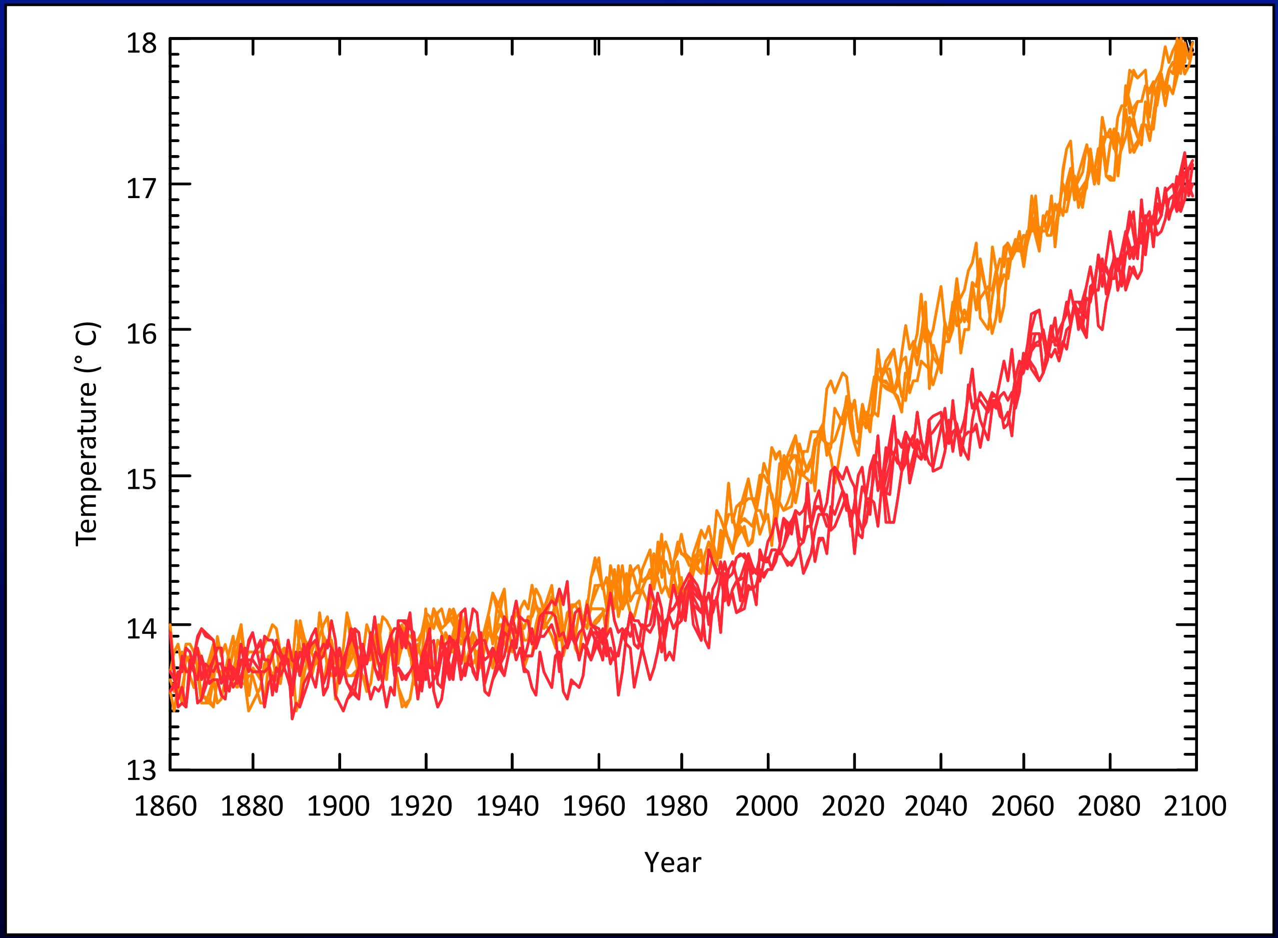
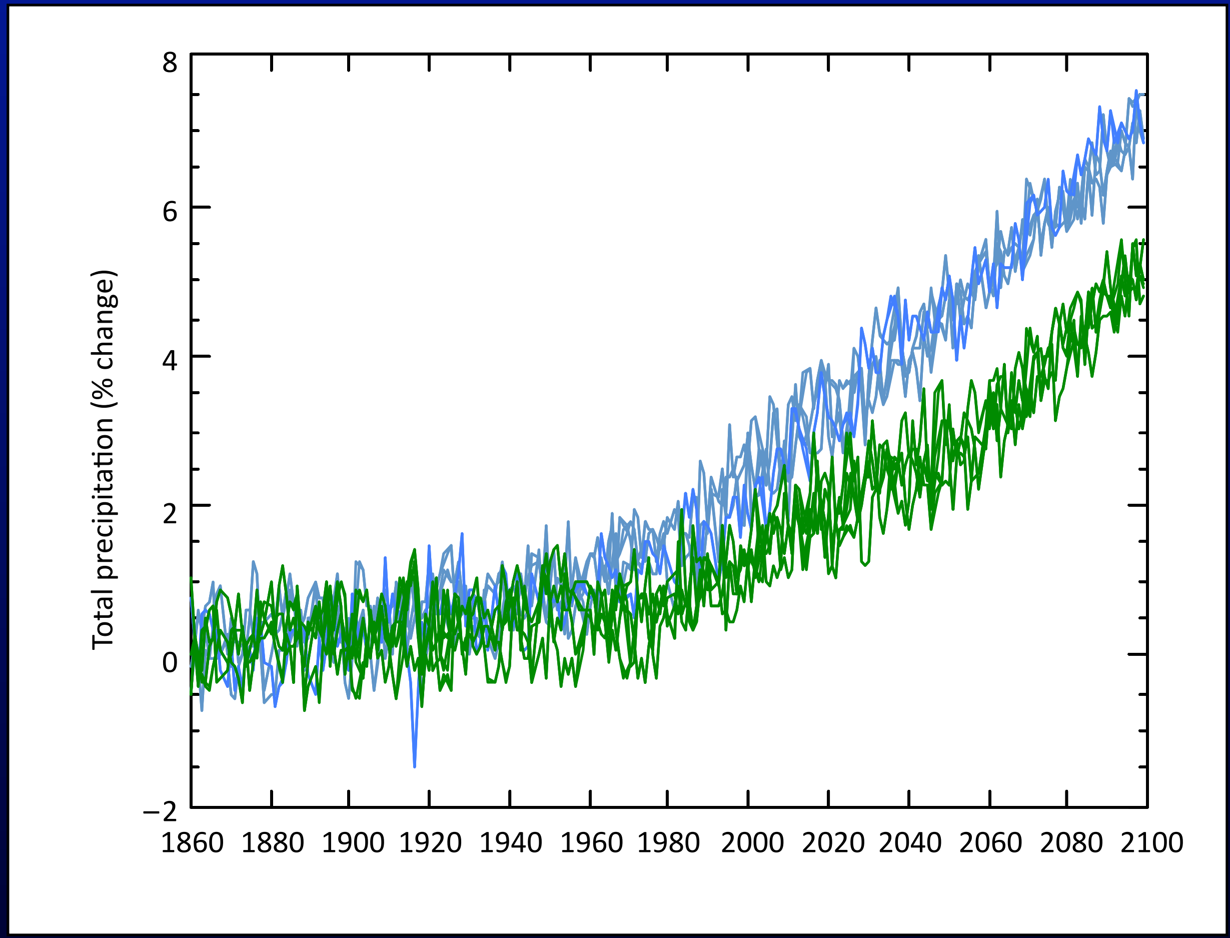
Global mean temperature predictions



Ensembles of four predictions of global mean temperature resulting from 'business as usual' changes in greenhouse gases following on from observed changes since 1860 (orange curves). The addition of sulphate aerosol cooling is shown in the red curves.

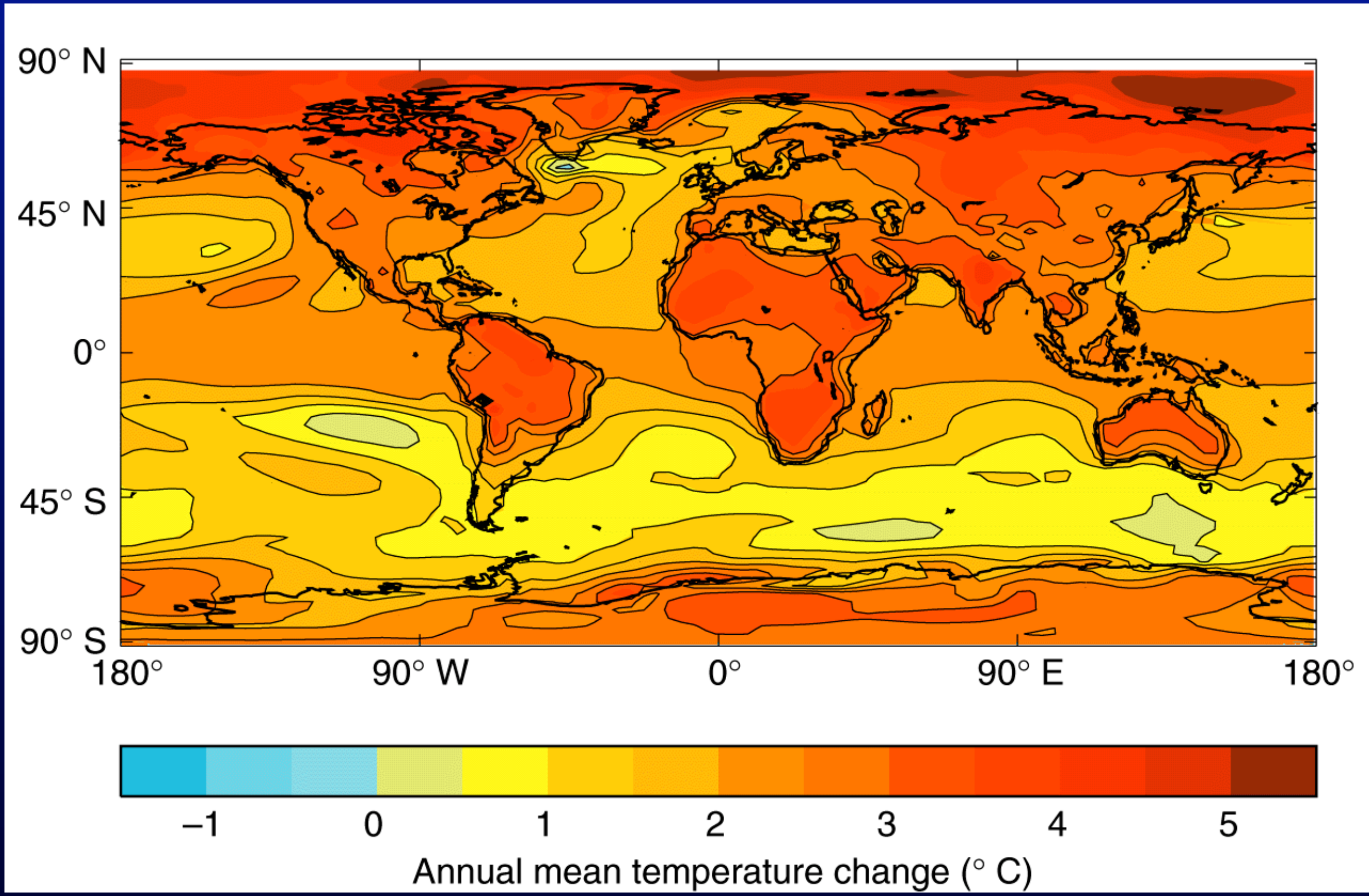
The Met.Office Hadley Centre for Climate Prediction and Research

Global mean precipitation predictions



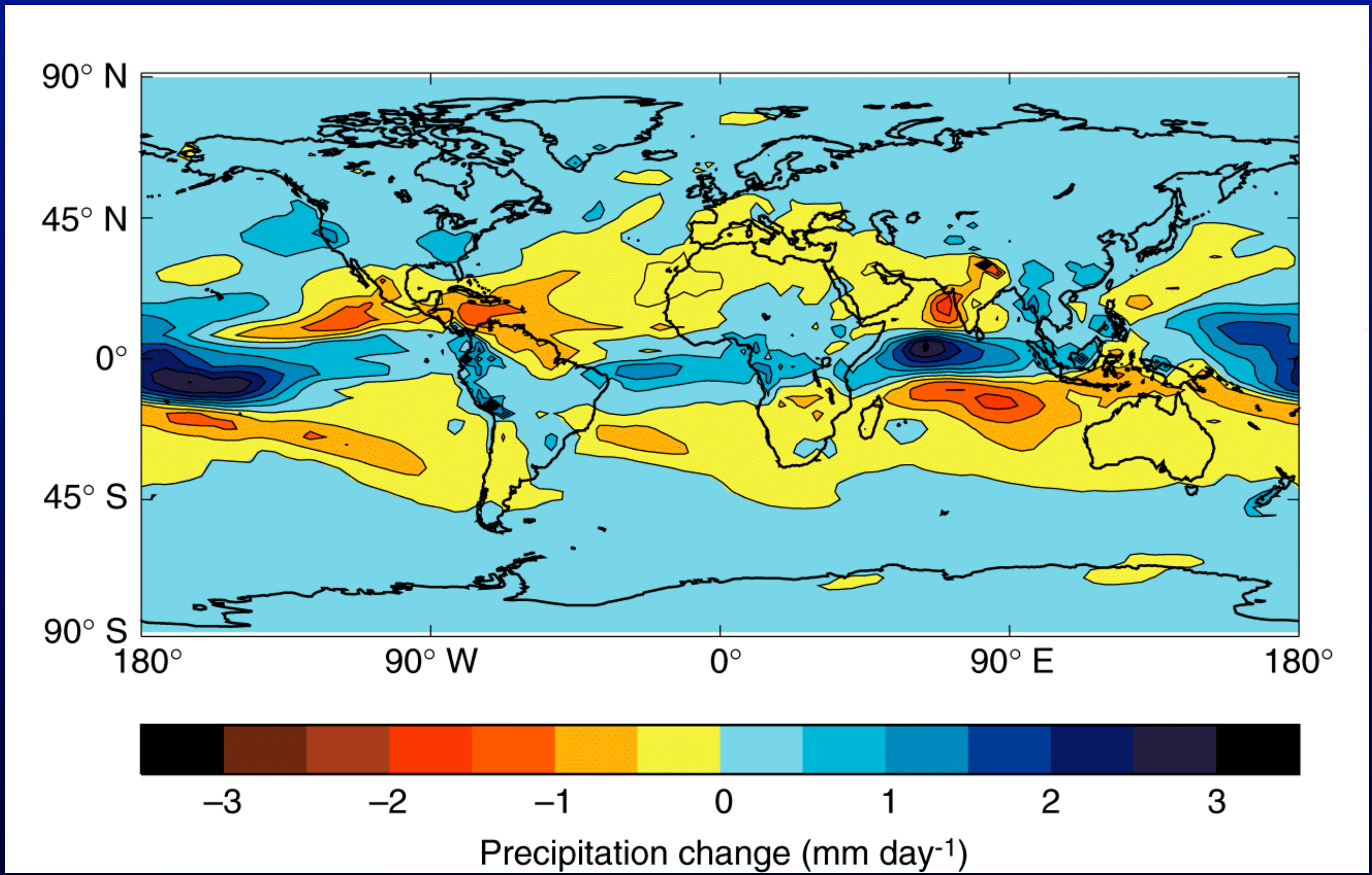
Ensembles of four predictions of precipitation (rainfall and snowfall) resulting from 'business as usual' changes in greenhouse gases following on from observed changes since 1860 (blue curves). The addition of sulphate aerosol cooling is shown in the green curves.

Change in annual temperatures for the 2050s



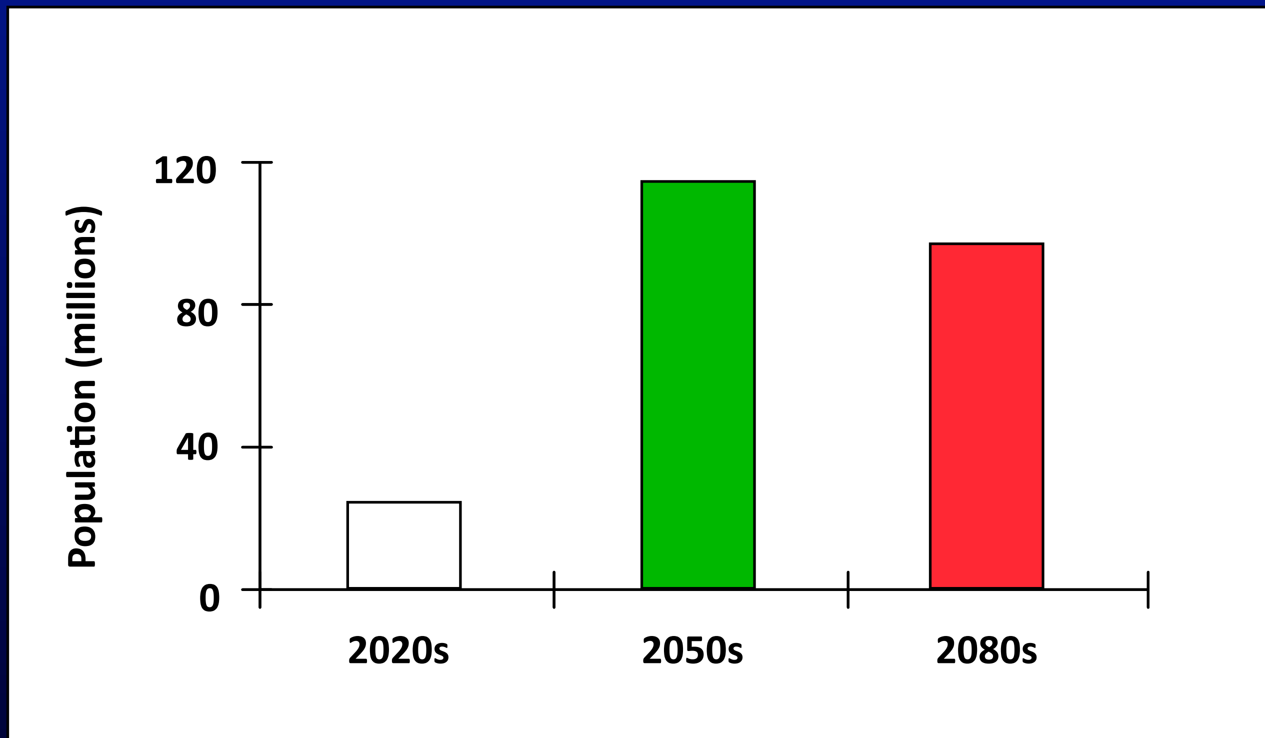
The change in annual temperatures for the 2050s compared with the present day, when the climate model is driven with an increase in greenhouse gas concentrations equivalent to about a 1% increase per year in CO_2. The picture shows the average of four model runs with different starting conditions.

Observed change in annual precipitation for the 2050s

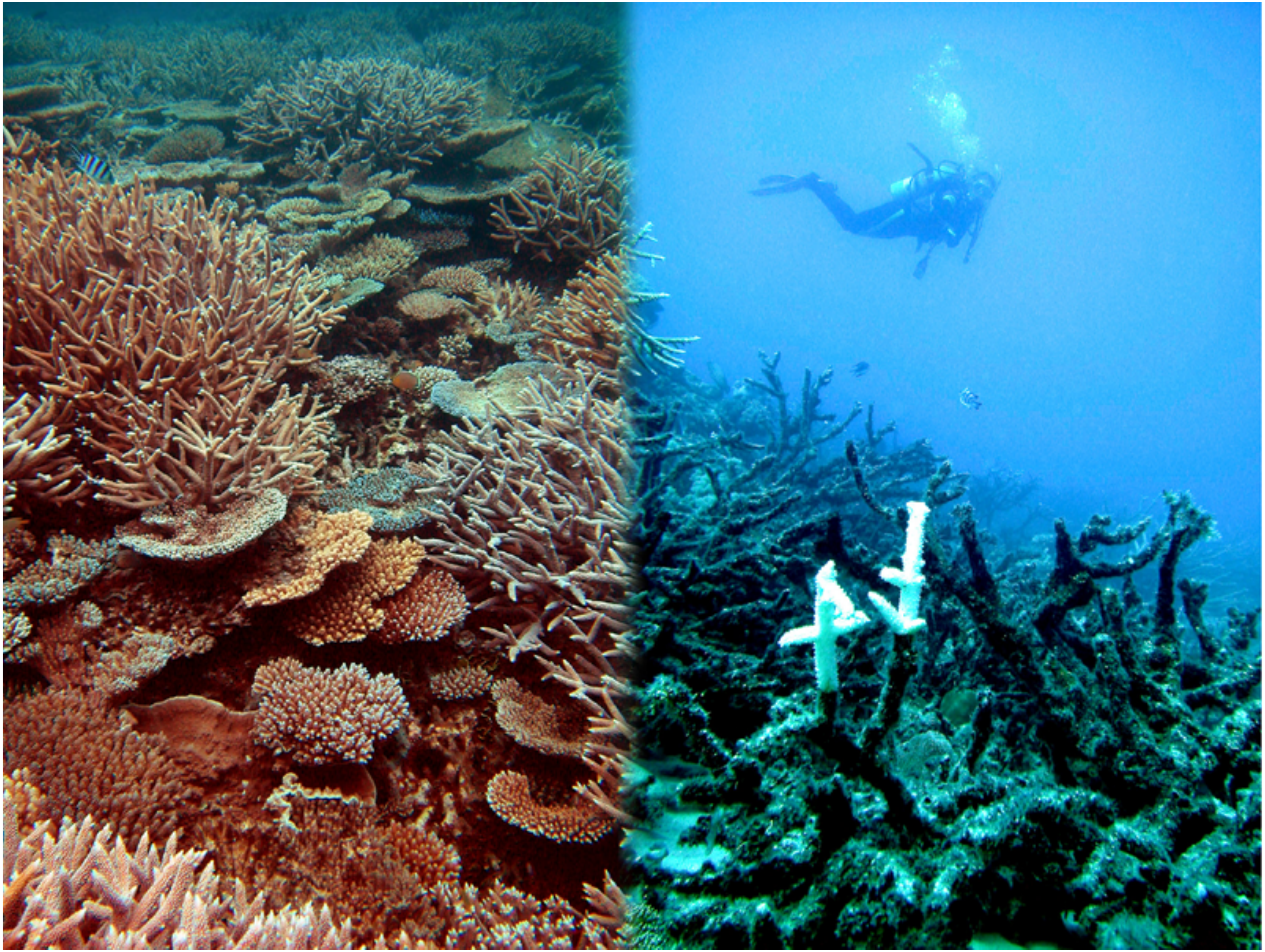


The change in annual precipitation for the 2050s compared with the present day, when the climate model is driven with an increase in greenhouse gas concentrations equivalent to about a 1% increase per year in CO_2. The picture shows the average of four model runs with different starting conditions.

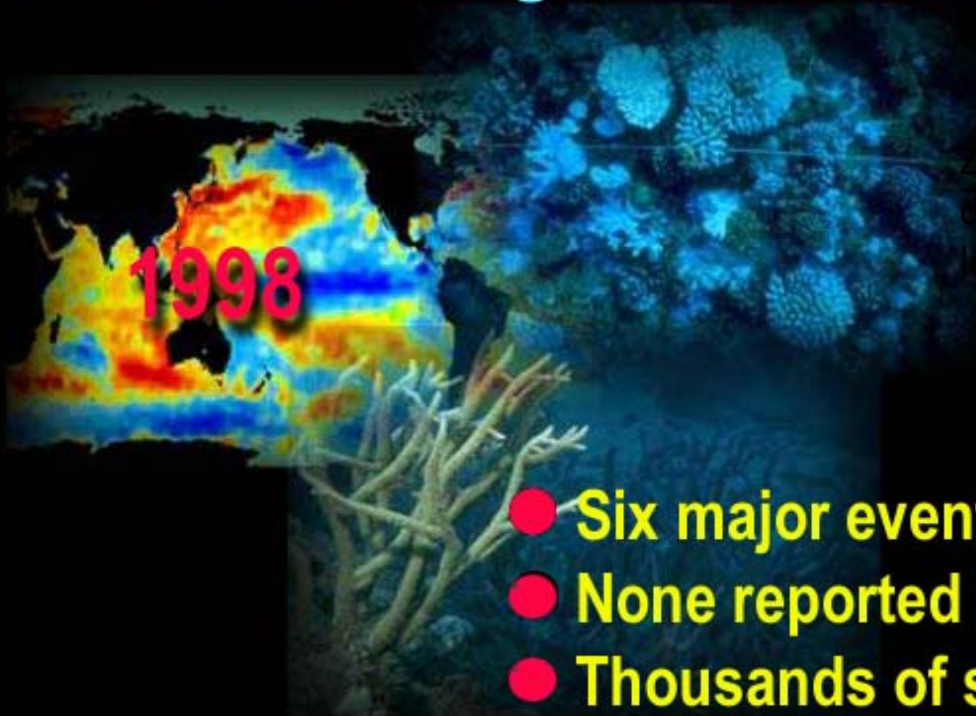
Population under extreme water stress

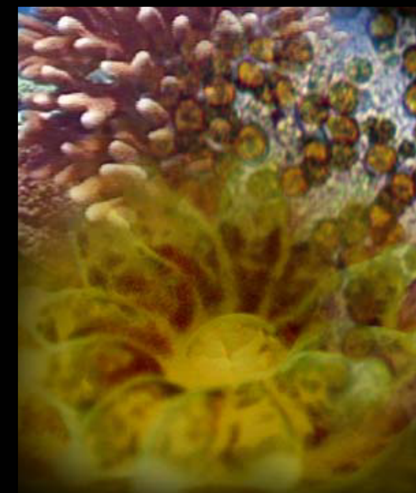


Change, due to climate change, in the number of people living in countries with extreme water stress.

Coral bleaching and mortality





- Six major events since 1979
- None reported formally before 1979
- Thousands of square miles affected
- May be followed by huge mortalities
- Increasing frequency and severity

1998 & 2002 & 2004

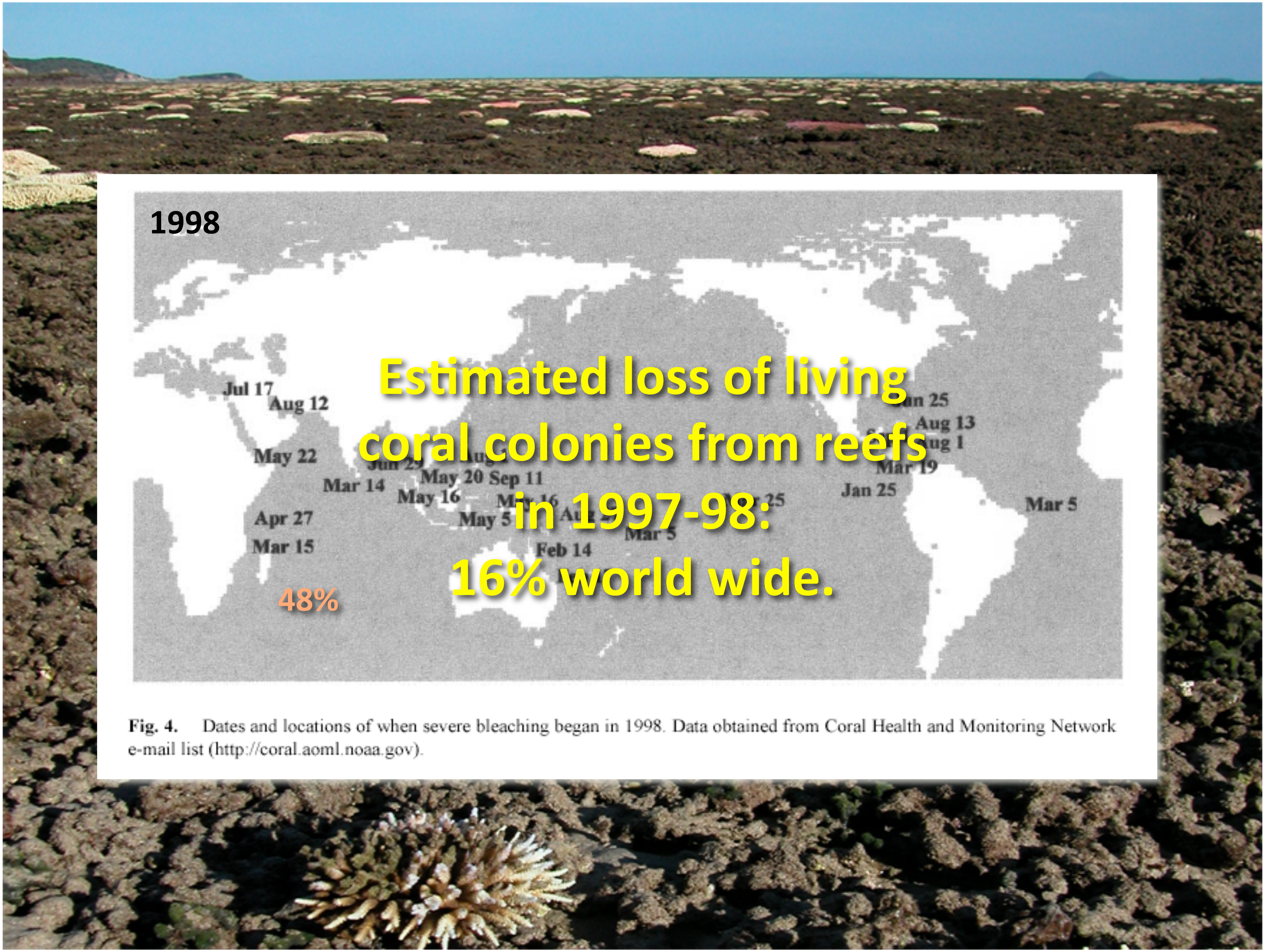
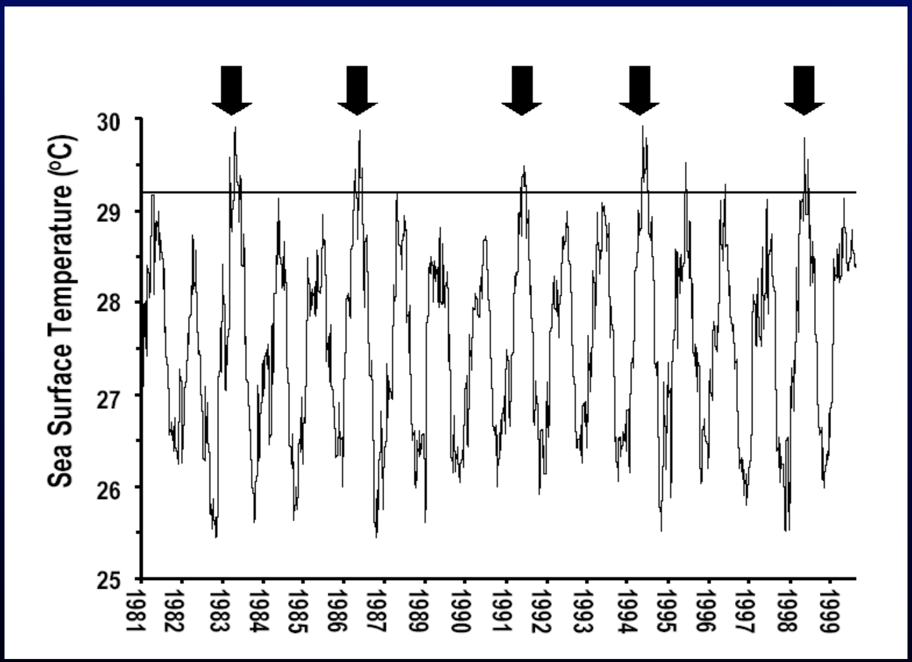
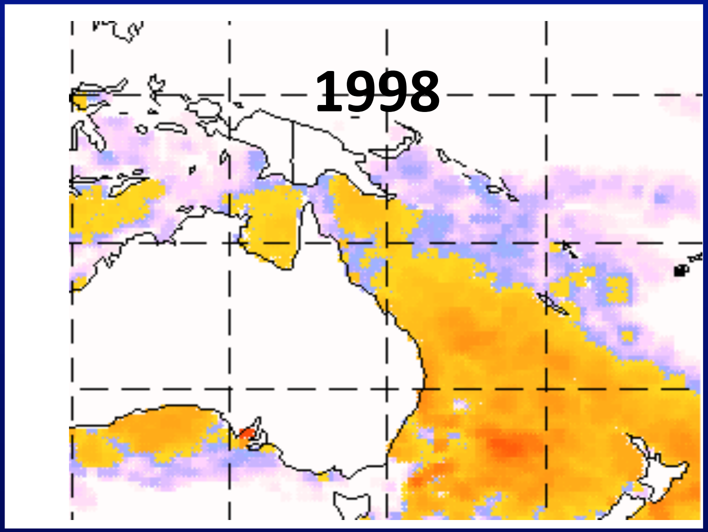


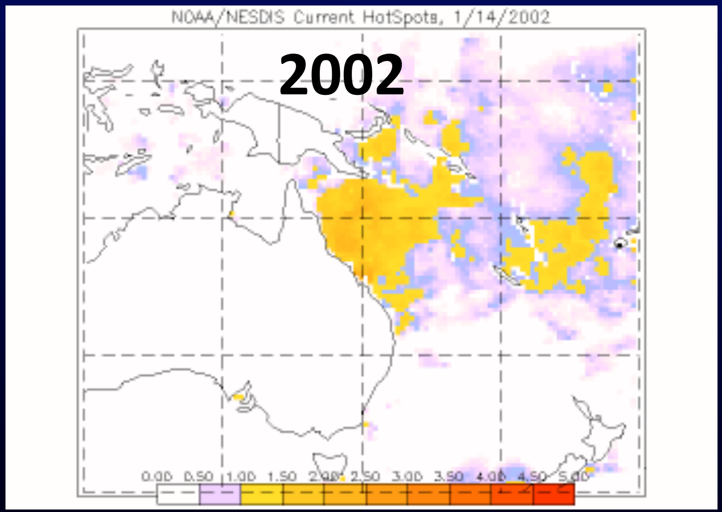
Fig. 4. Dates and locations of when severe bleaching began in 1998. Data obtained from Coral Health and Monitoring Network e-mail list (http://coral.aoml.noaa.gov).

Mass coral bleaching caused by thermal stress

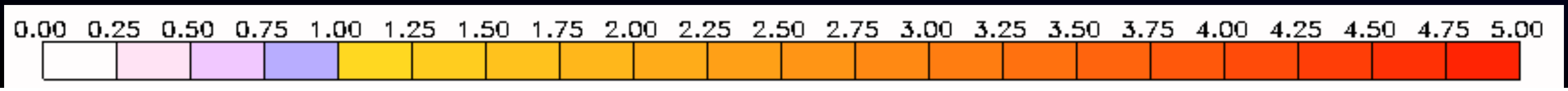
- 95% correlation with increases in sea temperature (1-2^{o}C above long-term summer sea temperature maxima) and bleaching.
- Backed up experimentally
- Basis for a highly predictive SST program at NOAA (HotSpots):

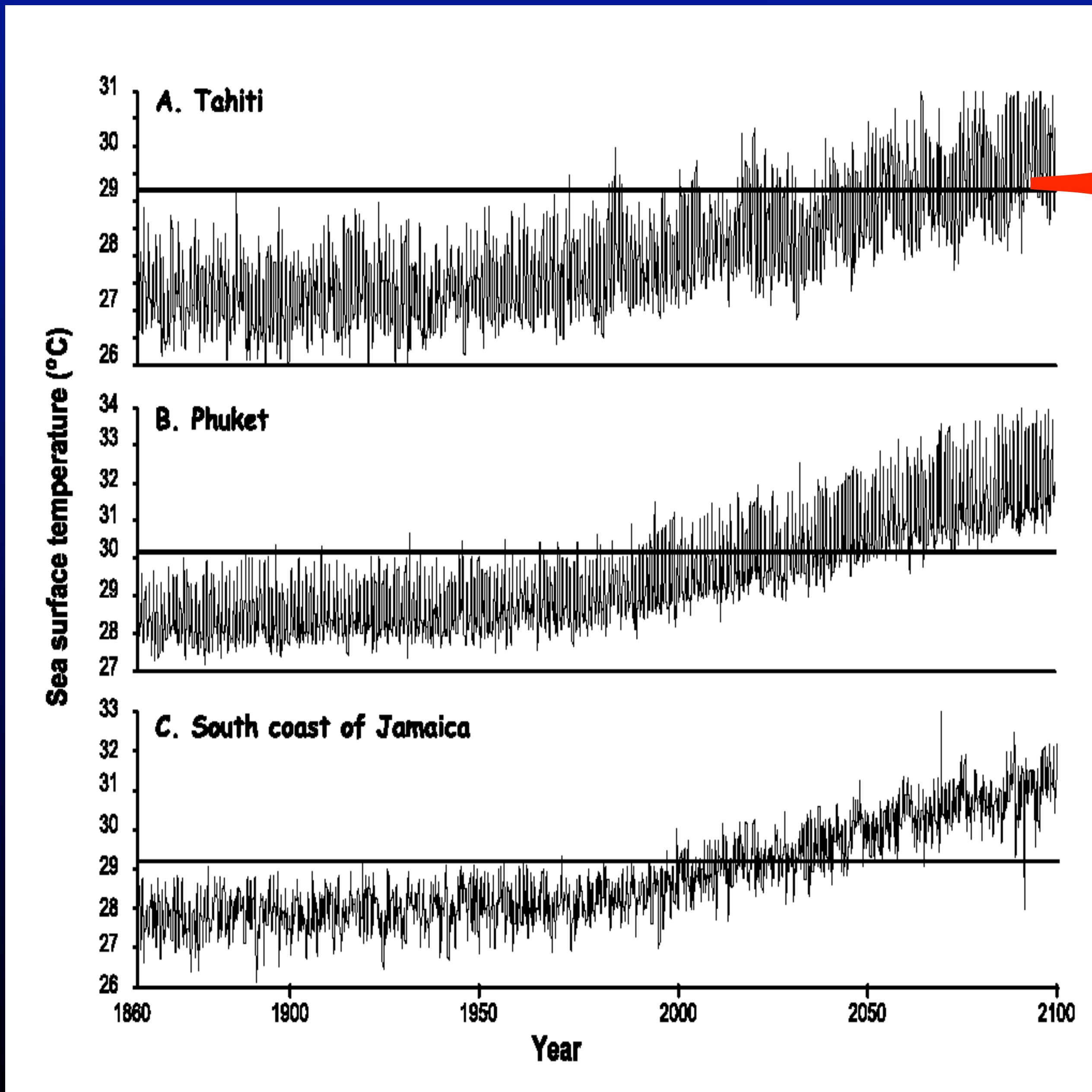






Strong, Hayes, Goreau, Causey and others

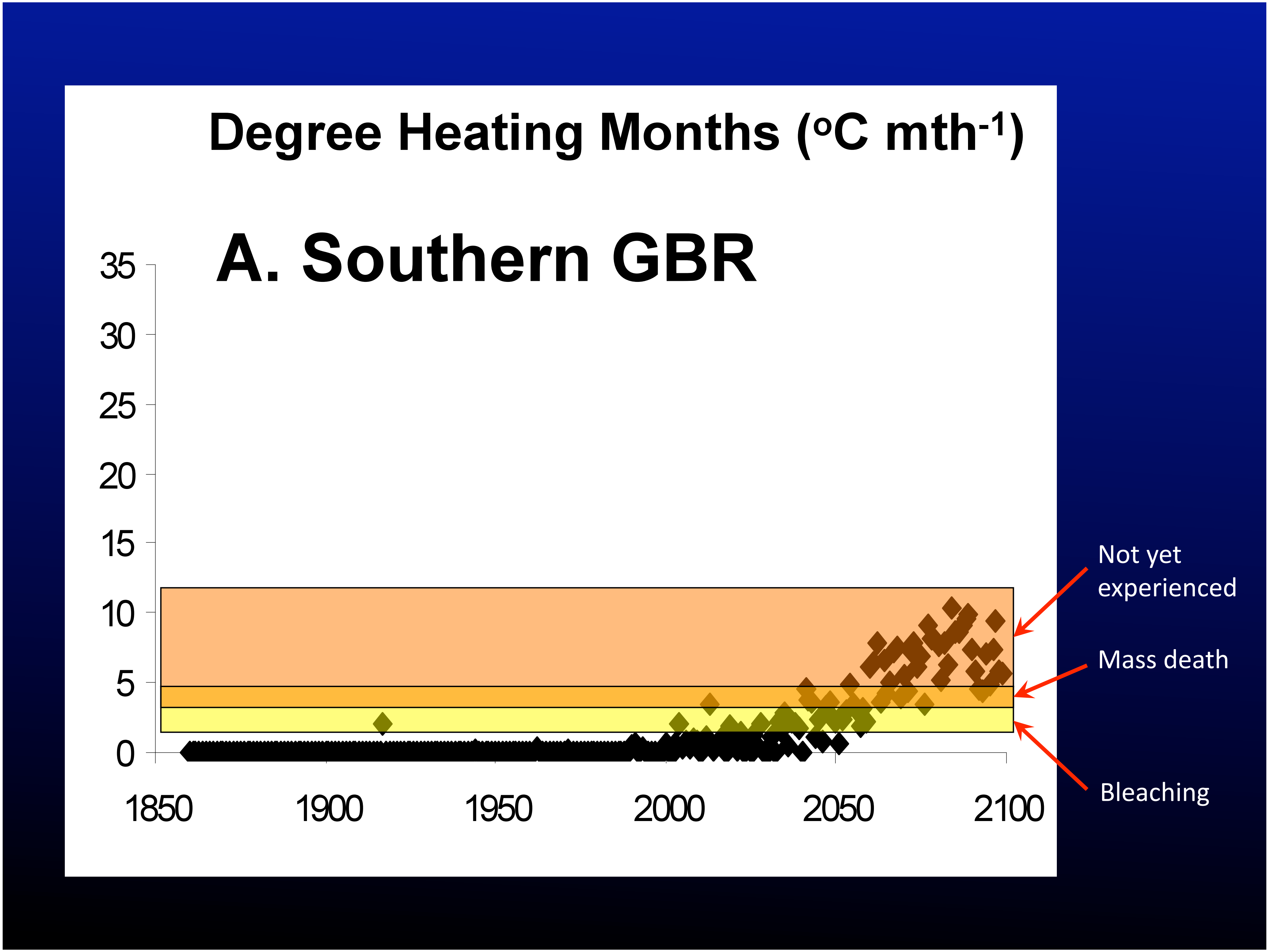




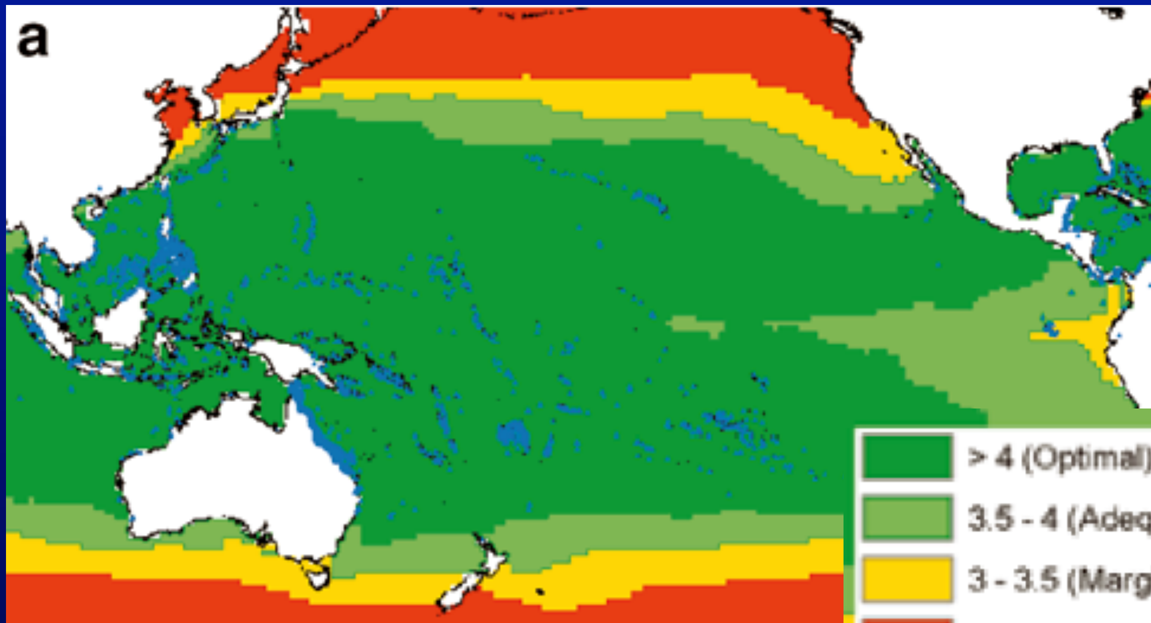
Threshold temperature – above which bleaching manifests itself (1-2oC above the long-term summer maximum temperatures

WHAT DOES THE FUTURE HOLD?

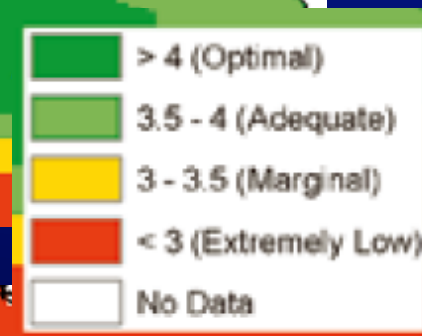
Hoegh-Guldberg (1999)

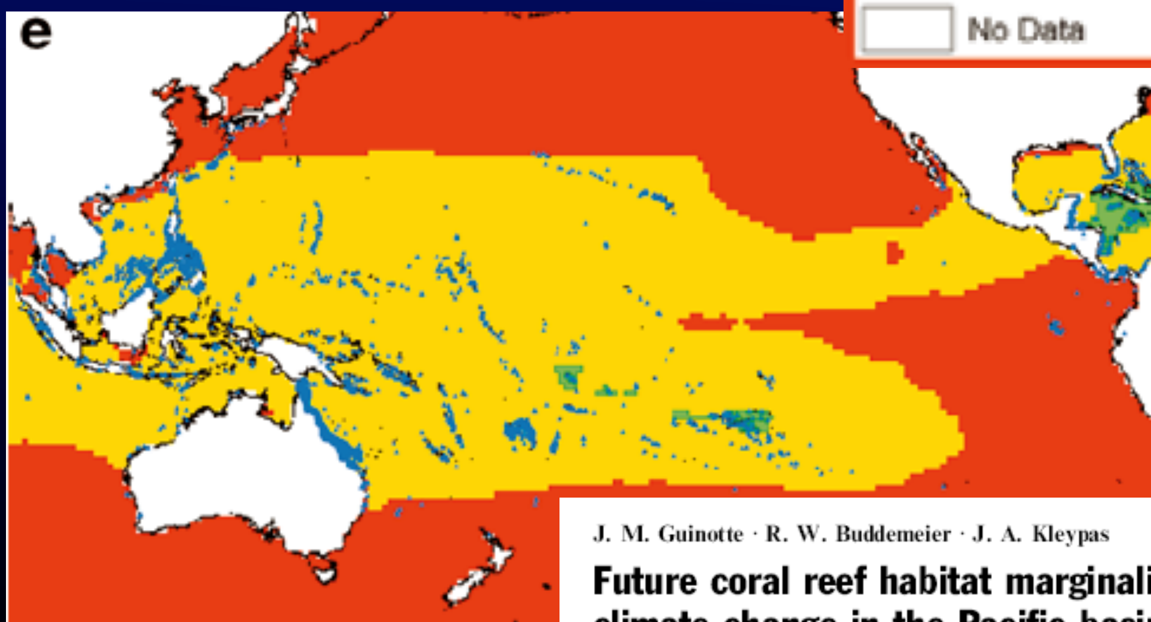


Degree Heating Months (°C mth-1)
A. Southern GBR
35
30
25
20
15
10
5
0
1850
1900
1950
2000
2050
2100
Not yet experienced
Mass death
Bleaching



Pre-industrial
pCO_2 – 280 ppm



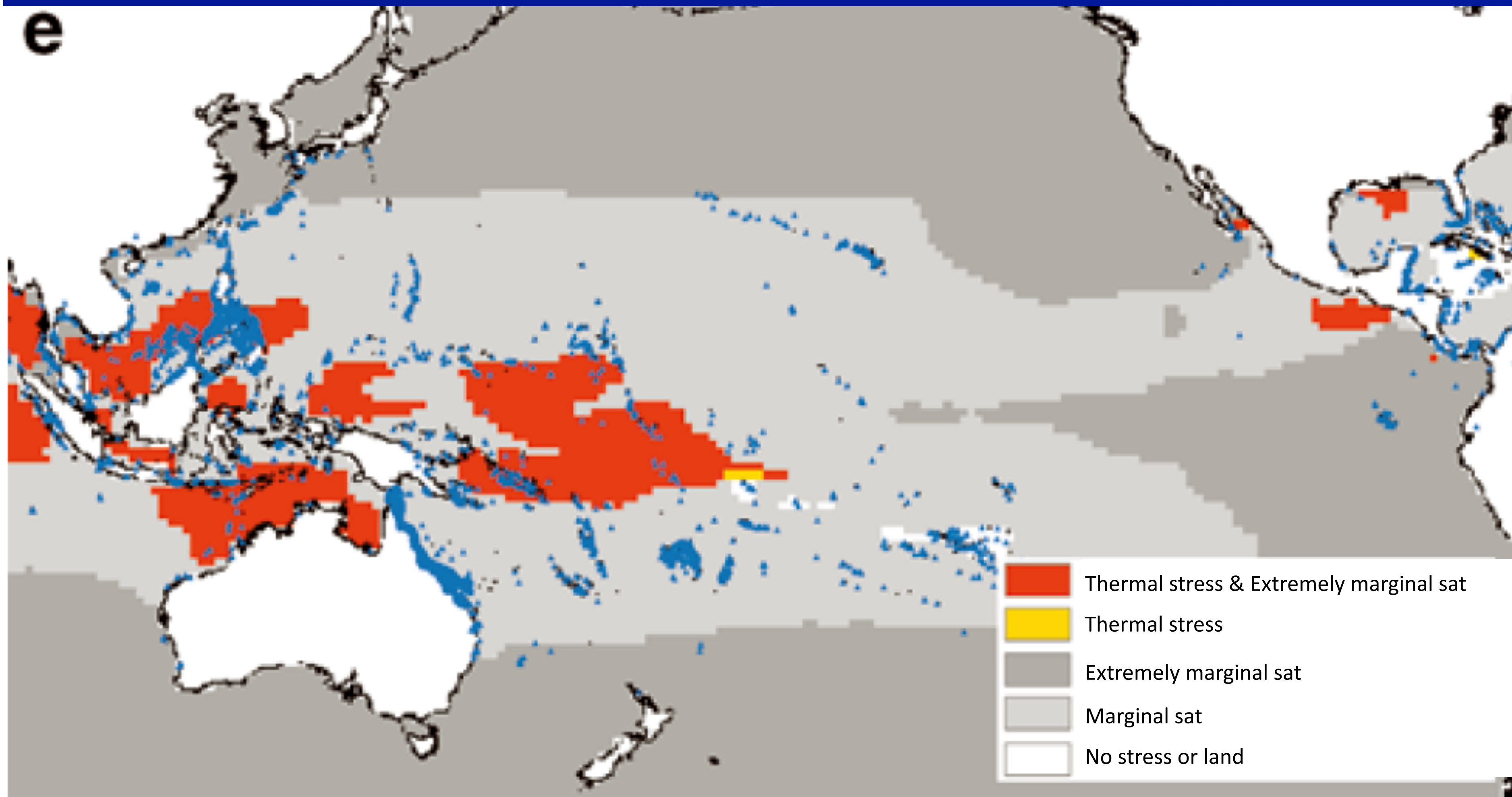


2060-69;
pCO_2 – 517 ppm

J. M. Guinotte · R. W. Buddemeier · J. A. Kleypas

Future coral reef habitat marginality: temporal and spatial effects of climate change in the Pacific basin

Coral Reefs (2003) 22: 551–558
DOI 10.1007/s00338-003-0331-4

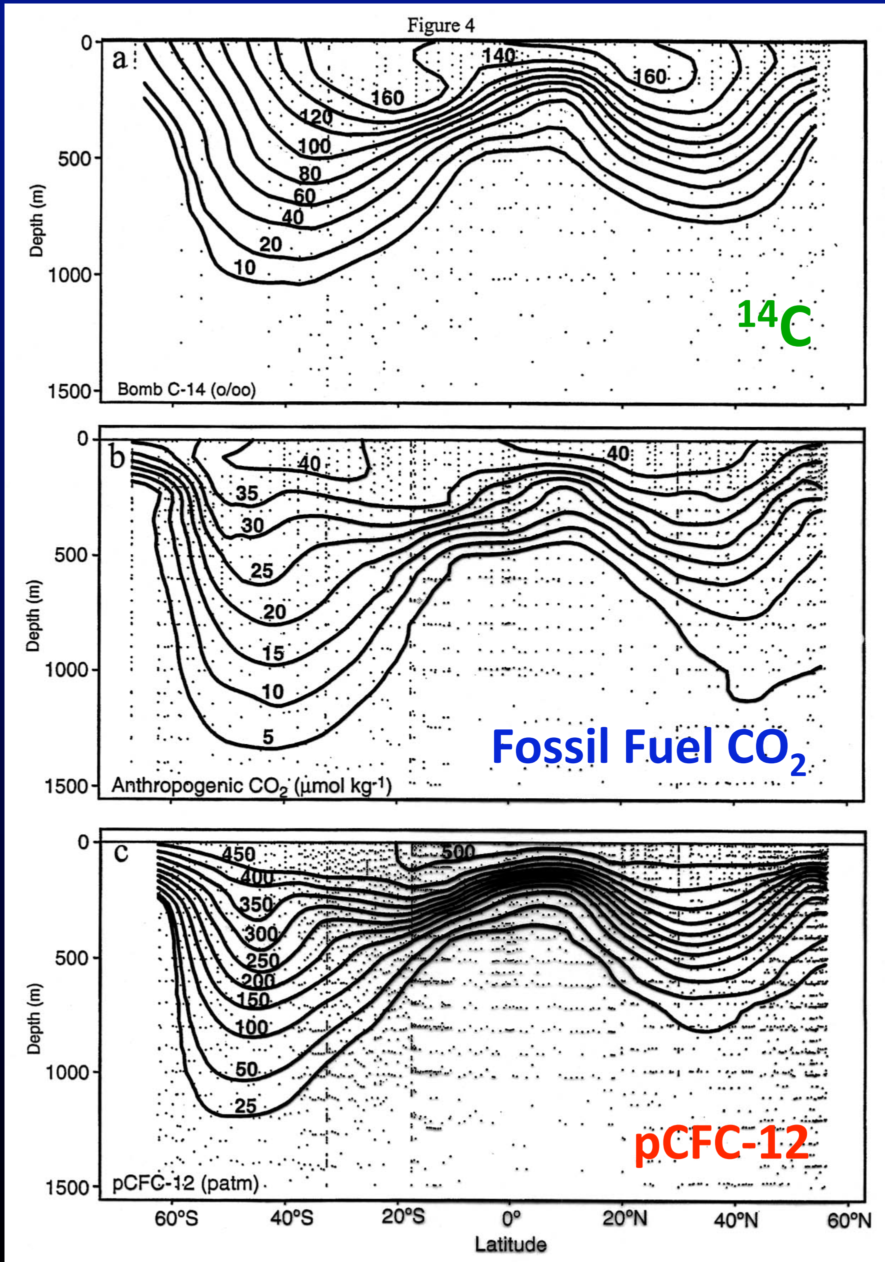


J. M. Guinotte · R. W. Buddemeier · J. A. Kleypas

Future coral reef habitat marginality: temporal and spatial effects of climate change in the Pacific basin

Coral Reefs (2003) 22: 551–558
DOI 10.1007/s00338-003-0331-4

Ocean CO_2 “Disposal” Today



From Sabine et al. 2002:

JGOFS/WOCE survey data. Pacific meridional section.

Fossil fuel signal has penetrated to >1000m. Surface values reach 50μmol/kg (2.2 mg/kg). The inventory is 44.5±5 Pg C in 1994.

We have disposed of ~ 163 billion tons of CO_2 in Pacific Ocean waters.

The ocean now has taken up ~400 GT of fossil fuel CO_2.

Global surface ocean CO_2 disposal is now about 20-25 million tons per day.

Some facts about ocean acidification

• Increasing pCO_2 in seawater causes the formation of carbonic acid (H_2CO_3), which causes acidification.

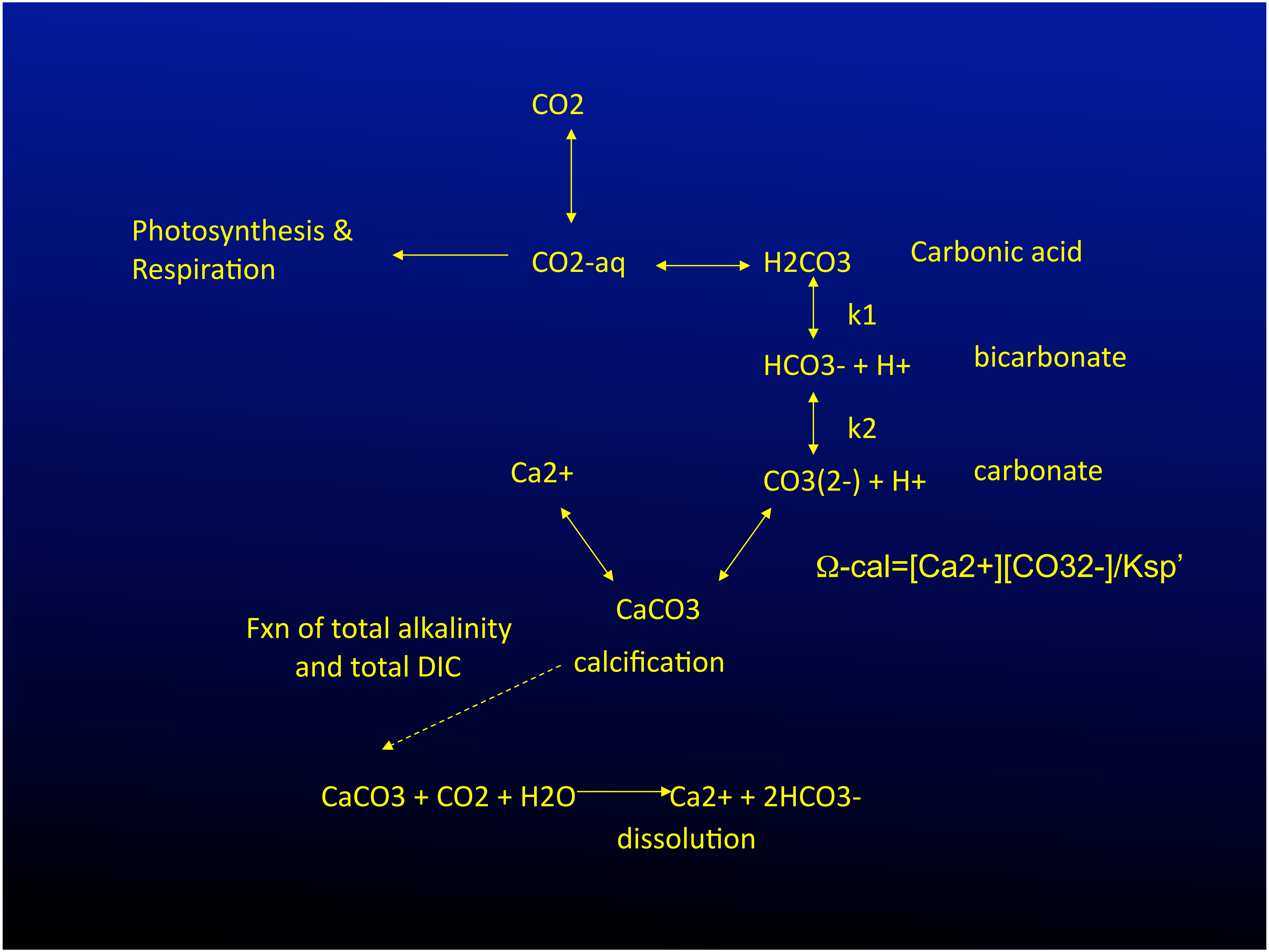
• $H_2CO_3 + CO_3^{2-} + H_2O \Leftrightarrow HCO_3^-$ (decrease in $[CO_3^{2-}]$) and the ocean's saturation state with respect to calcite (Ω-cal), the form of calcium carbonate ($CaCO_3$) produced by coccolithophores.

$$\Omega\text{-cal} = f\{[CO_3^{2-}], [Ca^{+2}]\}$$

• Elevated pCO_2 causes an increase in **$[CO_2]$**, the source of carbon for photosynthesis, and also in **$[HCO_3^-]$**, the source of carbon for calcification (**?**) in coccolithophores:

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + CO_2 + H_2O$$

• Consequently, a decrease in marine calcification without a concomitant decrease in organic carbon export would lead to an increased drawdown of atmospheric CO_2.


CO2
Photosynthesis &
Respiration
CO2-aq
H2CO3
Carbonic acid
k1
HCO3- + H+
bicarbonate
k2
Ca2+
CO3(2-) + H+
carbonate
Ω-cal=[Ca2+][CO32-]/Ksp'
CaCO3
Fxn of total alkalinity
and total DIC
calcification
CaCO3 + CO2 + H2O
Ca2+ + 2HCO3-
dissolution

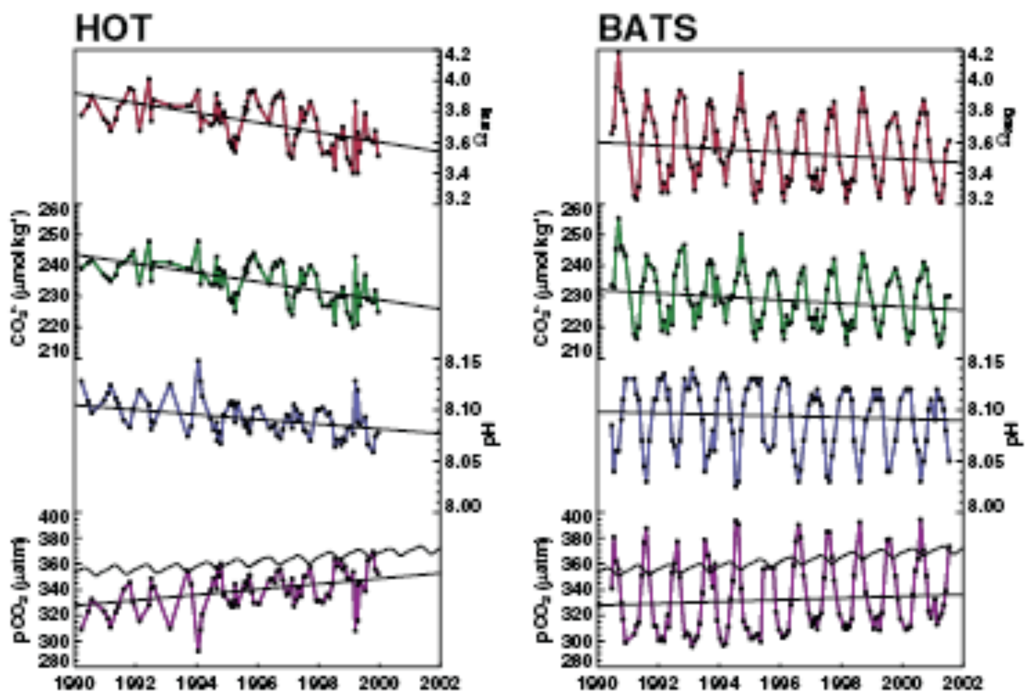
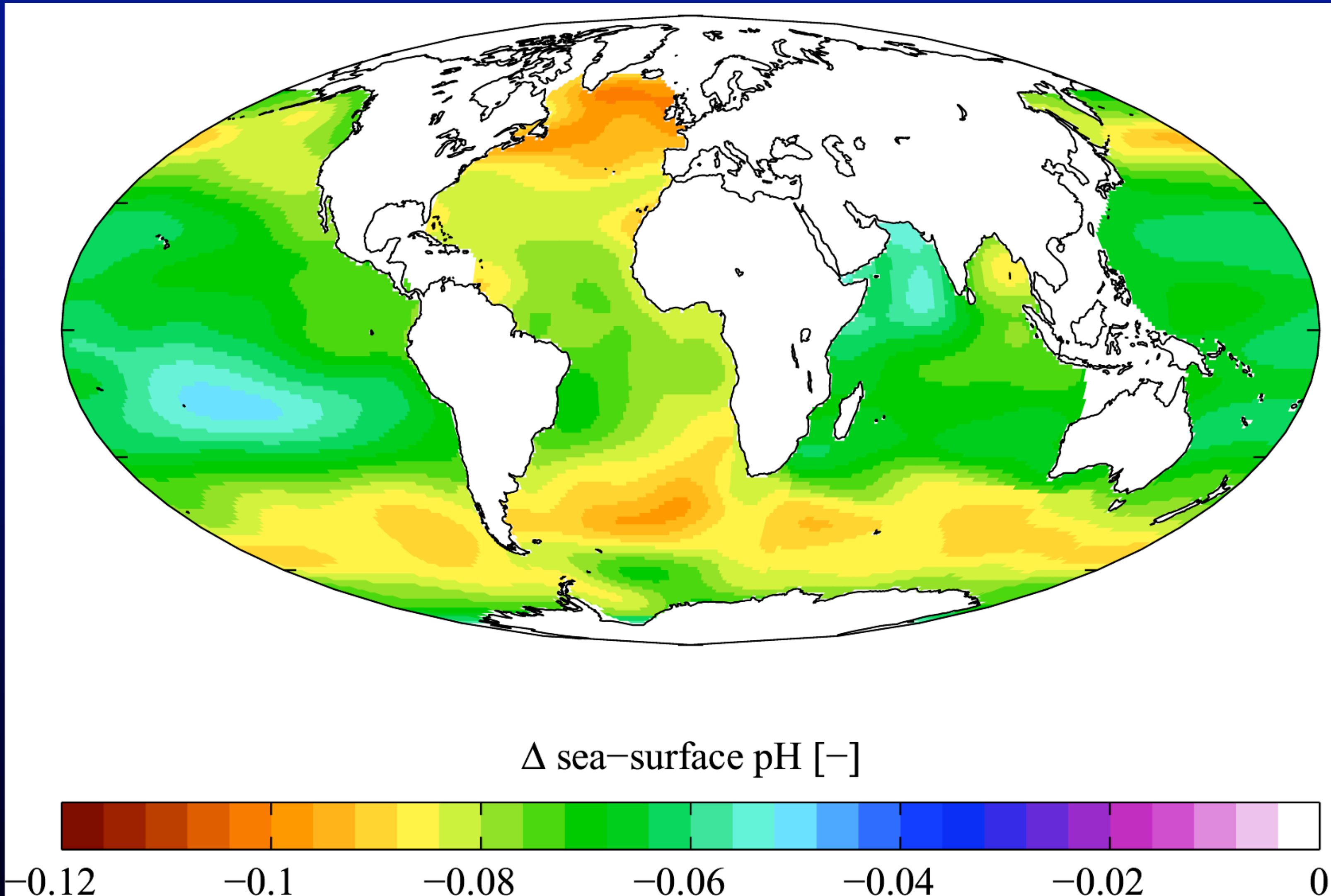


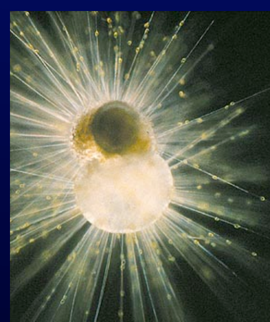
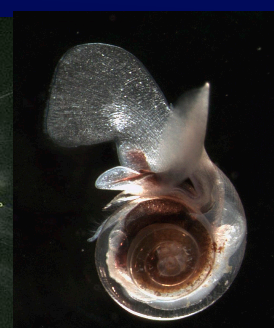
Figure 1–2: Monthly carbon-system parameters at two time-series stations in subtropical gyres: HOT (Hawaii Ocean Time-series station) and BATS (Bermuda-Atlantic Time-series Station). The lowest plot in each graph includes both the surface water pCO_2 (line with dots), and the Mauna Loa atmospheric CO_2 record (line without dots).

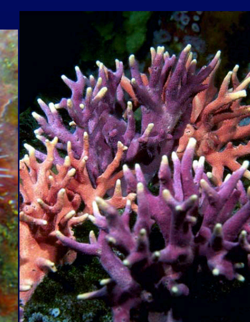

Δ sea−surface pH [−]
−0.12
−0.1
−0.08
−0.06
−0.04
−0.02
0

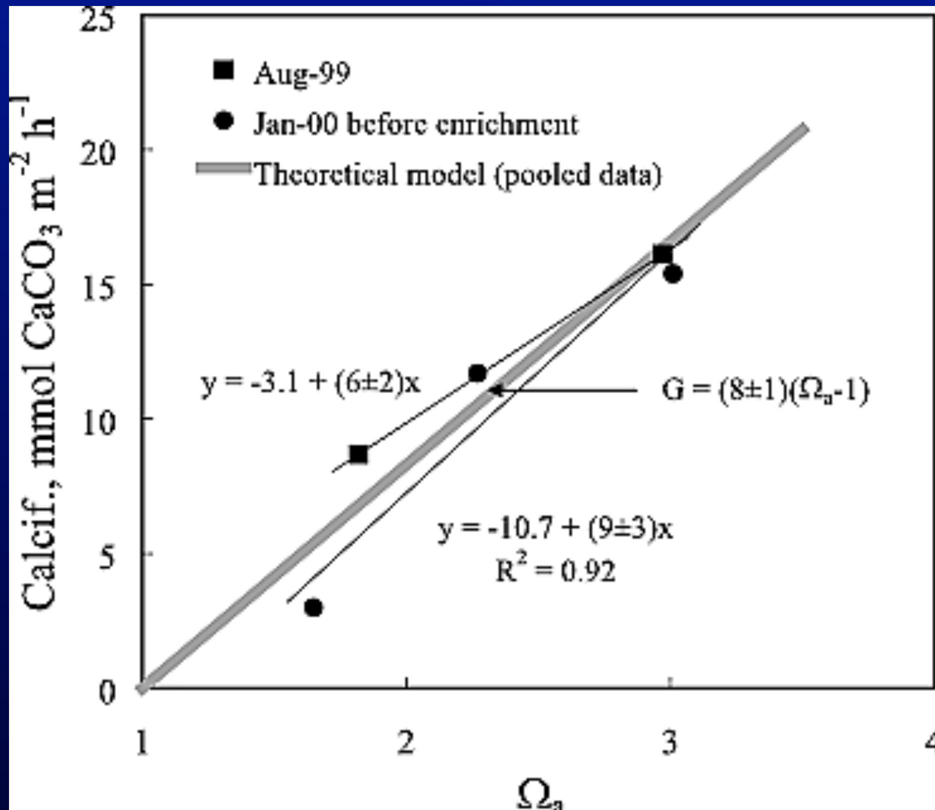
Ocean acidification

What do we know about the response of calcifyers to ocean acidification?



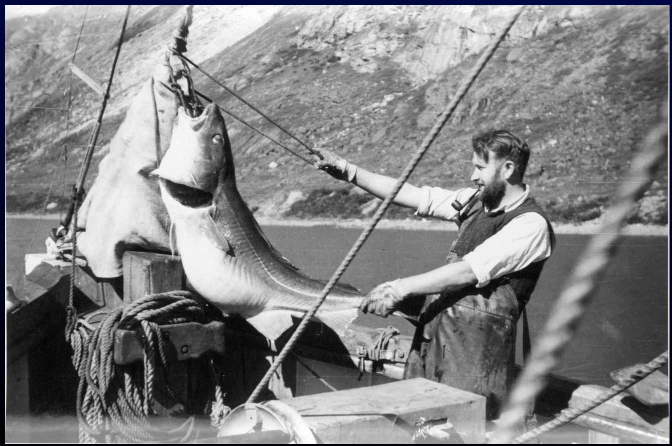


Effect of reduced aragonite saturation state (Ωa) on the calcification rate of the coral assemblage in August 1999 and in January 2000 before the nutrient enrichment.

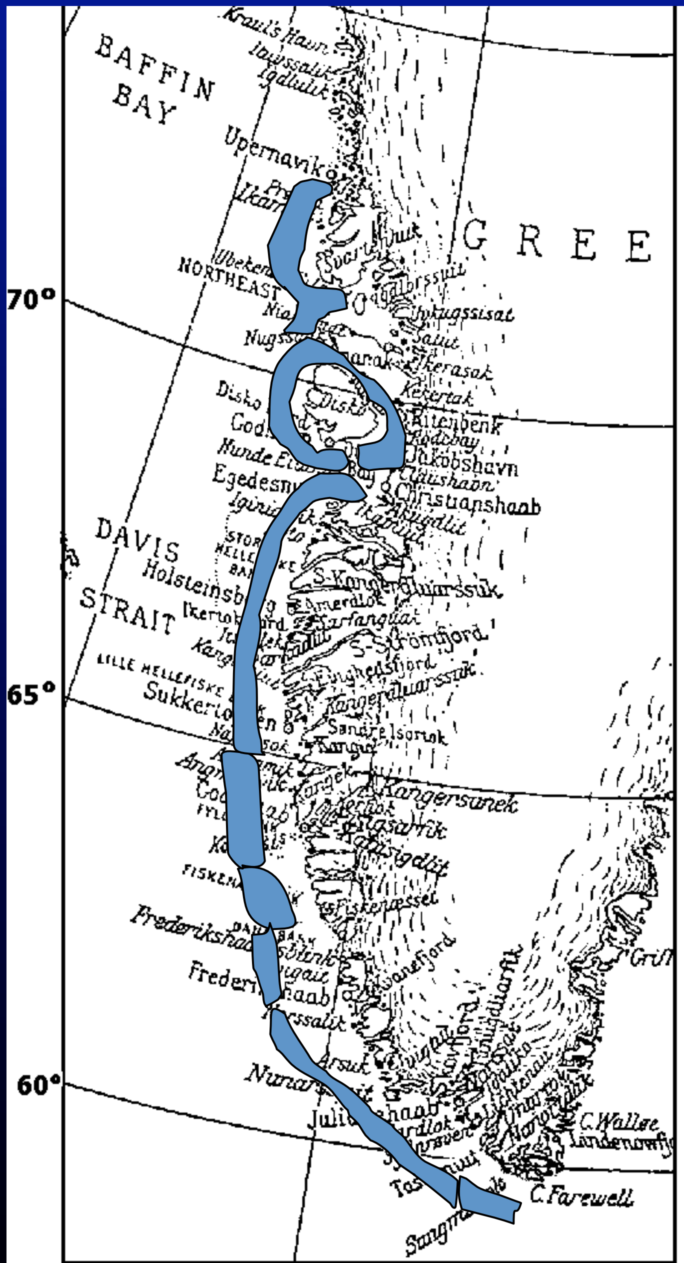
Langdon and Atkinson 2005

Large changes have long been recognized by humanity

It comes up to the shore here from the great fish pond which is the Icelandic Sea, towards the winter when the great part of other fish have left the land. And the herring does not seek the shore along the whole, but at special points which God in his Good Grace has found fitting, and here in my days there have been two large and wonderful herring fisheries at different places in Norway. The first was between Stavanger and Bergen and much further north, and this fishery did begin to diminish and fall away in the year 1560. And I do not believe there is any man to know how far the herring travelled. For the Norwegian Books of Law show that the herring fishery in most of the northern part of Norway has continued for many hundreds of years, although it may well be that in punishment for the unthankfulness of men it has moved from place to place, or has been taken away for a long period.



Clergyman Peder Claussøn Friis
(1545-1614)



Northward extension of cod stock from 1920 to late 1930's. Published in 1939

Det Kgl. Danske Videnskabernes Selskab.

Biologiske Medd. **XIV**, 8.

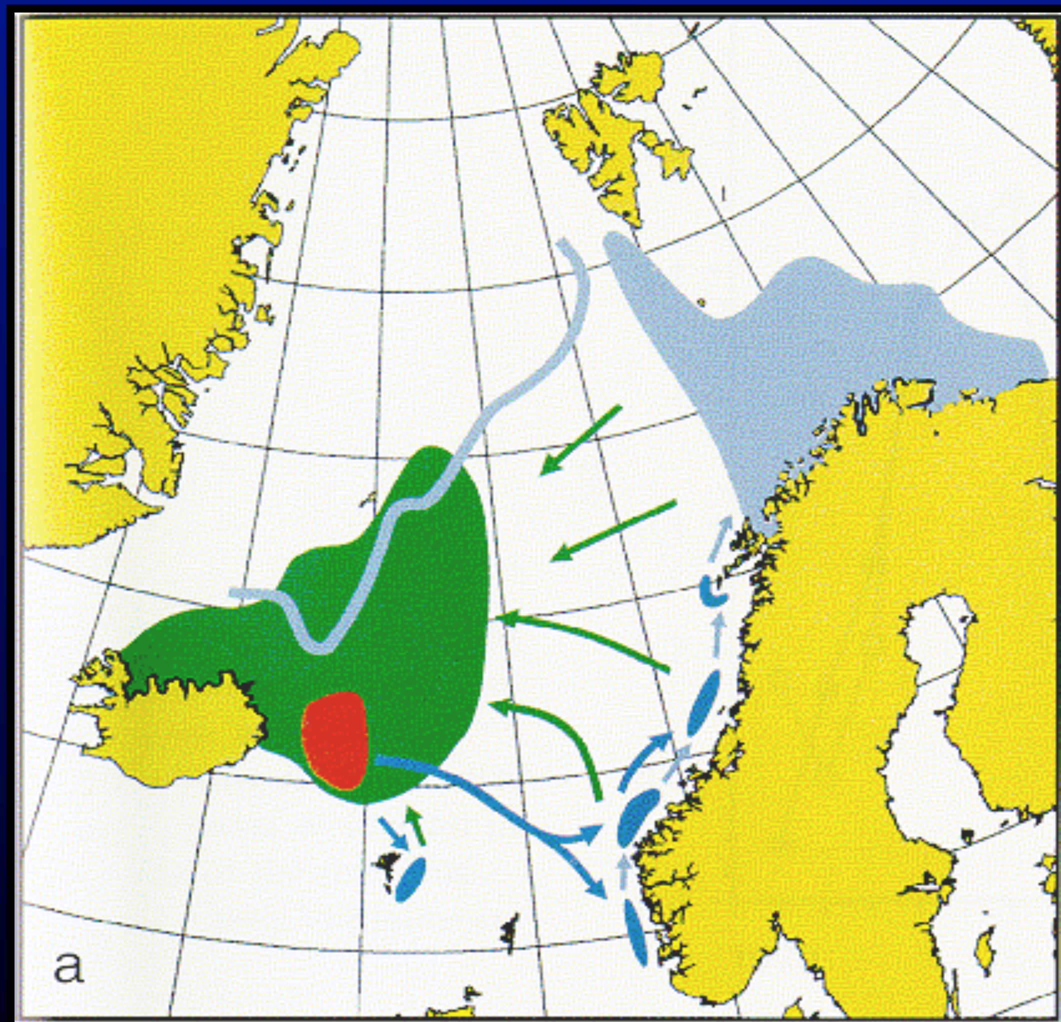
CONCERNING A CHANGE OF CLIMATE DURING RECENT DECADES IN THE ARCTIC AND SUBARCTIC REGIONS, FROM GREENLAND IN THE WEST TO EURASIA IN THE EAST, AND CONTEMPORARY BIOLOGICAL AND GEOPHYSICAL CHANGES

WITH 2 CHARTS

BY

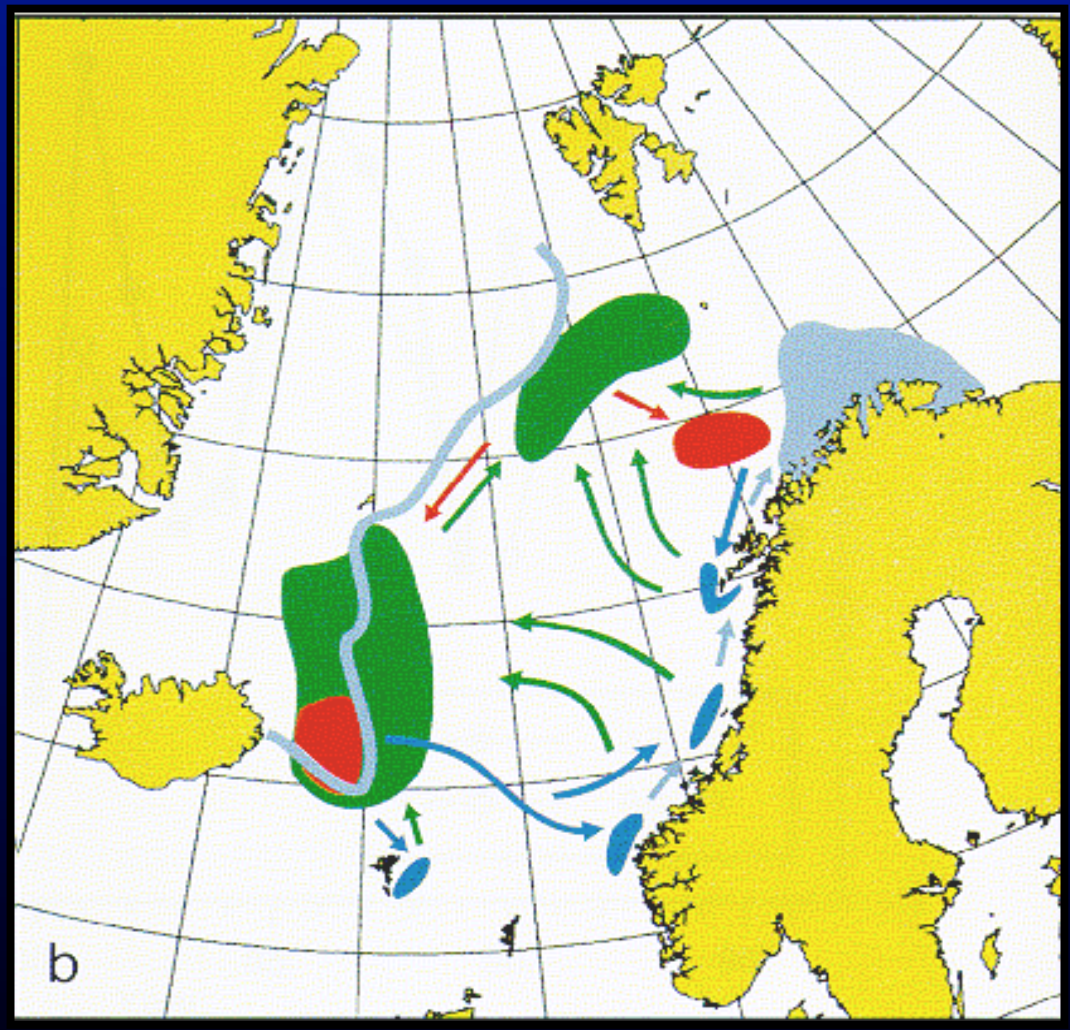
AD. S. JENSEN

Herring migration - “traditional”



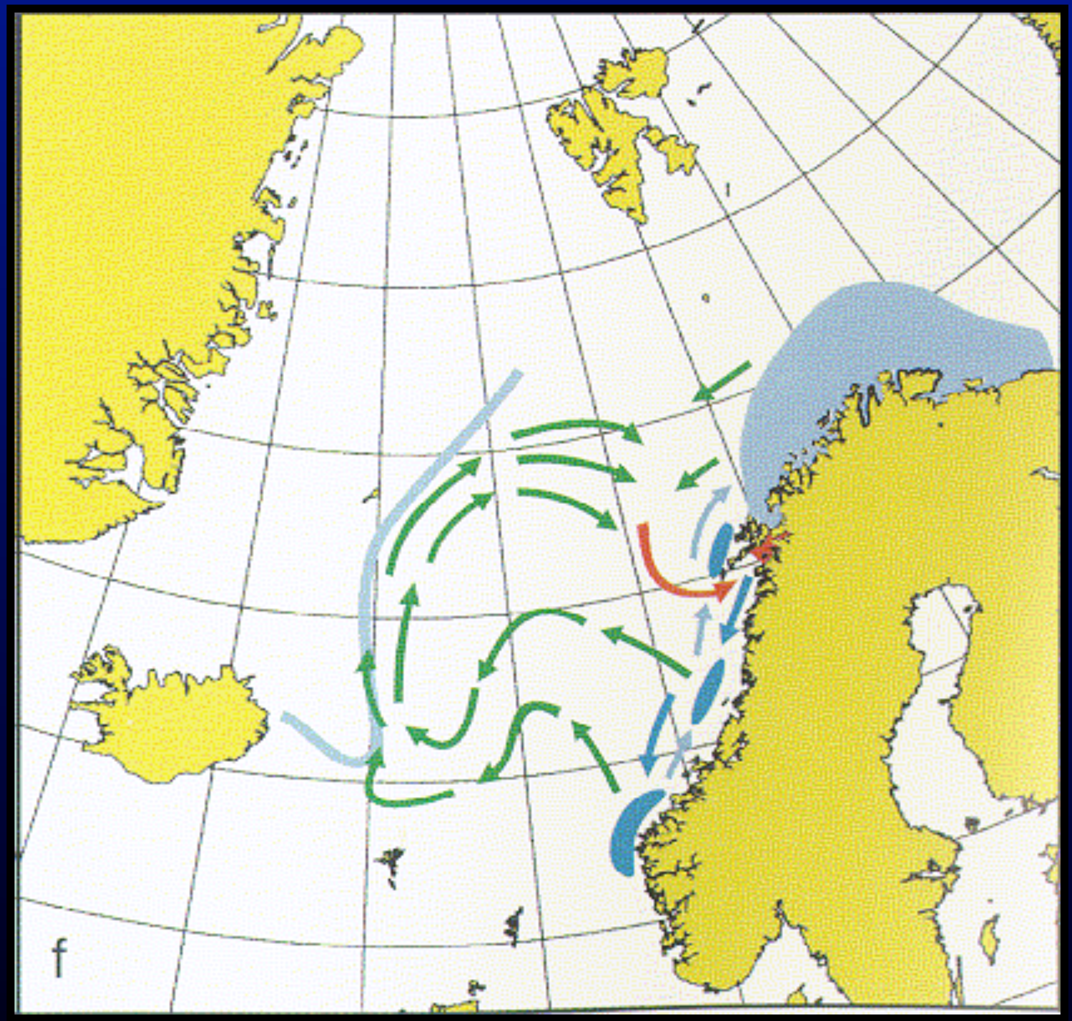
from Vilhjalmsson 1997

Herring migration 1965 - 66

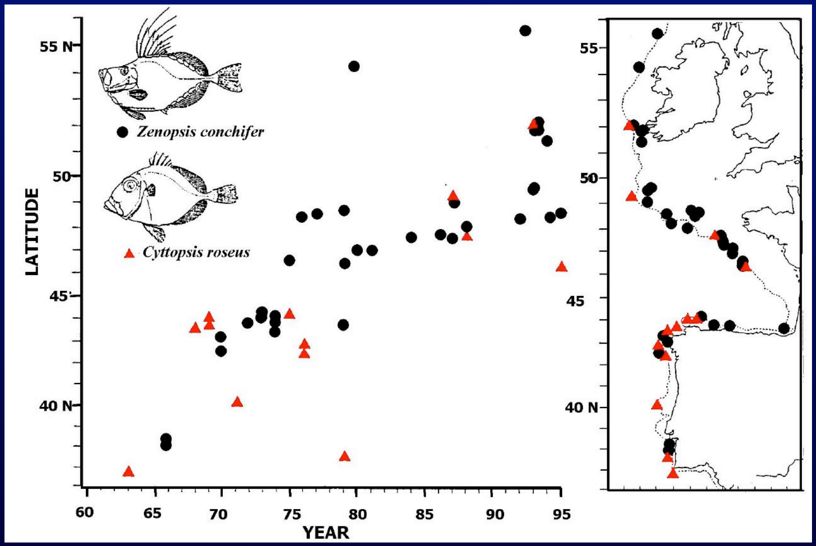


from Vilhjalmsson 1997

Herring migration 1995



from Vilhjalmsson 1997




MORGENAVISEN
Jyllands-Posten

Fredag den 16. januar 2004 · Uge 3 ★★★

Danmarks internationale avis

www.jp.dk

Foto: CARSTEN ANDREASEN

Dyrest og billigst

■ Daniel og Mia bliver passet i institutionen "Bakkehuset" i Middelfart Kommune. Her er taksterne så høje, at Bakkehusets leder erklærer, at han ikke ville have råd til at sende sine børn i vuggestue. Vi har også besøgt "Kagsmosen" i Herlev Kommune, hvor taksterne er i bund.

1. SEKTION, SIDE 4

Tropefisk i danske farvande

Stigende temperatur er i fuld gang med at ændre havet omkring Danmark. Tropiske fisk nærmer sig, mens torsken og muligvis også rødspætten er på vej væk.

KLIMAFORANDRINGER

Af LARS FROM

■ Tropiske fisk og planter har sat kurs mod Danmark og resten af Nordeuropa i takt med, at temperaturen i havet omkring os er steget op mod to grader i løbet af de seneste 15-20 år.

Hvert år rykker tropiske fisk og plankton 50 kilometer mod nord og dermed også tættere på Danmark, viser data og oplysninger fra forskere og biologer, Jyllands-Posten har talt med.

Flere nye, eksotiske fisk har allerede meldt deres ankomst. Det gælder f.eks. hestemakreller, rød mulle, multe og ansjoser, der i disse dage trækkes op af vandet i tonsvis.

Til gengæld er to af de mest danske fisk på vej væk: Torsken og rødspætten. Torsken er allerede forsvundet i stort tal, ligesom den vigtige industrifisk tobis er på kraftig retur. Og så mener både fiskerne og flere forskere, at også rødspætten kan være ved at forsvinde.

Skov- og Naturstyrelsen sender i dag et nyhedsbrev på gaden, hvor der bliver sat fokus på klimaforandringernes effekt for dyr og planter i og omkring Danmark.

Biolog Ulrik Christian Berggren fra Skov- og Naturstyrelsen er ikke i tvivl om, at de voldsomme forandringer, der allerede er sket, hænger sammen med den stigende temperatur i havet omkring os.

»Den seneste forskning dokumenterer, at indvandringen fra syd bevæger sig mod Danmark med 50 kilometer om året. Samtidig ved vi, at torsken kun vil leve i omkring 10 grader varmt vand, og da temperaturen i Nordsøen nu ligger på omkring 9,8 grader, kan det meget let ende med, at torsken helt forsvinder.«

Den registrerede temperaturstigning i Nordsøen og især Skagerrak har været langt kraftigere, end eksperterne havde regnet med. I Skagerrak er temperaturen således steget omkring to grader siden 1980'erne.

Seniorforsker Brian MacKenzie fra Danmarks Fiskeriundersøgelser forudser imidlertid endnu mere dramatiske ændringer de kommende år:

»Fisk er meget mobile og kan derfor ændre deres levevis hurtigt. Hvis klimaforandringerne fortsætter, som det ser ud til, vil mange arter flytte sig geografisk – nogle vil forsvinde og andre vil erstatte dem. Og hvis FN's klimapanel, IPCC, får ret i sine forudsigelser, vil der ske meget store ændringer for skaldyr, fisk og plankton omkring Danmark,« lyder vurderingen.

I Danmarks Fiskeriforening ønsker man øget forskning i, hvad der er ved at ske med vores havområder – og hvordan fiskerne kan forholde sig til det:

»Oplysningerne fra biologer og havforskere passer med det, vi hører og oplever. Jeg har således netop talt med en fisker fra Esbjerg, der har landet en fangst på 400 tons, hvoraf 70 procent var ansjoser. De mange ansjoser kan ikke redde industrifiskeriet, men det betyder noget og har gjort det det seneste halve år,« fastslår biolog Carsten Krog fra Danmarks Fiskeriforening.

1. SEKTION, SIDE 5

KLIMAFORANDRINGER

Tropiske fisk på vej nordpå

I takt med at havets temperatur stiger, rykker tropiske fisk længere mod nord. En undersøgelse foretaget af franske forskere ved Oceanologica Acta for perioden 1960 - 1995 viser, hvor man har fanget de to tropiske fiskearter Rosa Dory og John Dory.

Rosa Dory
SIGNATUR:

John Dory
SIGNATUR:

Der findes kun data for disse to fiskearters vej mod nord frem til 1995. Men undersøgelser, der går helt frem til i dag, af planktons bevægelse fra de tropiske egne mod nord viser præcis samme billede - nemlig en vandring på ca. 50 km mod nord hvert eneste år.

Danske fiskearter på vej væk
Torsk
Tobis
Rødspætte

Nye arter i danske farvande
Rød Mulle
Multe
Ansjos

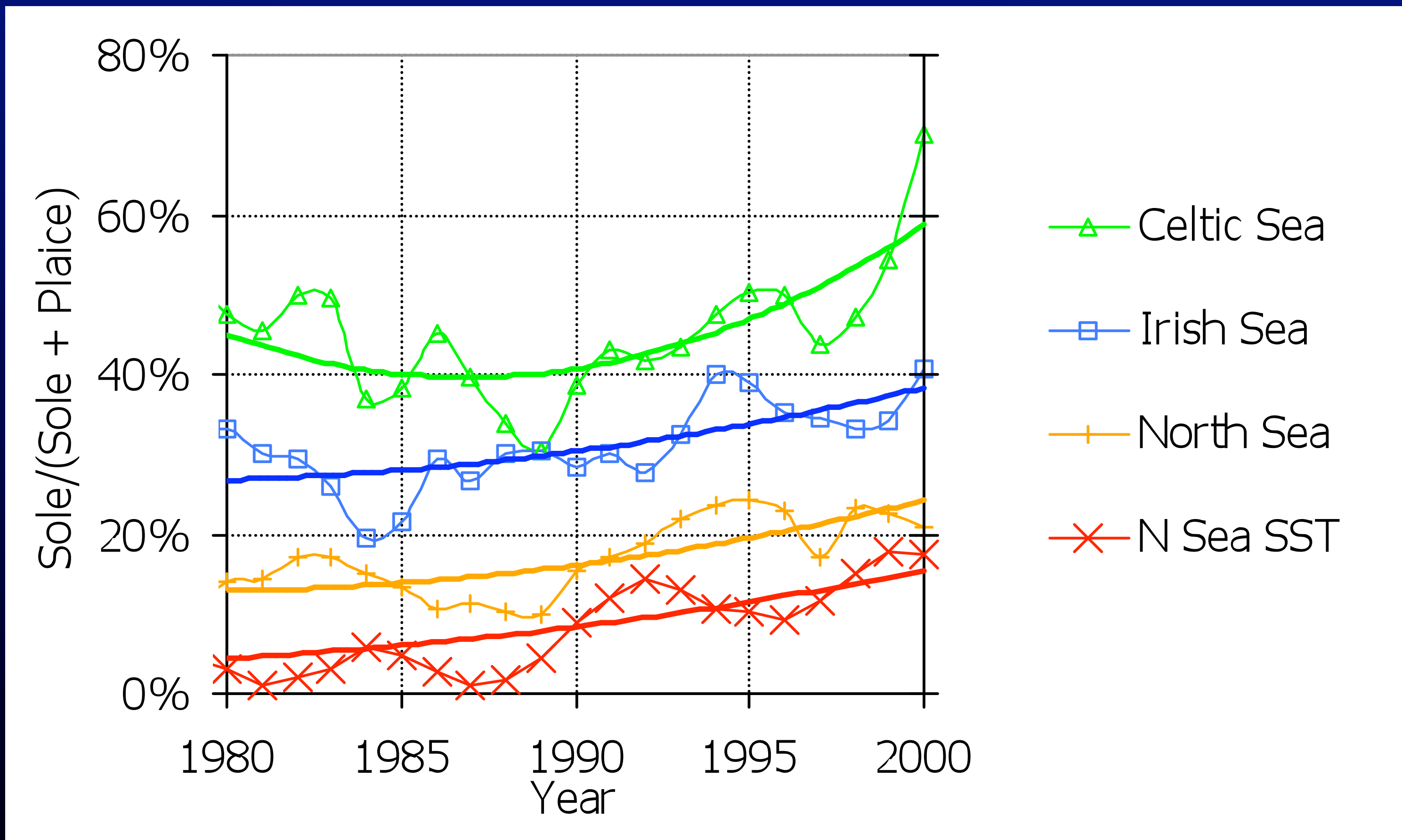
BREDDEGRADER
55
50
45
40
35

Jean-Claude Quero Ital.J.Zool.,65 Suppl.:493-499 (1998)

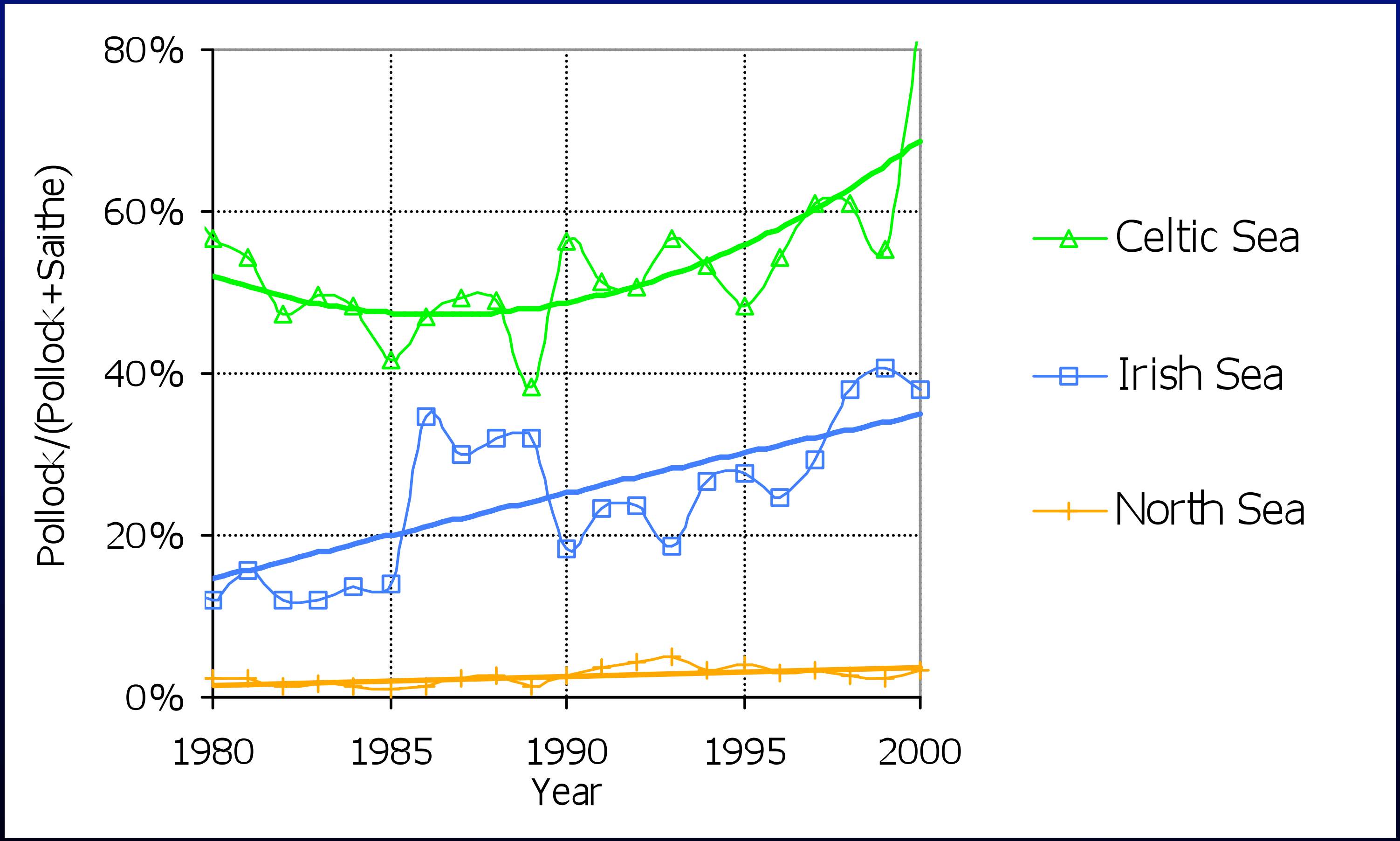
Climate change or fishing?

- Both climate and fishing affect populations
- The level of fishing is excessive on most stocks
- Populations increase when climate (and other conditions) are favourable
- (distribution and abundance are linked)

Ratio of catch of warm/cold species



Ratio of catch of warm/cold species



Pergamon

Progress in Oceanography 49 (2001) 439–468

Progress in Oceanography

www.elsevier.com/locate/pocean

The pelagic ecosystem of the tropical Pacific Ocean: dynamic spatial modelling and biological consequences of ENSO

Patrick Lehodey

GEOPHYSICAL RESEARCH LETTERS, VOL. 30, NO. 17, 1896, doi:10.1029/2003GL017528, 2003

A new climate regime in northeast pacific ecosystems

William T. Peterson[1] and Franklin B. Schwing[2]

Dynamic geography of small pelagic fish populations in the California Current System on the regime time scale (1931–1997)[1]

Rubén Rodríguez-Sánchez, Daniel Lluch-Belda, Héctor Villalobos, and Sofía Ortega-García

Geir Ottersen · Benjamin Planque · Andrea Belgrano
Eric Post · Philip C. Reid · Nils C. Stenseth

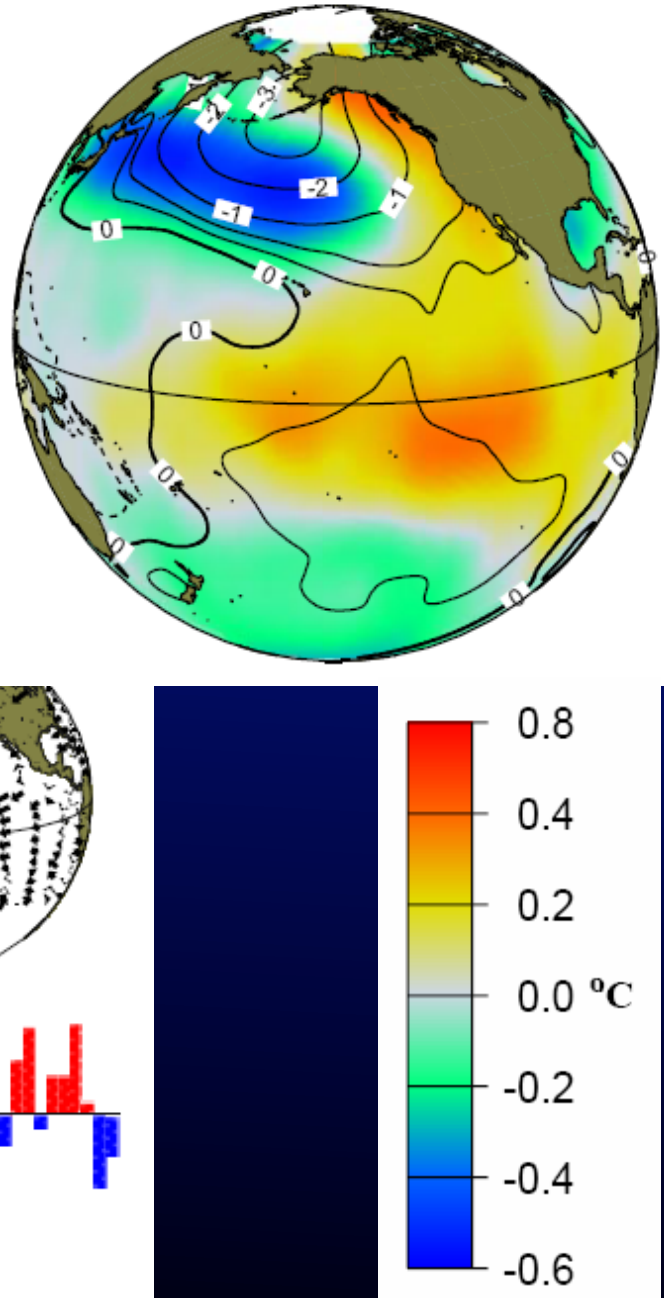
Ecological effects of the North Atlantic Oscillation

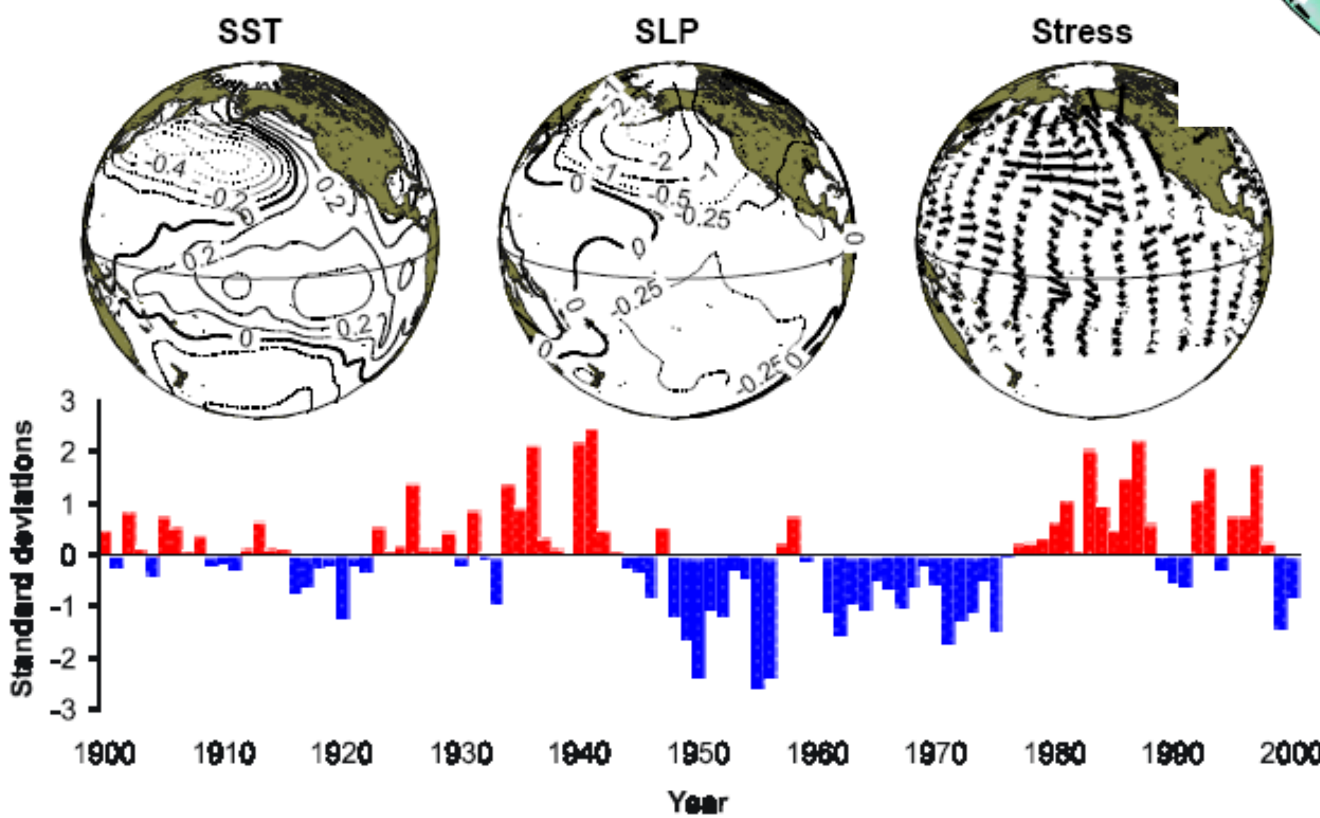
Received: 25 July 2000 / Accepted: 5 January 2001 / Published online: 13 March 2001

ICES Marine Science Symposia, 219: 261–270. 2003.

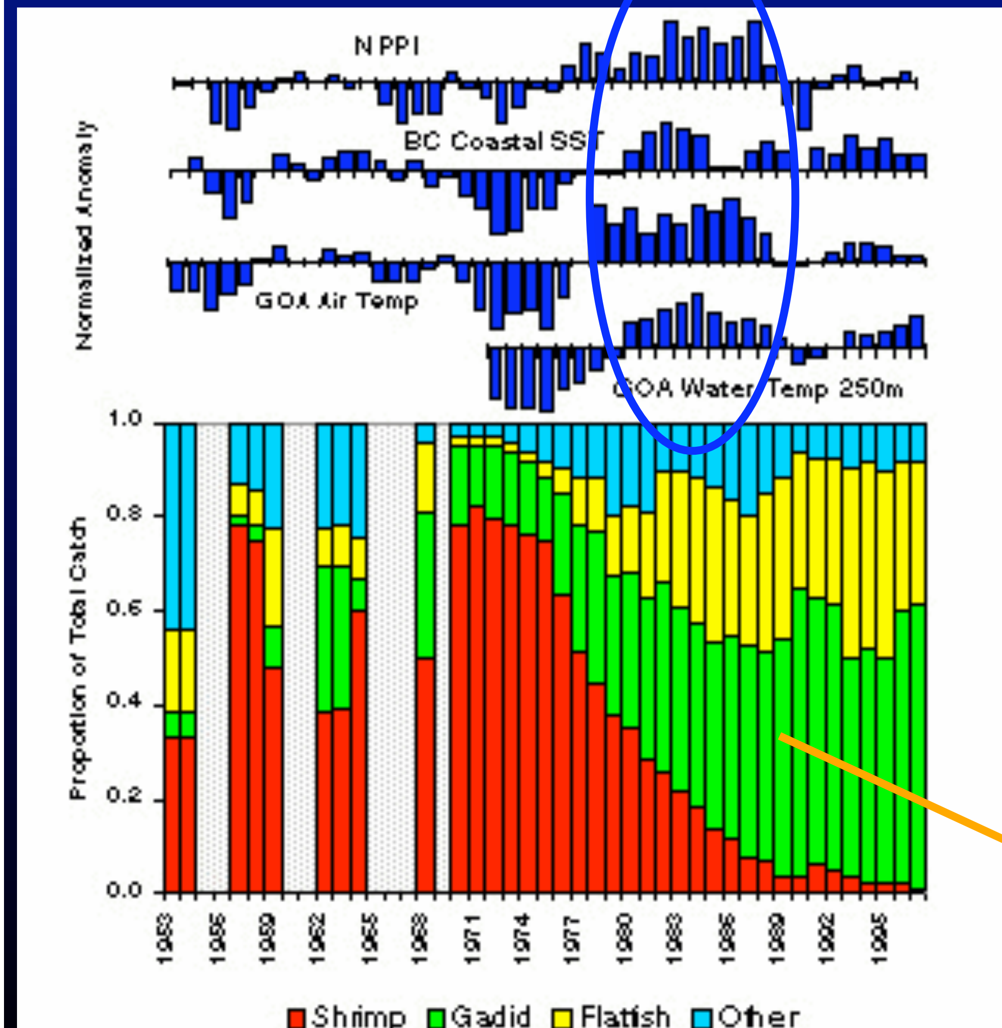
Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature?

K. Brander, G. Blom, M. F. Borges, K. Erzini, G. Henderson,
B. R. MacKenzie, H. Mendes, J. Ribeiro, A. M. P. Santos, and R. Toresen


0.8
0.4
0.2
0.0 °C
-0.2
-0.4
-0.6


SST
SLP
Stress
Standard deviations
3
2
1
0
-1
-2
-3
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year

Climate shifts perturb fisheries and have socio-economic impacts.



Late 1960's

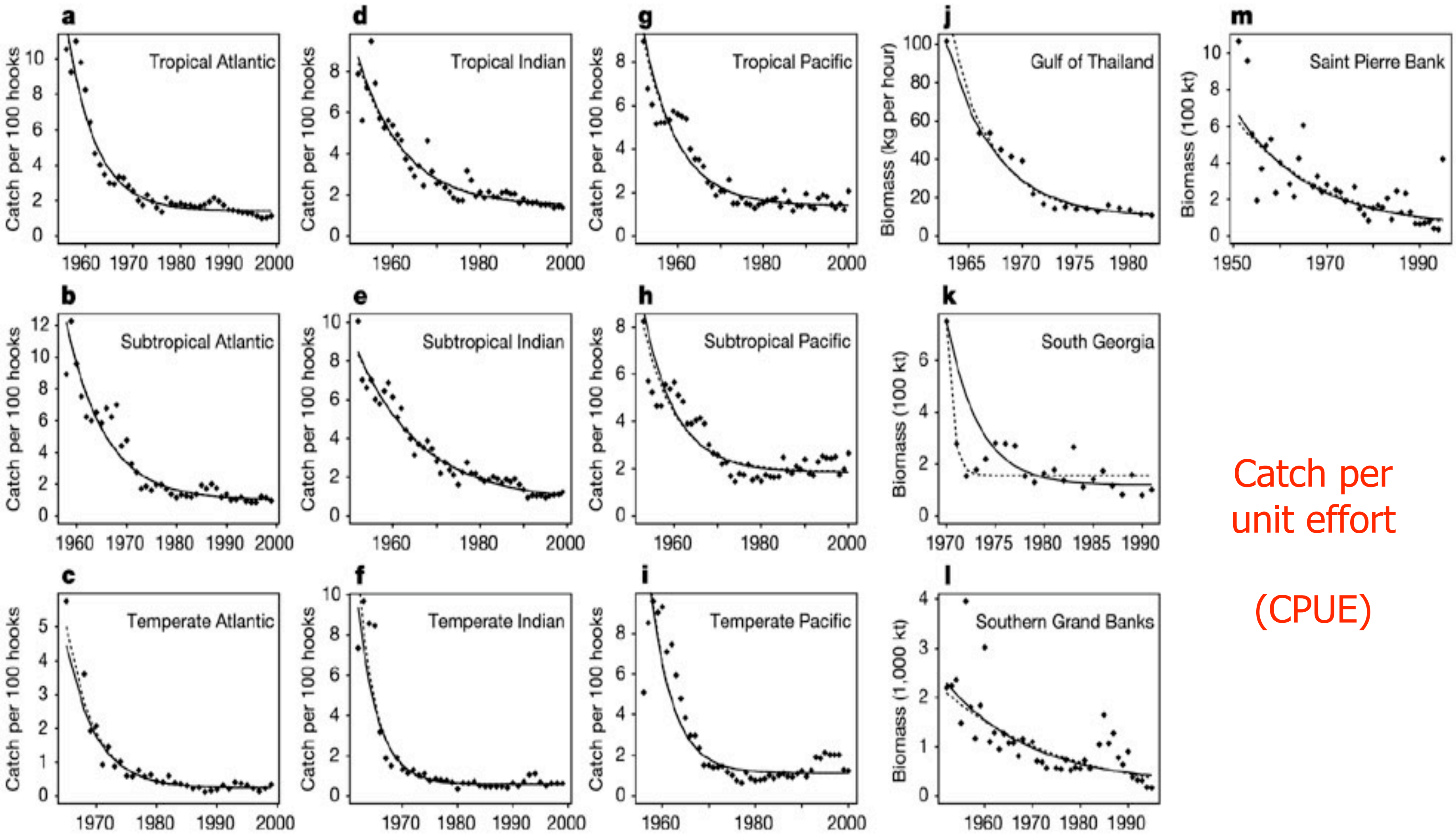
Late 1970's

1980's

Bottom trawl surveys, Pavlov Bay, AK

(from Botsford et al. 1997)

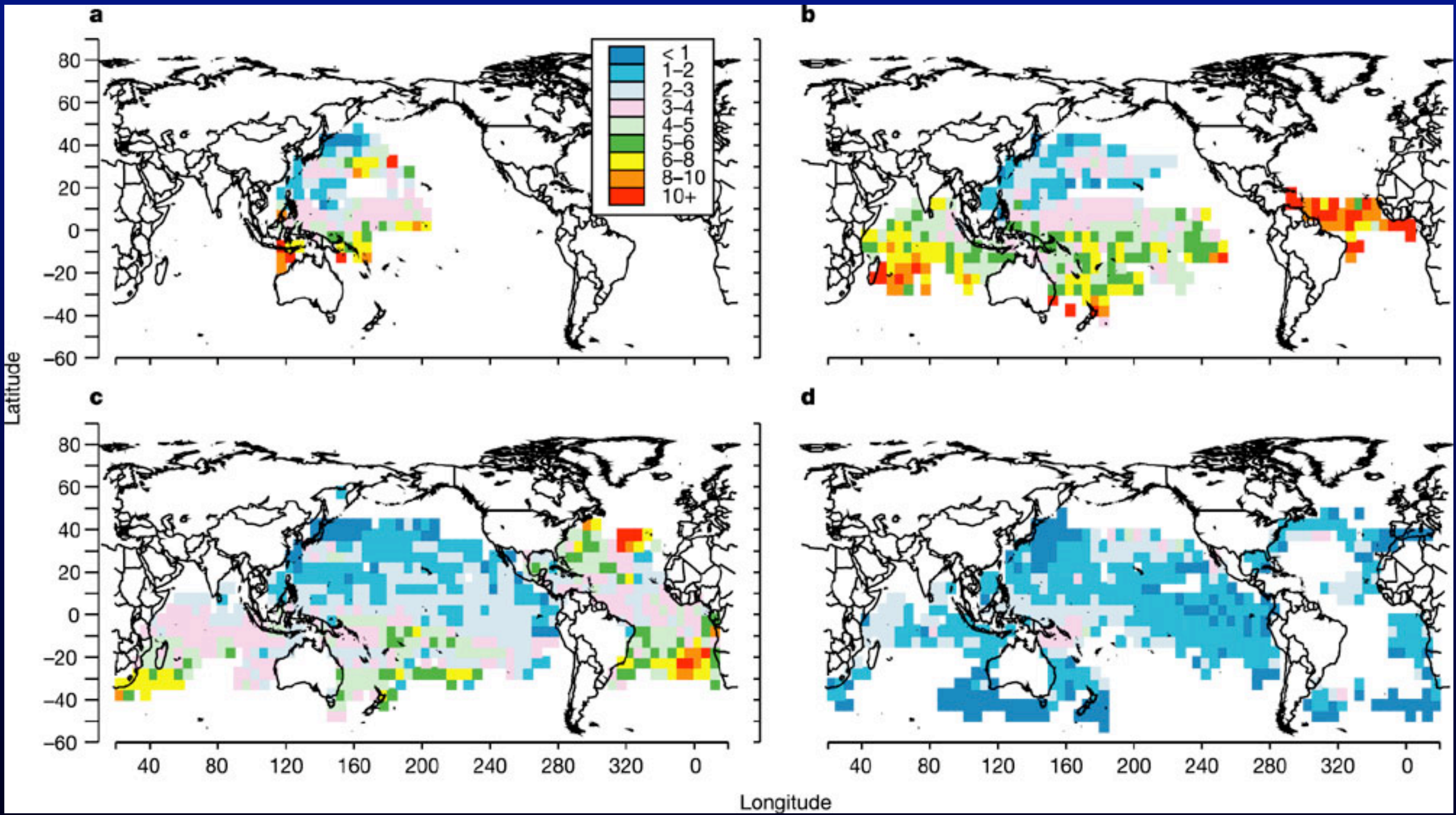
Fine-ing



Catch per unit effort

(CPUE)

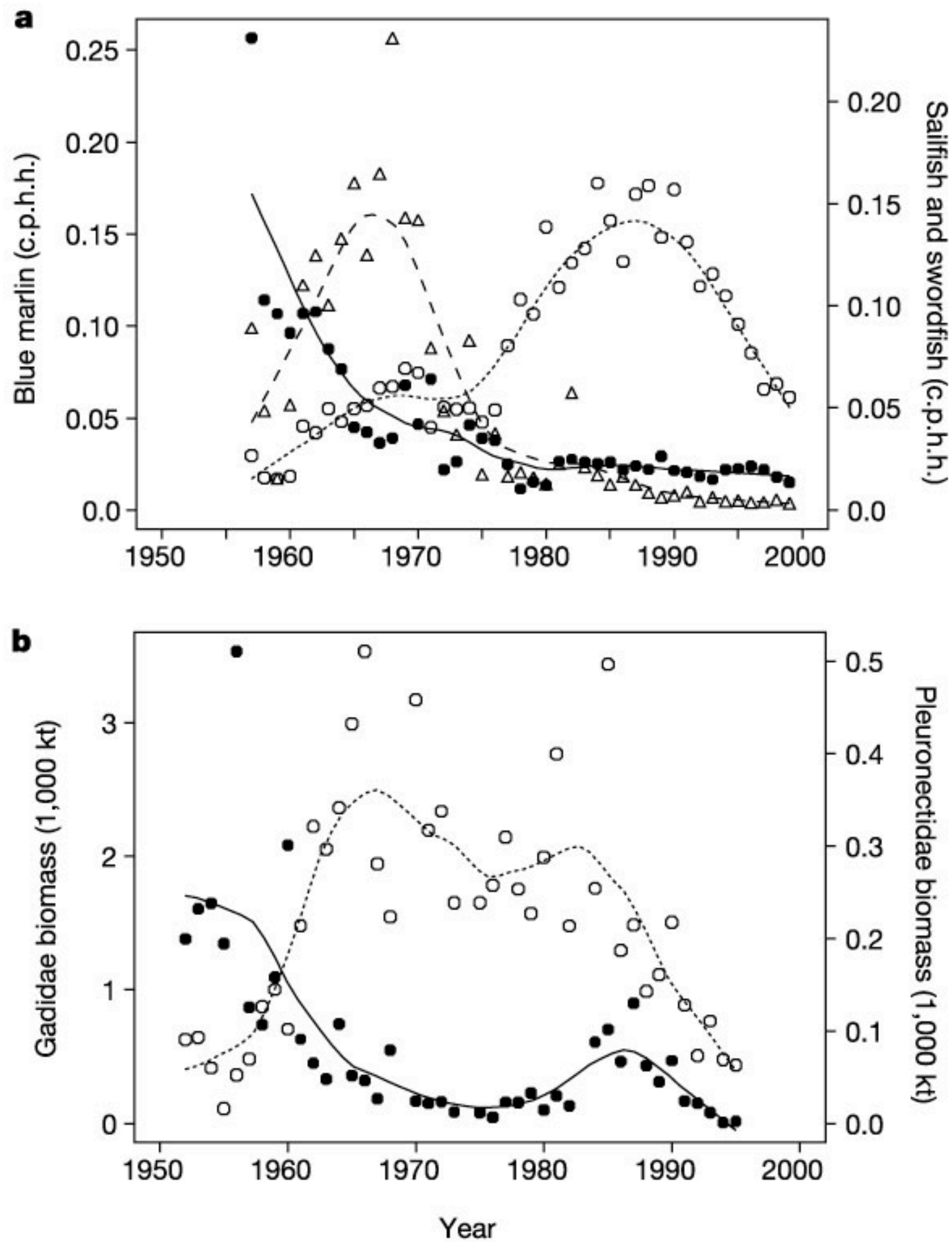
Fine-ing



Spatial patterns of relative predator biomass in 1952 (**a**), 1958 (**b**), 1964 (**c**) and 1980 (**d**). Color codes depict the number of fish caught per 100 hooks on pelagic longlines set by the Japanese fleet.

Fine-ing

Compensation in exploited fish communities. **a**, Oceanic billfish community in the tropical Atlantic, showing the catch per 100 hooks (c.p.h.h.) of blue marlin (*Makaira nigricans*; solid circles, solid line), sailfish (*Istiophorus platypterus*; open triangles, dashed line) and swordfish (*Xiphias gladius*; open circles, dotted line). **b**, Demersal fish community on the Southern Grand Banks, showing the biomass of codfishes (Gadidae; solid circles, solid line) and flatfishes (Pleuronectidae; open circles, dotted line).



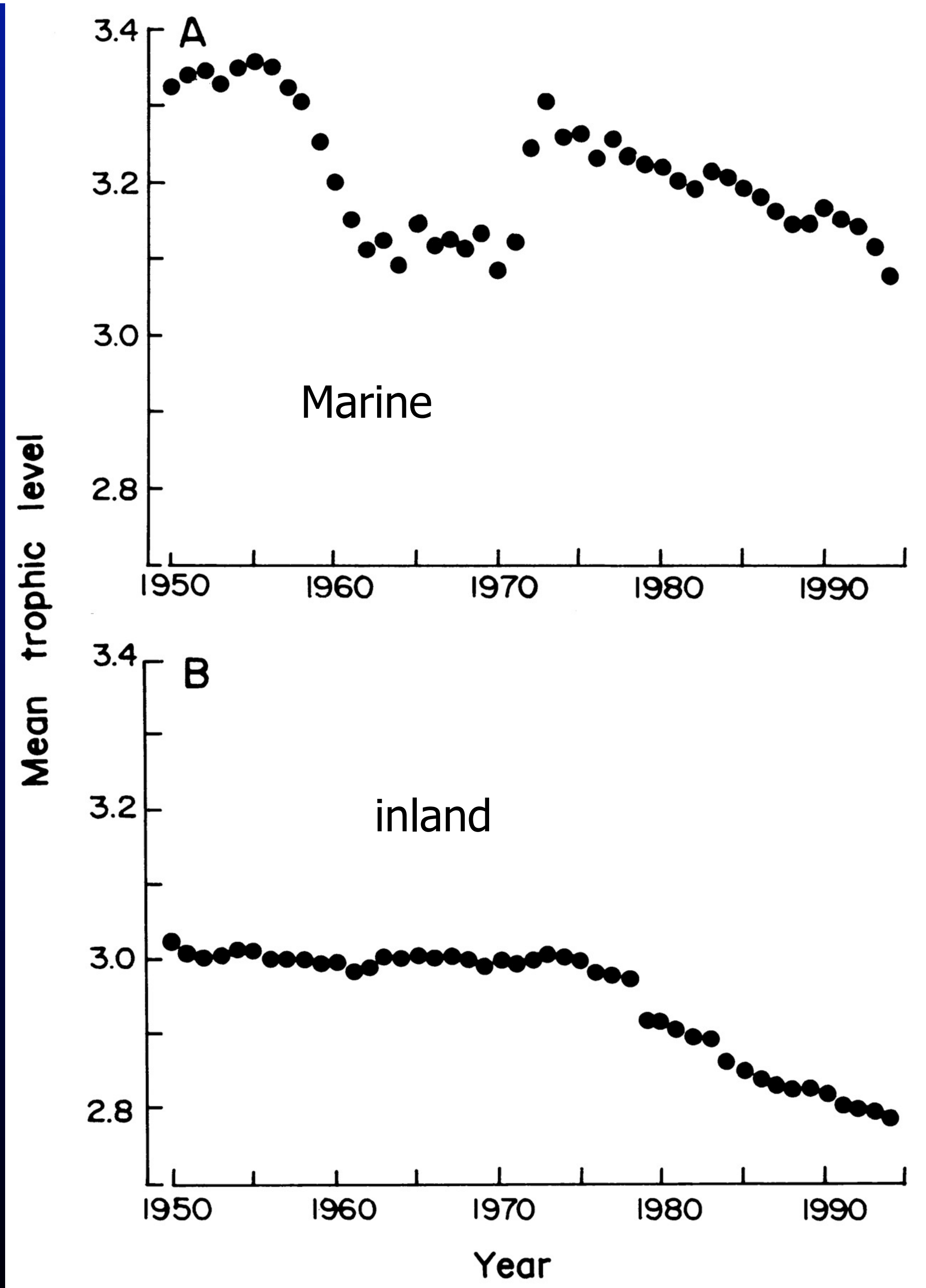
Fine - ing

- We take the best tasting, most profitable fish first…
- Worldwide depletion of predatory fish
  - 10% of pre-"industrial" carrying capacity
  - What was the baseline???
- Removing the top-level predators alters the structure of the marine food web

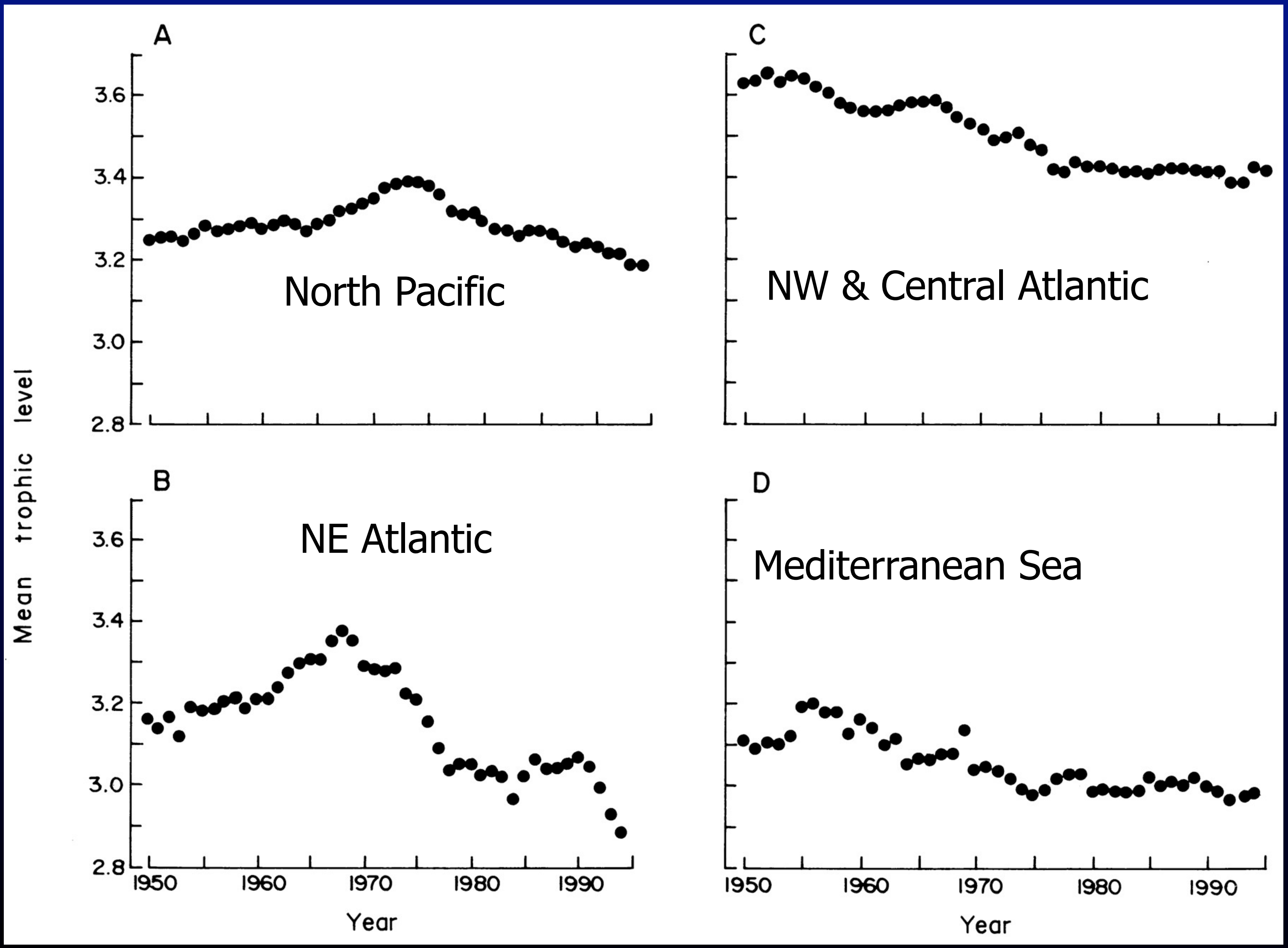
Fishing down the food chain

- Fishing occurs further down the food chain
- Long-lived, high trophic, piscivorous bottom fish shift to short-lived, low trophic level invertebrates and planktivorous pelagic fish
- Leads at first to increased yields but appears to be unsustainable
- Most pronounced in Northern Hemisphere
- Pauly et al [1998] - *Science*

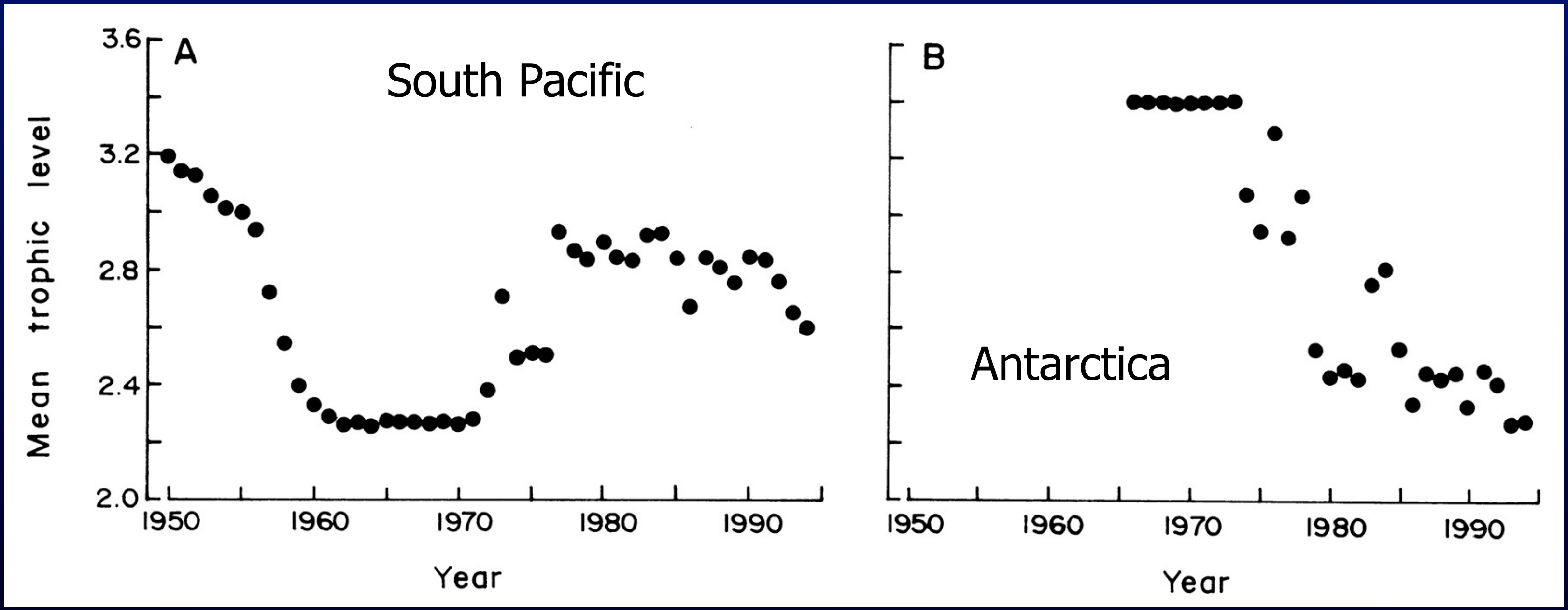
Fishing down the food chain



Fishing down the food chain



Fishing down the food chain



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