Physiological Impacts of Climate Change Using Remote Sensing

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Forecasting Effects of Extreme Events on Shellfisheries as a Management Tool

- 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

www.farodevigo.es
FARO DE VIGO

Un estudio pionero en España para alertar sobre eventos climáticos extremos

Biólogos de Vigo desarrollan un sistema de predicción de olas de calor e inundaciones en bancos marisqueros

Elsa Vázquez lidera un proyecto del plan nacional que permitirá pronosticar con varios días de antelación los cambios en la temperatura o la salinidad y evitar mortandades -Colaboran las cofradías de Redondela, Carril, Campelo y Cambados

Sandra Penelas | 04.10.2015 | 09:06

Vigo lidera un proyecto pionero en España para determinar los riesgos y efectos que el cambio climático ya está ocasionando en los bancos marisqueros gallegos y cuyo objetivo último es desarrollar un sistema de predicción que alerte a las cofradías ante la llegada de olas de calor e inundaciones para que puedan tomar medidas y evitar mortandades. El estudio cuenta con financiación nacional -177.870 euros hasta 2017- y está coordinado por la catedrática de Zoología Elsa Vázquez. También colaboran dos expertos de la universidad estadounidense de South Carolina y cinco cofradías de la provincia -Redondela, Carril, Campelo y Cambados-, además de contar con el respaldo de la Consellería do Mar.

Las cajas de los experimentos. // J. Santomé

Fotos de la noticia

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.

GOBIERNO DE ESPAÑA   MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Three primary clam species harvested in NW Spain

www.mariscosdelortegal.com

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
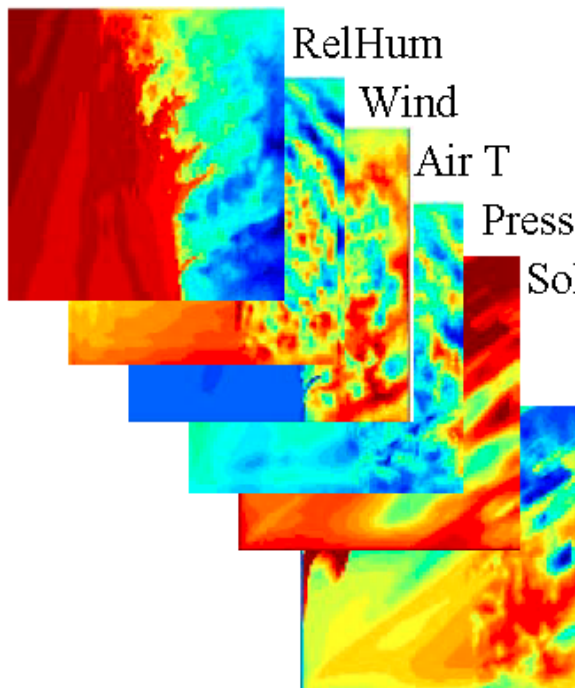Ameixa xaponesa
Burrowing depth ~4 cm
Avg 7.5€/kg Max 27€/kg in shell at dock
Total dock sales 2015 **13.7 million euros**

MARISCO Temperature, Salinity, and Mortality Forecasting

Meteo Galicia
WRF Meteo Forecast

RelHum
Wind
Air T
Press
Solar
LWave

NOAH Sandflat Model

Community Noah land-surface model

MeteoGalicia
MOHID Forecast SST
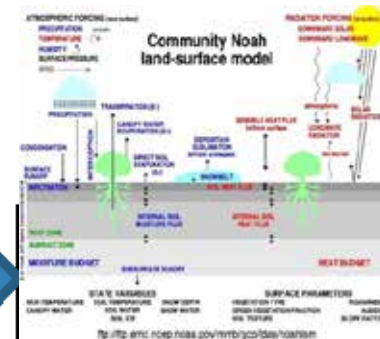
Shellfish Temperature Forecast

Predicion Temperatura Bancos Marisqueros 2015-05-20

Forecasts at 250 m
spatial scale
within shellfish beds

http://tbone.biol.sc.edu/forecasting_test/galicia.html
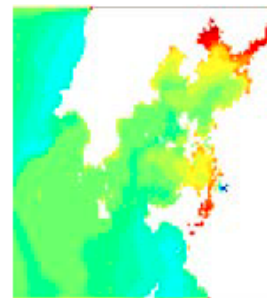
Mortality from High Temperature Exposure
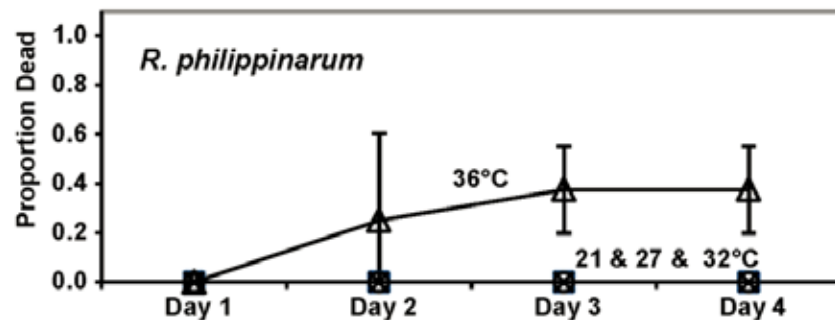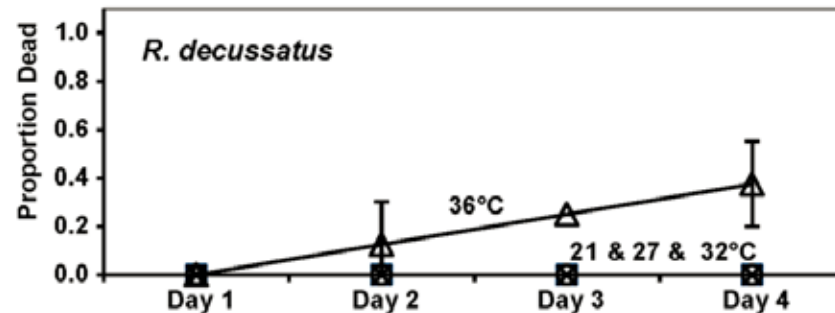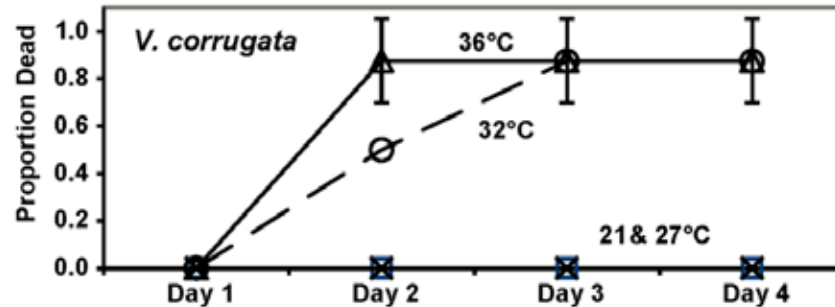
Effects of Extreme Events – Mortality due to Low Salinity

Date	Cerastoderma edule	Venerupis senegalensis (corrugata)	Tapes decussatus	Tapes philippinarum	Type	Identifier
28/02/77	T (Total)	T	T	T	SM	Sev0277
22/12/78	T	T	T	T	SM	Sev1278
31/12/81	PT (Practically Total)	PT	PT	PT	SM	Sev1281
23/10/87	T	T	T	T	SM	Sev1087
28/12/89	90%	99%	10%	0%	SM	Sev1289
14/01/91	0%	80%	0%	0%	MM	Mod0191
04/01/94	0%	0%	0%	0%	MB	Morb0194
12/01/94	17%	87%	0%	0%	MM	Mod0194
19/01/96	60%	96%	5%	43%	SM	Sev0196
27/04/00	0%	80%	0%	0%	MM	Mod0400
07/12/00	0%	95	0%	0%	MM	Mod1200
27/11/02	0%	0%	0%	0%	NM	NoMort1102
16/01/03	PT	PT	PT	PT	SM	Sev0103
29/03/06	71%	50%	45%	78%	SM	Sev0306
25/11/06	0%	10%	2%	5%	MB	Mod1106
07/03/07	33%	97%	2%	6%	MM	Mod0307
05/02/09	30%	30%	7%	14%	MM	Mod0209

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
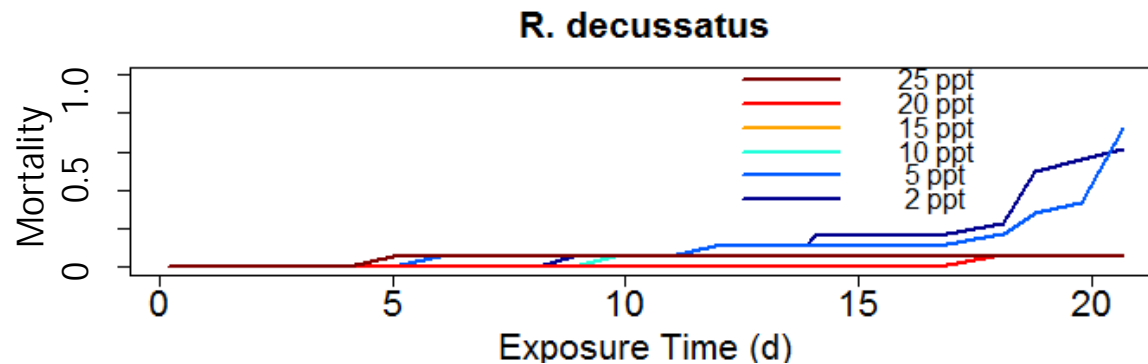 Feeding rate   )for
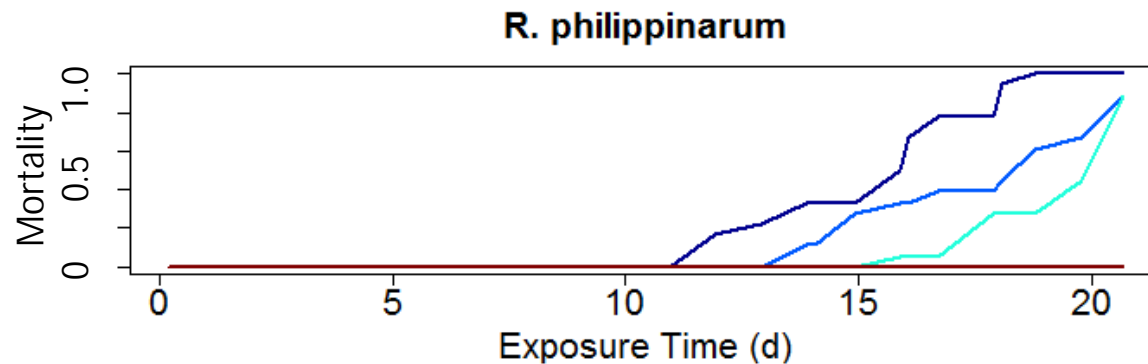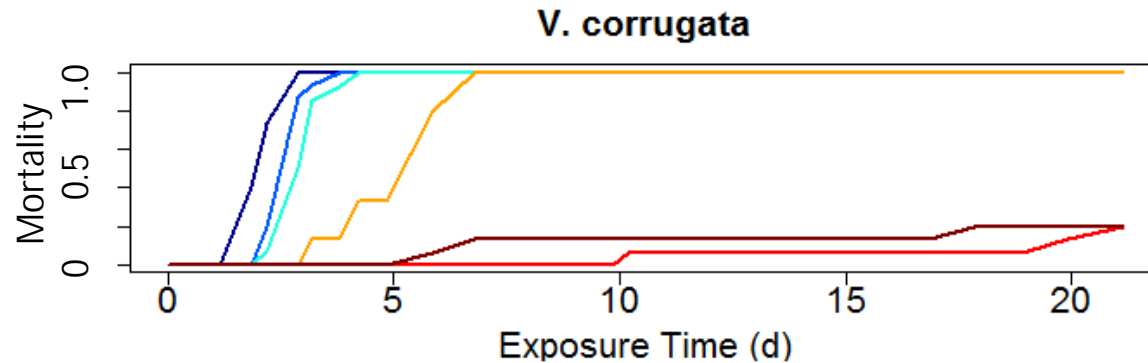 Defecation rate   )growth
  N excretion rate
  Gonad index
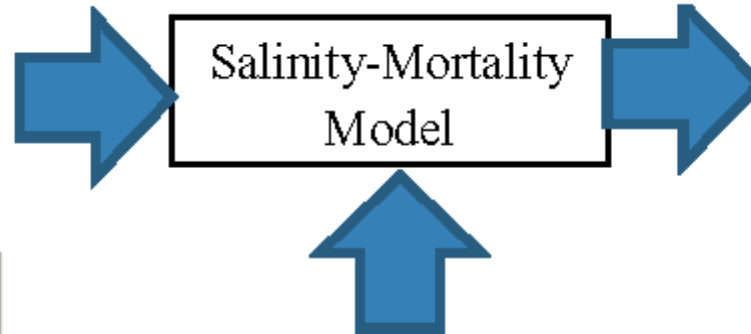 Burrowing rate
  Subsurface activity
  Mortality rate

Mortality from Low Salinity Exposure

Forecasting Low Salinity Exposure Effects in Sandflats: Mortality
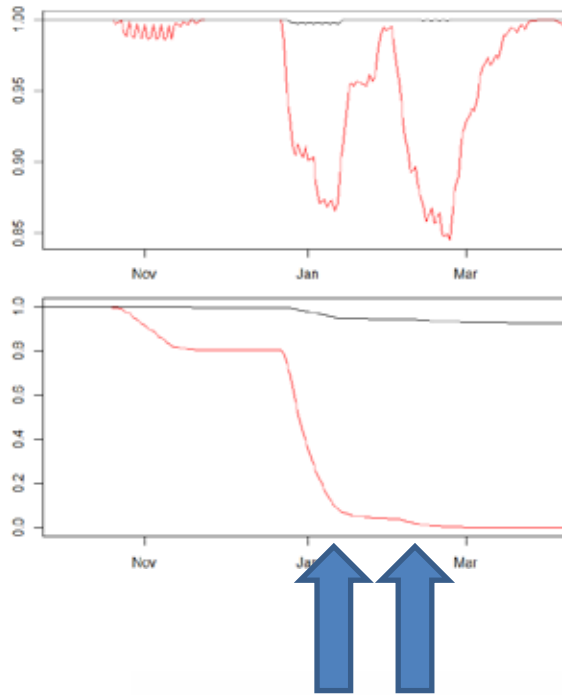

MeteoGalicia
MOHID Ocean Forecast

Sal
Sal
Sal
Sal

Salinity-Mortality Model
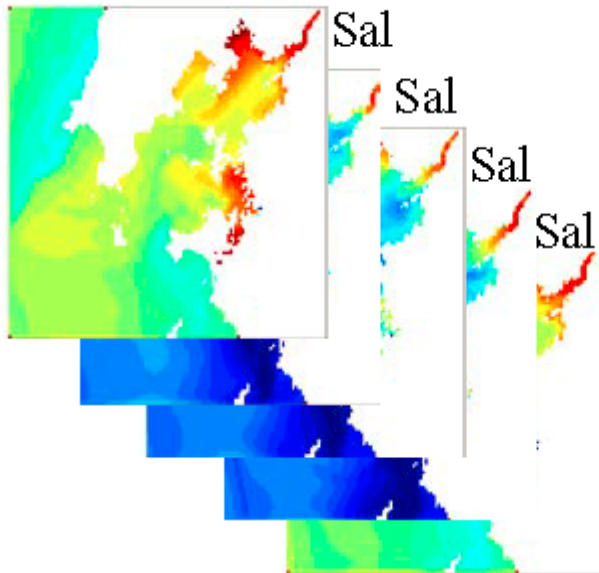
Laboratory Experiments
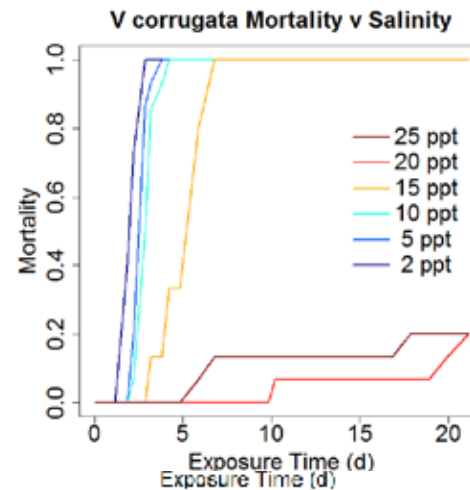
Shellfish Mortality Forecast

V corrugata Mortality v Salinity

Mortality

Exposure Time (d)
Exposure Time (d)

- 25 ppt
- 20 ppt
- 15 ppt
- 10 ppt
- 5 ppt
- 2 ppt
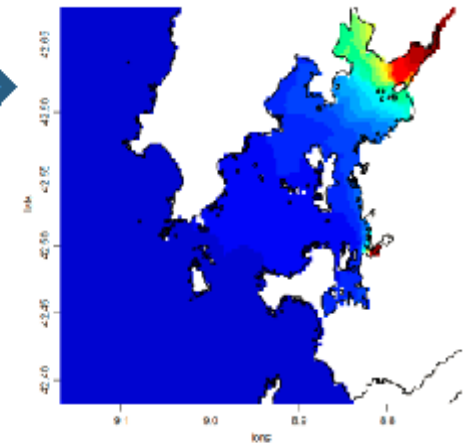
Forecasts at 250 m spatial scale
within shellfish beds

V corrugata Mortality

Catastrophic harvest losses in winter 2013-2014: heavy rains caused low salinity in upper Ría de Arousa
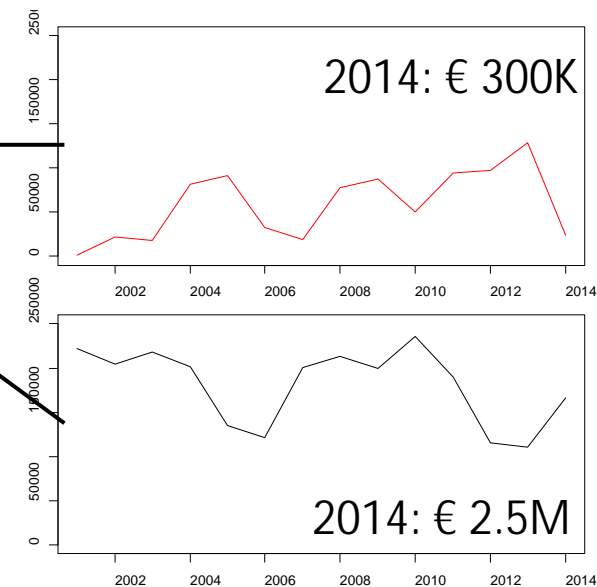
Our model predicted high mortality in the upper estuary at time of reports of mass mortality (RED)

Also predicted low mortality in the mid estuary where low mortality was observed (BLACK)

Diario de Arousa.com

Los arenales se llenan de almejas muertas que confirman pérdidas millonarias en Carril

S. L. villagarcia | 03 de Febrero de 2014

Conchas y almejas muertas por la baja salinidad del agua llenan ya las playas G. Salgado

V corrugata Mortality
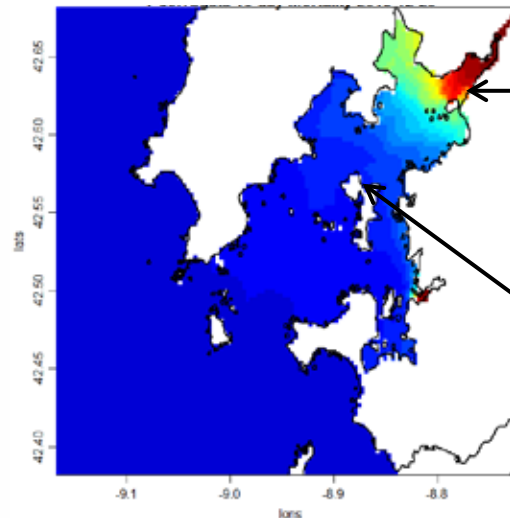
V corrugata Harvest

2014: € 300K

2014: € 2.5M
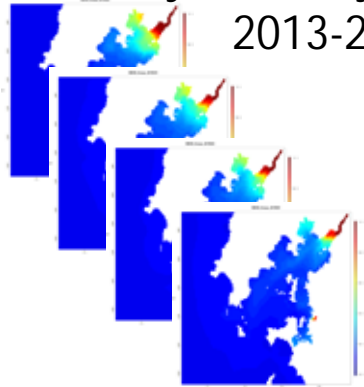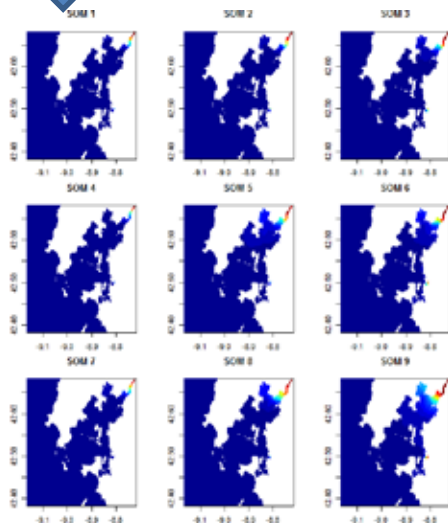
Self-Organizing Maps for Hindcasting and Forecasting without running a coupled atmosphere / ocean model

MOHID Mortality Model
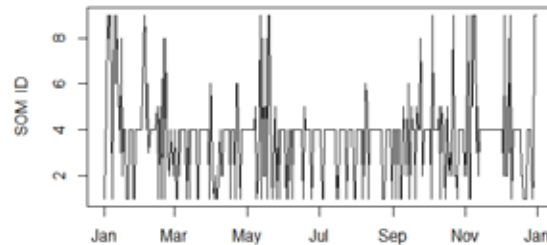600 daily mortality maps
2013-2014

SOM Category No
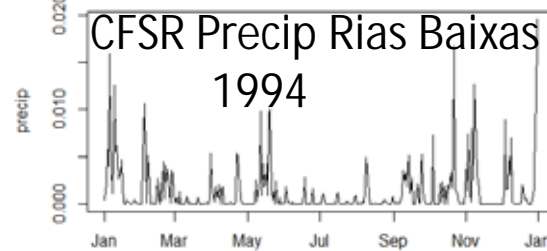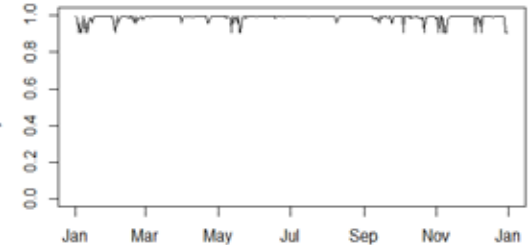
Daily Survival

SOM calculation

Predict SOM ID from
Regression equation

Cumulative Survival

CFSR Precip Rias Baixas
1994

LombosDeUlla 1994

9 mortality categories

$R^2=0.55$
Regression
SOM Category No
 vs
CFSR precipitation
2013-2014
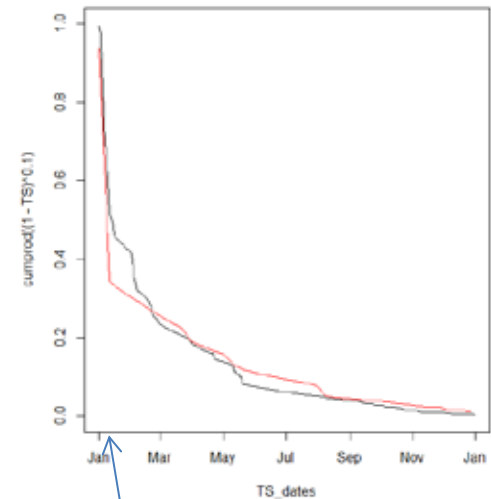
Parada et al 2012
87% Mort 1994-01-12

Oliver, Rognstad, Wethey. 2015. Mar Ecol Progr Ser
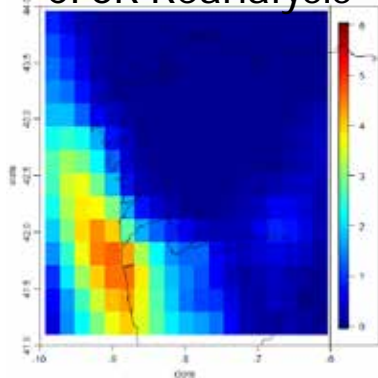
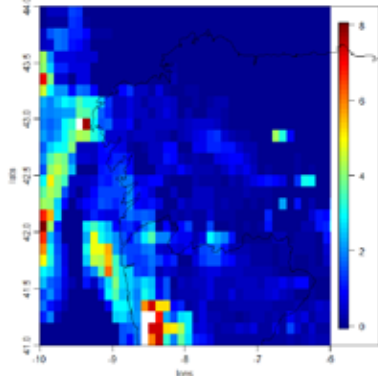# Rainfall/Salinity Hindcasts for Recovery of Financial Losses
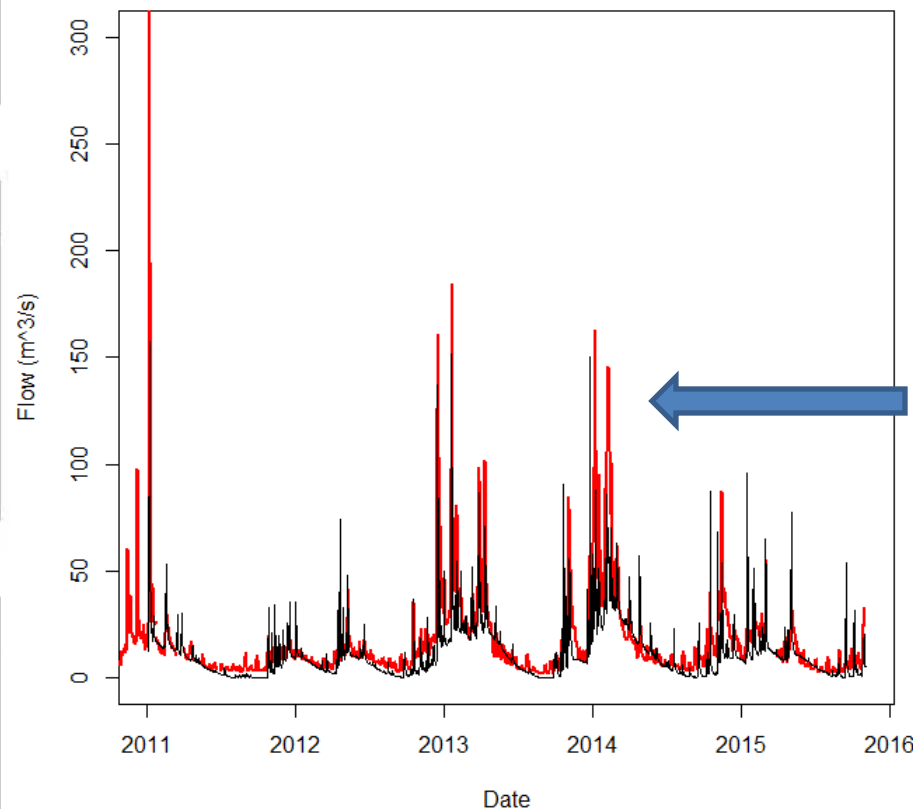
WRF model forecast
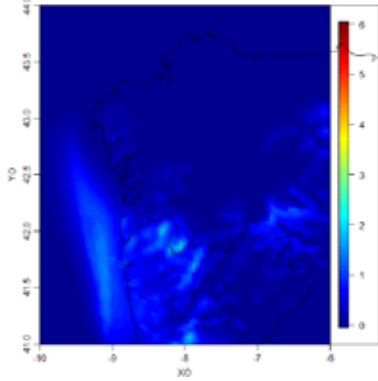
CFSR Reanalysis

NASA GPM

Umia SWAT Model (B) vs Flow Gauge (R)

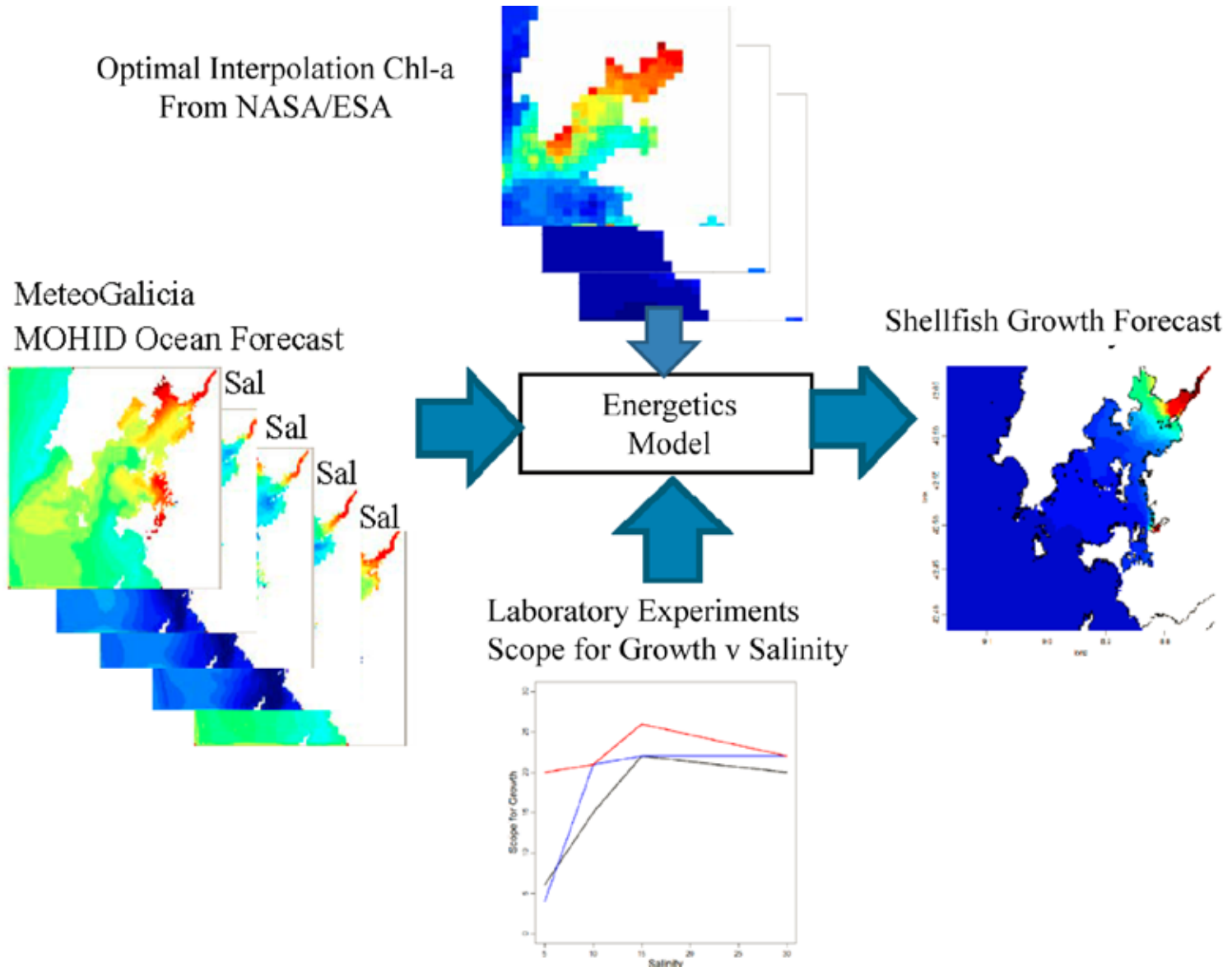Dam operations not included in SWAT model

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

Optimal Interpolation Chl-a From NASA/ESA

MeteoGalicia MOHID Ocean Forecast

Sal
Sal
Sal
Sal

Energetics Model

Shellfish Growth Forecast

Laboratory Experiments Scope for Growth v Salinity

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