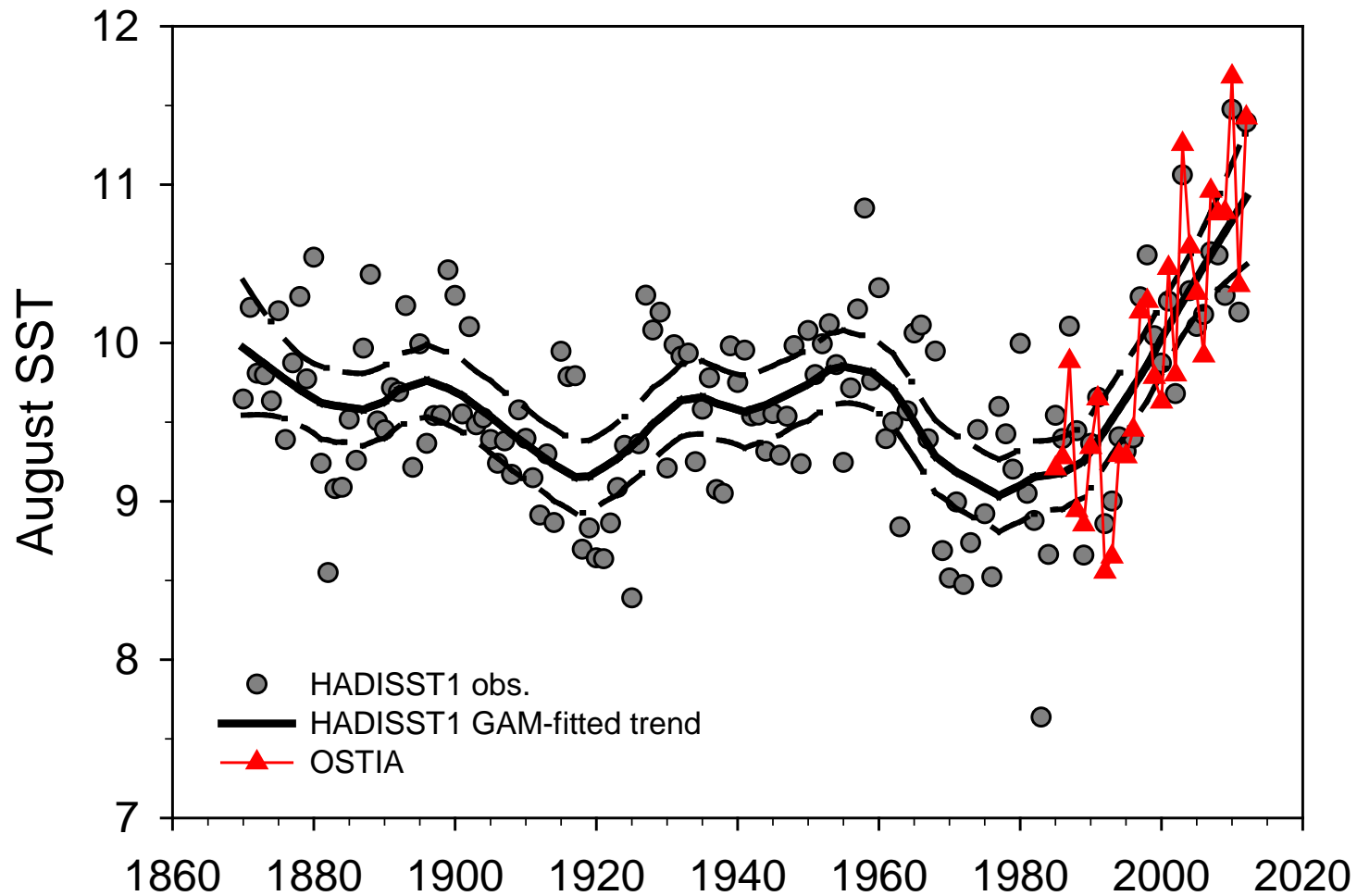
Fromentin et al. 2013
 Fish. Oceanogr.

-rare/absent in
 E. Greenland & Irminger Sea

Capture Location in 9-11° C Water

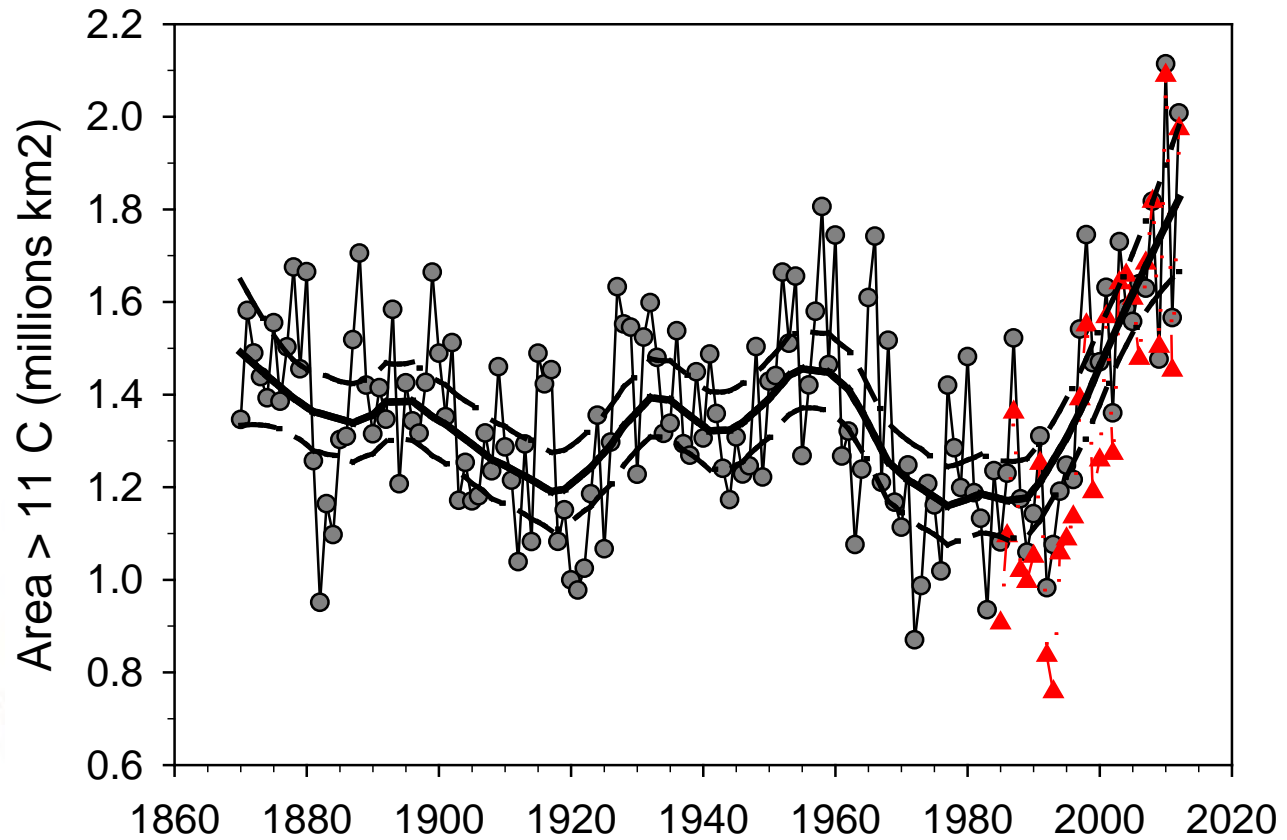
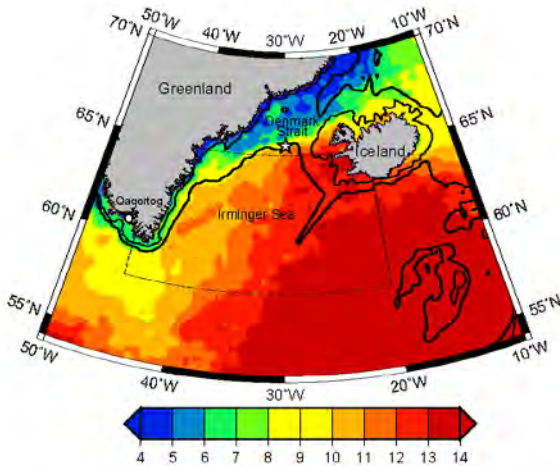


Rising Temperatures in East Greenland-Irminger Sea



Quantifying Variability of Thermal Habitat

How large is the area of water with SST > 11 C in this box?



-area of suitable habitat increased by amount similar to France



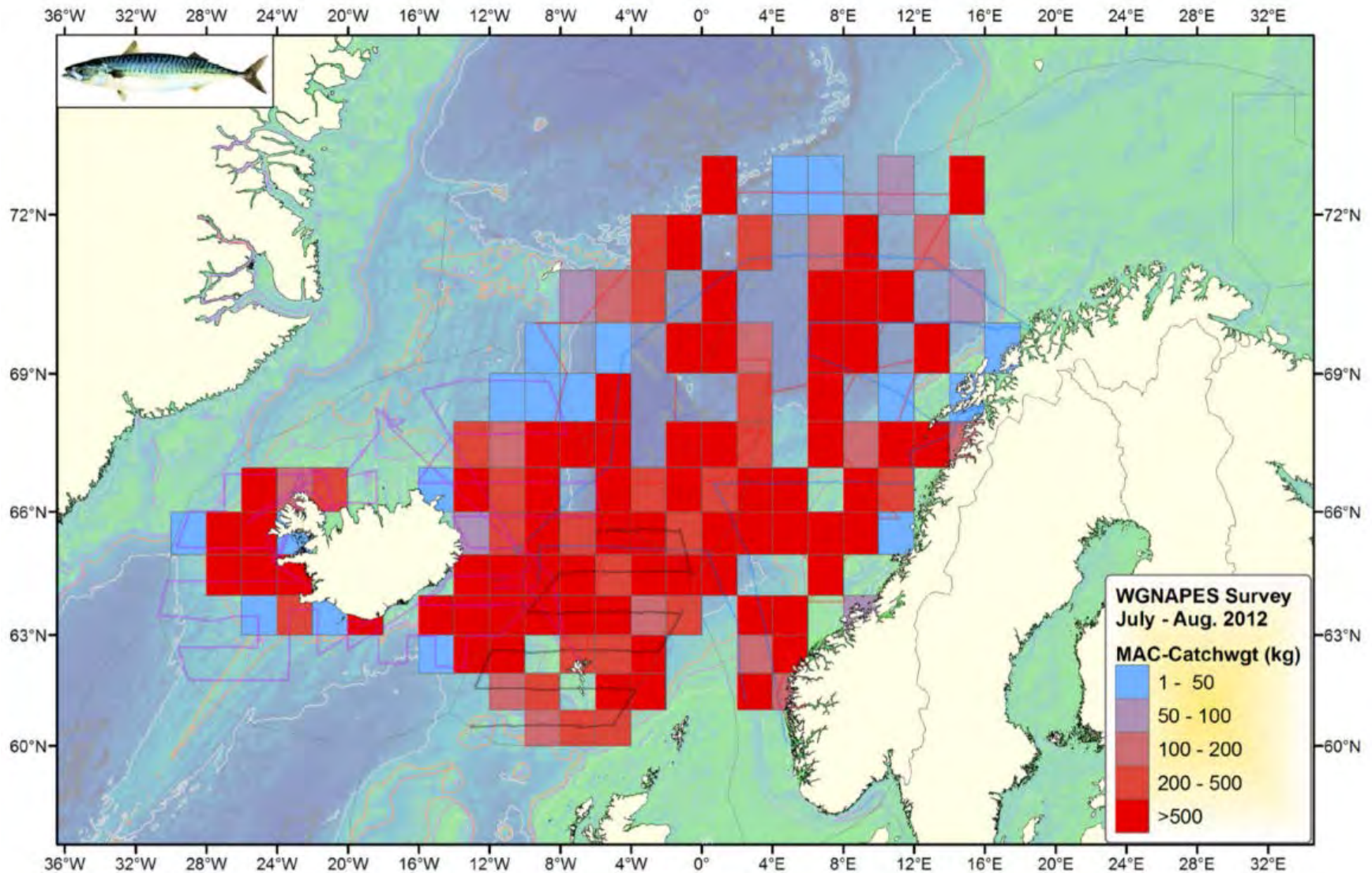
A changing marine ecosystem

- changes in distributions of pelagic fish stocks

 - mackerel, herring, blue whiting

- changes in species interactions and food web

Mackerel Distribution Expansion to Iceland



Changes in Zooplankton Spatial Distributions in N. Atlantic

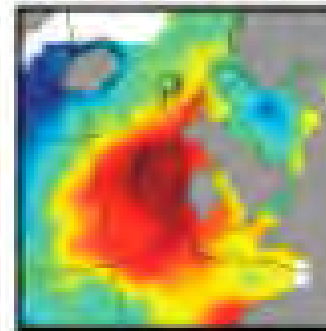


Photo: DFO Canada

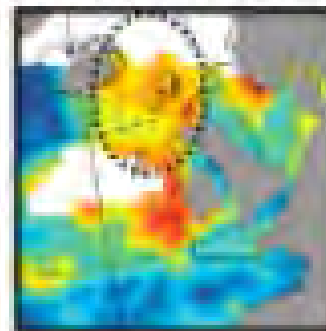
Replacement of Arctic species
by cold-temperate
species near Iceland-Færoes

Cold-temperate
species

1958–1981

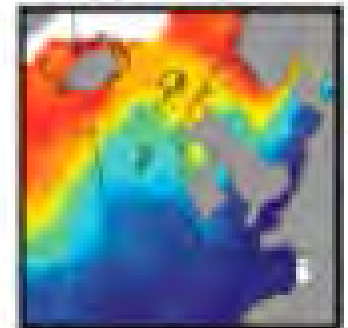


2003–2005



Arctic
species

1958–1981

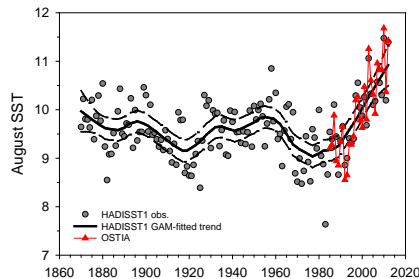


2003–2005



Warming Leads a Trophic Cascade

Increasing temperature



Northward shifts in zooplankton species distributions (early-mid 90s) e. g., Beaugrand papers

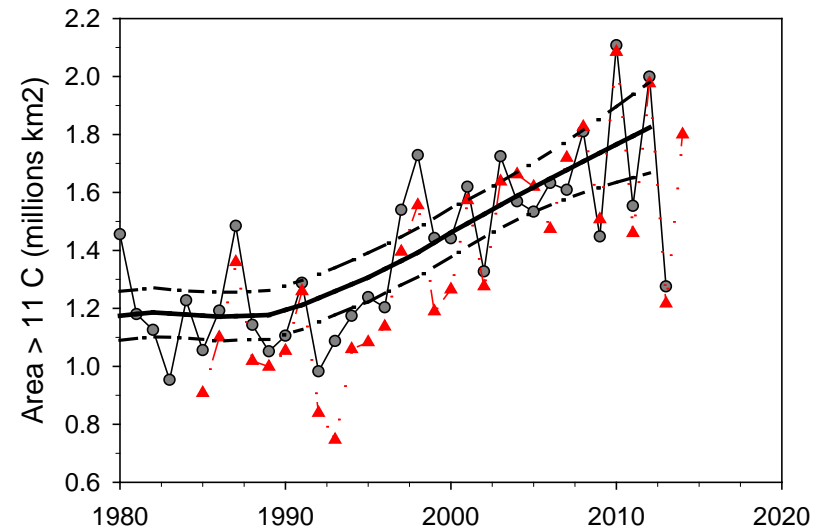
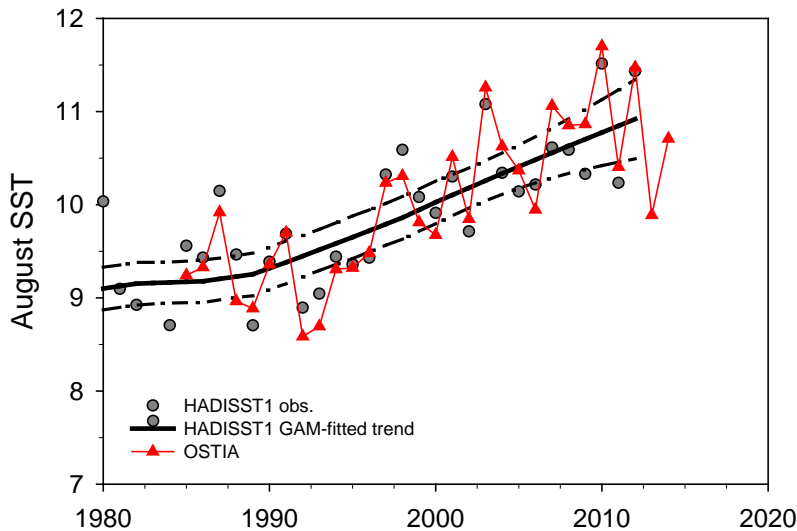


Changes in distributions of zooplanktivorous fish spp. (00s-10s) e. g., ICES WGWIDE, Astthorsson et al. 2012, etc.



Migration of large piscivorous fish (10s), e. g., this study

A developing story... what has happened since 2012?



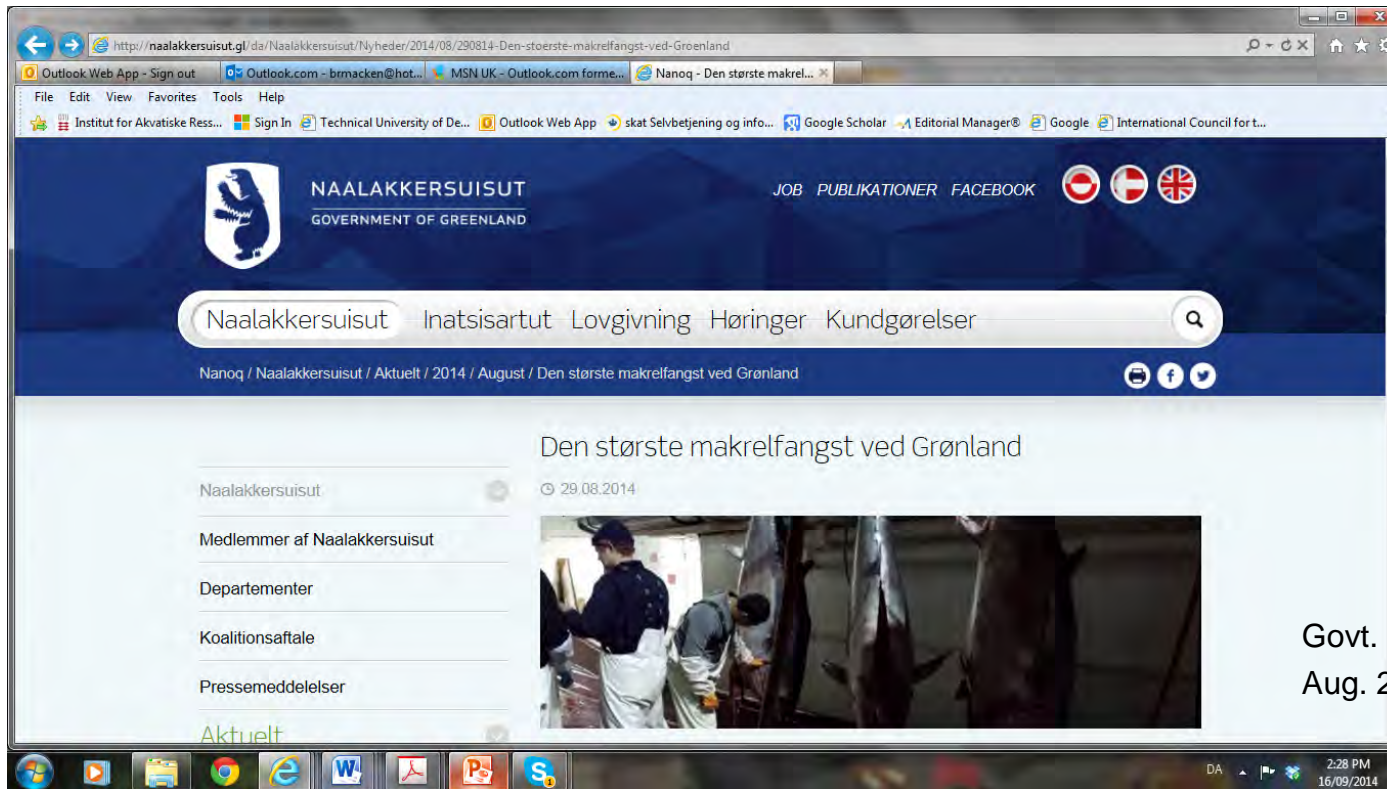
2013 – colder temperatures, more mackerel fishing, but no tuna

2014 – temperatures rose again, more mackerel fishing, and...

More tuna!



2014 –Present Again



Govt. Of Greenland website,
Aug. 29, 2014

- 21 bluefin tuna** had been caught in mackerel fishery by late August (along with 65,000 t mackerel)
- also being caught in Icelandic waters (30 t quota)

The Sunday Times

3 August 2014

Greenlandsposten

Week 33, 2014

6 ONSDAG 13. AUGUST 2014

nutaarsiasat nyheder



Assimi aalibaq, tunit 100 illoinn ogmissuullit ilaat takkarsimassut. Royal Greenlandit kisassarsuutit iluutit tupassimagaq tunit aalibaqsuullu 6 tonsit qaqarsit.

Biladet viser en af de 100 Royal Greenland overbåret Royal Greenland bestyring Newbord i 2012 som den seks ton mæske.

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Andreas Ingvald andreas@ag.gl

Manna akkut aalisaruit ungasinnu qanittullu avlersa arcor-niutit. Tunup imarsa anersaput. Avlersa arcor unku kungul-nera Sewallimut ilandilla ul-pannik ungasarsuut nikallarsit-imeppat.

Kisianni 2013 mi aalibaq puul-root taasa mamartoo silu nusi-ningarsaavut. Taasa ilimasuut-riktit ilangutassimi nusi mi, il-istagut ungasarsa mi. Global

Aalisagarsuit avlarsaartuut ilaat tunit pingasut Tunup imartaani pisarineqarsimasut

Aalisagarsuit avlarsaartuut ilaat tunit qillertuusaamisinnat nunatsinnut qaqutiginnaq takkuttarpit. Kisianni 2012-mi Tunup avaatani taamaattunit pingasut pisarqoarsimasuq ilimasuussikittit ilangutassiami ilangunneqartumi takuneqarsinnaavoq, ilangutassiami nunaarsup kisassikkiartornera tamunungua pisuutaanneqarpaa.

unnu arminvoq, allat aalisakkt ta-makkua unna nersa anerrut pil-lop kilissata a tunit pingasut angit-umut kiiorut aalingsina sumik Im-annami Aalilersa armit aruukit De-mentia. Aalisakkt tunit 100 illoinn og-missuullit 2012-mi pinneqartut imanni 2013-mi 15-ink kisassil-likunni misilersaluk aalisaruit ul-pannik ungasarsuut ilimasuut ar-ruusarimmut, tunu amut pas-illarsanngaput - ukkumut agva-tyigitigullu grammaff armik ki-annunnilu.

1980-ikkunni Tunup avaatani imarsa agvaqussigulluq grammaff-rikut ungasarsuut ilimasuut ar-ruusarimmut, tunu amut pas-illarsanngaput - ukkumut agva-tyigitigullu grammaff armik ki-annunnilu.

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Students face £6,000 fees for Oxbridge

Elite's grip tightens

A new analysis by the Sutton Trust has revealed that 70 per cent of students who attend elite schools will go on to attend Oxbridge.

The Sutton Trust, a think tank that represents leading British schools, has published a study to be published as the 10-year-olds who have degree will have the best chance of high future earnings. It will also transform the debate on social mobility of teenagers unskilled who and what they needed to study to have a well paid career.

Figure suggest that 80% of graduates from Oxbridge universities earn more than £2,000 three years later.

The figure for Oxbridge universities is £22,000 a year. The government's own figures suggest that 80% of graduates will not command high enough salaries.

A research executive looking for 10,000 graduates have been in starting salaries over the past 21 years is expected to spark demands that taxpayers stop paying for students to take degree with poor salary prospects.

Willetts said he understood that the research by the Cambridge and Harvard professors James Heckman and Paul Shephard showed "the most important research in the UK".

At Oxbridge, Cambridge, and the last time the head of the had the last few employment rates.

They were by take on their graduate's loans, he said, they would have a pretty solid stream of income from repayments. Graduate with some of the lowest salaries and employment rates are understood to have studied for a few years in university in inner-city areas.

Willetts said he understood that the data was likely to be mixed. It is compared to the student course, for instance. He said that unemployment rate six months after graduation fell from 20% at one university to 4% at others, with Glasgow Caledonian



Tuna follow global warming to Arctic

British leader

When they did not find them in any time since each weighing more than 200lb and reportedly part of a school.

There are two populations of Atlantic halibut, one based in the Mediterranean and the other in the Gulf of Mexico. Both range across the Atlantic, venturing north in winter and returning south in summer, but typically settling in any water below about 1°C.

This is because, like most northern species, their metabolism is slow at low temperatures. It means that individuals in the 10-100 °C range are more active and discovered that halibut tuna could become a seasonal component of the region's fish fauna, said Mackenzie and his colleagues. Halibut tuna, which can reach 1,300lb and 10ft in length, are among the most sought after commercial fish with prices reaching £100 per lb.

One of the main fisheries in the Mediterranean, but overfishing has severely depleted stocks.

After questioned by the scientists where the tuna caught off Greenland came from, using satellite imagery they traced the warming of the ocean. Greenland from the southeast, suggesting the tuna may have migrated to the Mediterranean. The alternative is they may have arrived from the northwest Atlantic.

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Maggie is popular with groups of British school-leavers



Diana Carrivale smiles in her son's 'Pagan school before she wants to meet Andy Murray



Conclusions:

Temperatures have been rising in the East Greenland – Irminger Sea area

Temperatures have reached levels that support bluefin tuna in other summer feeding areas

Bluefin tuna were captured in the area, together with their prey.

If temperatures continue to be $> \sim 11$ C, and if stocks managed well, all could become regular summer residents in future.

