Physiological Impacts of Climate Change Using Remote Sensing

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Vigo biologists develop prediction system for heat waves and floods in shellfish beds

Elsa Vázquez leads a nationally funded project for predicting changes in temperature and salinity several days in advance in order to mitigate mortality risks.

- Mass mortality due to heat waves in summer
- Mass mortality due to low salinity in winter
- Losses can be as high as 100%

- Hindcasting – assign blame for crop losses due to low salinity events
- Forecasting – provide time for harvesters and depuration operations to move shellfish to rafts at mouth of estuaries

Partnership with U Vigo and Fisheries Coops

Vigo biologists develop prediction system for heat waves and floods in shellfish beds

Elsa Vázquez leads a nationally funded project for predicting changes in temperature and salinity several days in advance in order to mitigate mortality risks.
Three primary clam species harvested in NW Spain

Venerupis corrugata
Ameixa babosa
Burrow depth ~8 cm
Avg 13€/kg  Max 52€/kg in shell at dock
Total dock sales 2015  **13.7 million euros**

Ruditapes decussatus
Ameixa fina
Burrowing depth 15-20 cm
Avg 24€/kg  Max 80€/kg in shell at dock
Total dock sales 2015  **13.3 million euros**

Ruditapes philippinarum
Ameixa xaponesa
Burrowing depth ~4 cm
Avg 7.5€/kg  Max 27€/kg in shell at dock
Total dock sales 2015  **13.7 million euros**
MARISCO Temperature, Salinity, and Mortality Forecasting

Meteo Galicia
WRF Meteo Forecast

NOAH Sandflat Model

RelHum
Wind
Air T
Press
Solar
LWave

MeteoGalicia
MOHID Forecast SST

Shellfish Temperature Forecast

Forecasts at 250 m spatial scale within shellfish beds

http://tbone.biol.sc.edu/forecasting_test/galicia.html
Mortality from High Temperature Exposure

**V. corrugata**

- Proportion Dead vs. Days at 36°C
- Proportion Dead vs. Days at 32°C
- Proportion Dead vs. Days at 21 & 27°C

**R. decussatus**

- Proportion Dead vs. Days at 36°C
- Proportion Dead vs. Days at 21 & 27 & 32°C

**R. philippinarum**

- Proportion Dead vs. Days at 36°C
- Proportion Dead vs. Days at 21 & 27 & 32°C
## Effects of Extreme Events – Mortality due to Low Salinity

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Salinity Stress Experiments

4 salinity combinations
5 – 20  (low tide – hi tide)
10 – 25
15 – 30
30 – 30

4 species
V corrugata
R decussatus  ) clams
R philippinarum  )
C edule  cockle

Multiple Metrics
Respiration rate  ) scope
Feeding rate  ) for
Defecation rate  ) growth
N excretion rate
Gonad index
Burrowing rate
Subsurface activity
Mortality rate
Mortality from Low Salinity Exposure

**V. corrugata**

**R. philippinarum**

**R. decussatus**
Forecasting Low Salinity Exposure Effects in Sandflats: Mortality

MeteoGalicia
MOHID Ocean Forecast

Sal
Sal
Sal
Sal

Salinity-Mortality Model

Laboratory Experiments

Shellfish Mortality Forecast

Forecasts at 250 m spatial scale within shellfish beds
Catastrophic harvest losses in winter 2013-2014: heavy rains caused low salinity in upper Ría de Arousa

Our model predicted high mortality in the upper estuary at time of reports of mass mortality (RED)

Also predicted low mortality in the mid estuary where low mortality was observed (BLACK)
Self-Organizing Maps for Hindcasting and Forecasting without running a coupled atmosphere/ocean model

MOHID Mortality Model
600 daily mortality maps
2013-2014

SOM Category No

Predict SOM ID from
Regression equation

CFSR Precip Rias Baixas
1994

R^2=0.55
Regression
SOM Category No
vs
CFSR precipitation
2013-2014

Daily Survival

Cumulative Survival

Parada et al 2012
87% Mort 1994-01-12

Oliver, Rognstad, Wethey. 2015. Mar Ecol Progr Ser
Rainfall/Salinity Hindcasts for Recovery of Financial Losses

- WRF model forecast
- CFSR Reanalysis
- NASA GPM

Dam operations not included in SWAT model

Hydroelectric dams used for peaking power generation in winter when consumers use electric heat.

During peaking power generation, river flow is higher than expected from SWAT rainfall-runoff relationship.

SWAT and Flow data: MeteoGalicia

Coops can sue the power companies if they are to blame for low salinity and associated crop losses
Forecasting Low Salinity Exposure Effects in Sandflats: Growth
Modeling for Shellfisheries Management

- Satellite Observations & Met forecasts of exposure to extreme events
- Lab & field experiments determine responses
- Predict mortality, growth, reproduction

- Spanish Fisheries partners interested in
  - Assigning blame for crop losses
  - Developing mitigation plans
  - Long term economic effects of changing climate: Gender bias because species harvested by women are at greater risk than those harvested by men