A Sustainable Strategy to Develop Time Series for Ecologically and Commercially Important Fishes in European Waters

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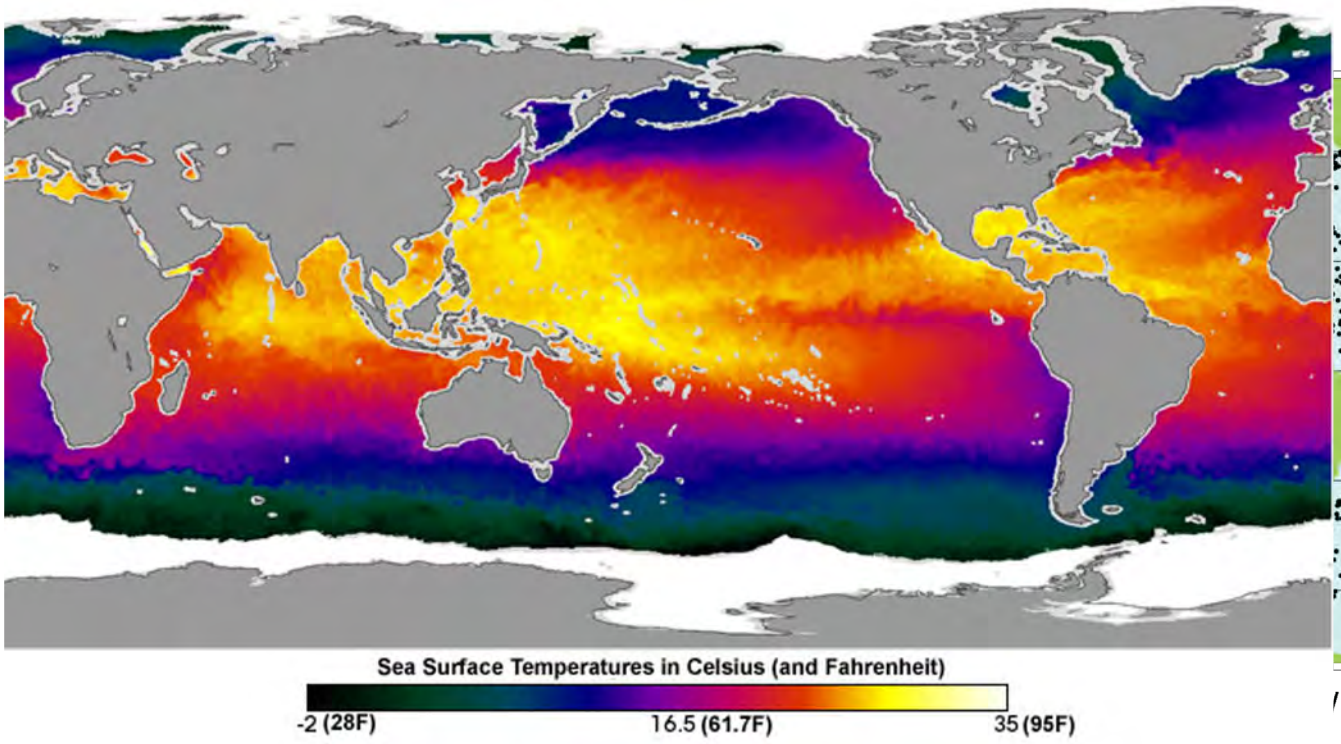
Why Ecological Time Series are Needed

- The oceans today are subject to a host of anthropogenic stressors:
  - impacts of (over)fishing, habitat modification/loss, increasing energy and mineral extraction, nutrient runoff —> eutrophication & coastal dead zones, invasive species, pollutants, warming, acidification, deoxygenation….
- The oceans are also subject to natural variability on various time-space scales:
  - ENSO, NAO & other ocean climate cycles
- To distinguish secular change from natural variability requires multi-decadal time series. For ecology, species-level resolution required for core groups

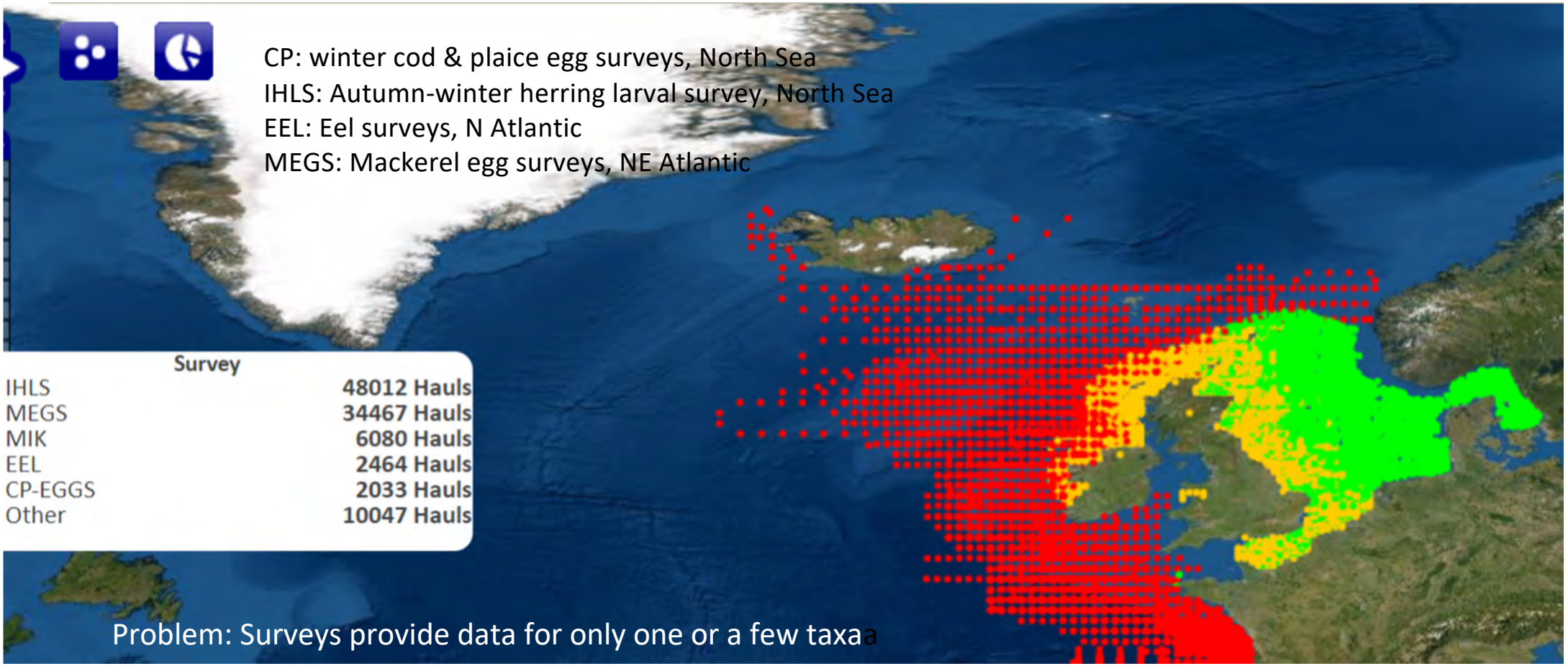
Impacts of a changing ocean:
A key issue for oceanography in the 21st Century

Remote sensing (satellites, Argo floats) has dramatically improved global coverage of the physics and chemistry of the ocean: T, S, chl (O_2 & nutrients on the way!)



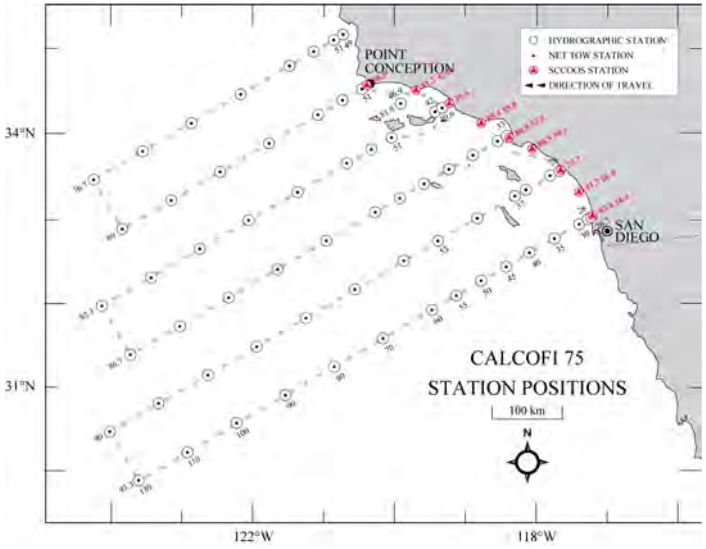
But ecological observations, esp. species-resolved, remain “a notable gap” (Alverson 2008): often placed in the too-hard basket

The Framework in EU waters for Comprehensive Fish Community Time Series: Ichthyoplankton Surveys



CalCOFI Model: Fish ***Community*** Data Set

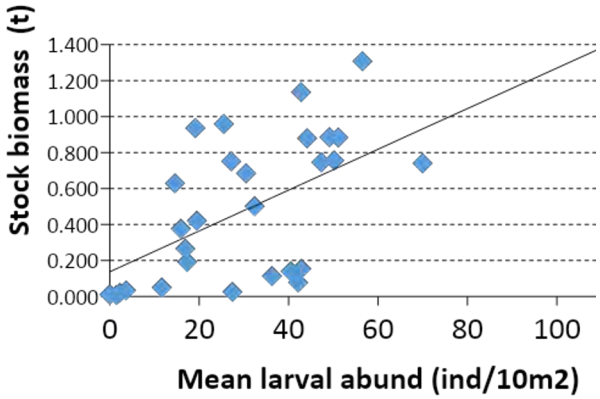
- California Cooperative Oceanic Fisheries Investigations (CalCOFI) ichthyoplankton time series, 1949-present
- Started 1949 to investigate the decline of the sardine fishery but within the sardine's ecosystem/oceanographic context
  - Monthly/quarterly sampling
  - At each station, CTD casts to 500 m: T, S, nutrients, O_2, chl
  - Oblique net tows to 210 m depth, all fish eggs/larvae removed, identified, enumerated (~500 taxa: Ahlstrom/Moser legacy)



Why the CalCOFI model?

- It's the most efficient, cost-effective way to obtain quantitative time series for regional fish communities
  - Most marine fishes (even mesopelagics!) are broadcast spawners, their eggs/larvae inhabiting the upper water column
  - Most fish larvae can be ID'd to species by eye (morphometrically)
  - Avoidance is minimal pre-flexion:, so readily sampled with a plankton net
  - Early larvae have experienced relatively little mortality; their abundance provides a quantitative index of adult abundance

Sardine (Hill et al. 2010)

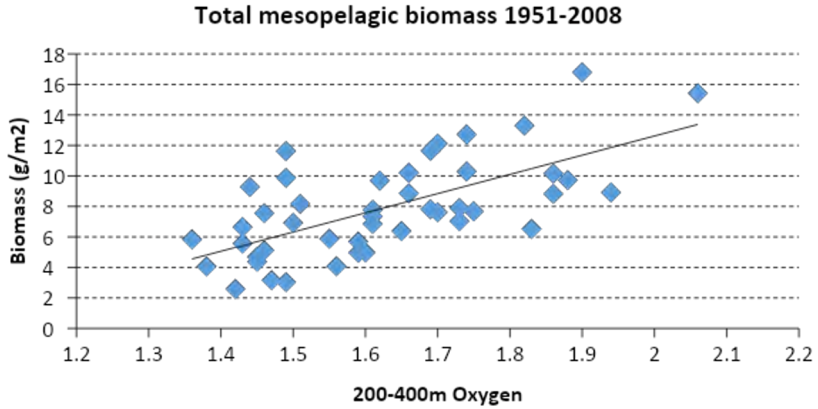


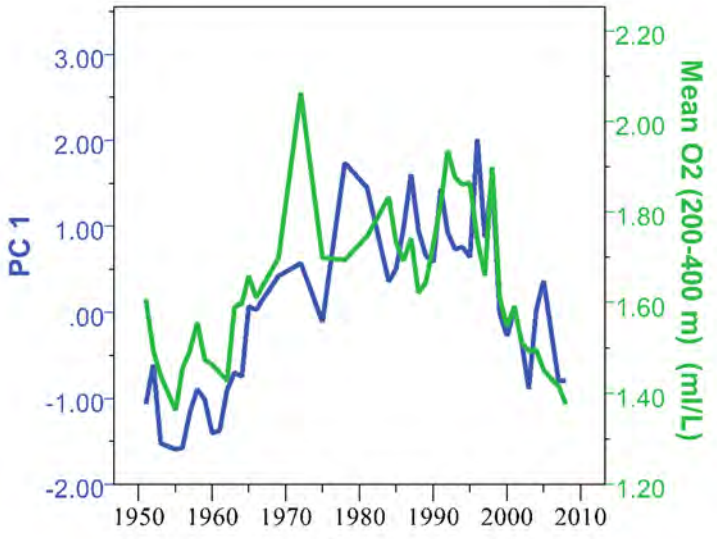
- The CalCOFI model is now widely adopted: USA, Mexico, Peru, Taiwan – but not EU!

What can we learn from Ichthyoplankton Time Series?

Climate change/variability impacts on non-commercial but ecologically important fishes

PC 1 for CalCOFI ichthyo analysis: 3.5-fold change in 24 common mesopelagic fishes related to [O2] 200-400m, explaining 20.5% var

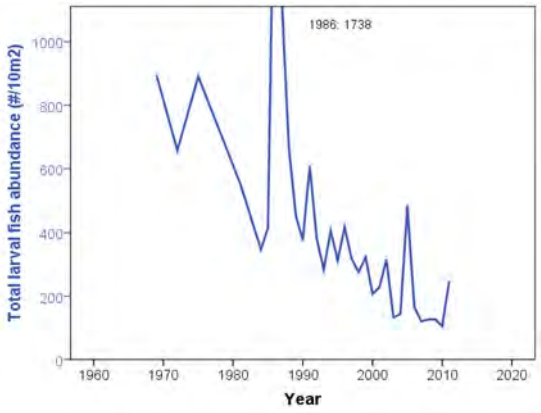




Koslow et al. 2011

72% decline in overall abundance of fish larvae post-1969 based on decline of cool-water affinity fishes (PC 2) (Koslow et al. 2013)

Trend not captured by commercial fisheries data



Further studies based on CalCOFI ichthyo data demonstrate changes in fish biodiversity, phenology, oceanographic influences on abundance, etc etc

The Way Forward

Why have the ICES ichthyoplankton surveys not followed the CalCOFI model?

- The incremental cost & effort. BUT
  - Most of the cost is in the field work (ship-time)
  - Removing ALL larvae (vs 1 taxon) from the plankton samples requires little additional effort
- Silo effect: fisheries agencies isolated from ocean observing/oceanographic institutions

What are the advantages of expanding the scope of ICES ichthyo surveys?

- Scientific value of regional fish community time series
- Broadening stakeholder/management base, scientific output enhances time series sustainability

Summary & Conclusions

Fish are essential ocean variables that need to be monitored systematically:

- important ecologically and to human economies & health
- sensitive to climate & other anthropogenic influences
- commercial fishery data biased, single-species surveys inadequate
- fish community data time series reveal major unknown patterns

Broader use of existing ichthyoplankton surveys is a no-brainer!

- Provide quantitative fishery-independent time series for broad regional fish communities
- Minimal incremental cost
- In Europe, the expertise is readily available (many US NOAA labs use Polish sorting center)
- Fosters collaboration between fisheries & ocean observing/oceanographic communities
- Enhances sustainability of ocean observing programs


Questions?