Heat and Desiccation Risk Prediction in Intertidal Shellfisheries

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Shellfisheries

- Worldwide - Clams, Mussels, Oysters 13 M t /y, $20.5 B/y
- France - Yearly ex farm value ~ $1 B
  - 700 mussel farms, 2600 oyster operations
- Spain - Yearly ex farm value ~ $1 B
  - 70 fisheries guilds, 1600 delineated shellfish beds
- Industrial scale farming on tidal sandflats
- Heat & desiccation stress during low tide causes mortality and reduced growth
- Stress potentially quantifiable by ECOSTRESS at scale relevant to the farmers
- Timing of stress varies with site, phase of the moon, weather, and shore level
Temperature and Desiccation Matter a Lot

Mussel Survival after 6 hr exposure on 5 successive days

Temperature

Survival

Relative Metabolic Rate

Jones et al 2010
J Biogeography

Thomas & Bacher 2018
Global Change Biology

Mortality Rates of Mussels vs Desiccation Stress

Jenewein & Gosselin 2013
Marine Ecology Progress Series

Metabolic Rates of Mussels and Oysters Relative to 20°C

Temperature

% Mortality

LD$_{50}$ = 1.01 kPa

VPD (kPa)
Intertidal Mussel and Oyster Culture
France

Oyster Racks
Mussel Bouchots
Clam Harvest on Foot

Spain

2 km

200 ha
ECOSTRESS Resolves Tide Position

03556_013_20190220T1257
Tide 0.31m

03477_003_20190215T1048
Tide 6.13m

03479_009_20190215T1402
Tide 9.33m

03632_010_20190225T1017
Tide 11.26

Contours: IFREMER WW3 tide prediction | Black Line: France digital coastline
TES algorithm does not capture emissivity of wet intertidal surfaces or ocean surface.

At sensor radiances:

- ASTER seawater emissivities
- TES emissivities

VIIRS SST ≈ ECOSTRESS + 3.5°K
MODIS SST ≈ ECOSTRESS + 2°K

LST from ASTER emissivity + VIIRS 1km SST
MODIS 1km SST
ECOSTRESS LST and SST
Geolocation

ECOSTRESS products are experimental
Geolocation errors can be large
May not be flagged in metadata

Problem for AppEEARS analyses

Need coastline ground control points

Landsat Ground Control Points

3798_001  No clouds **8.8 km error**
Build ID 0503
Orbit Correction  TRUE
Automatic Quality Flag PASS  (Why ?)

8592_001  No coastal clouds **2 km error**
Build ID 0600
Orbit Correction  FALSE  (Why not ?)
Automatic Quality Flag SUSPECT

6761_001 Few clouds **500 m error**
Build ID 0600
Orbit Correction  TRUE
Automatic Quality Flag PASS  (Why ?)
Project Goals

• Thermal Stress Index
  – LST from TES emissivity vs ASTER seawater emissivity for wet surfaces
  – Atmospheric transmittance from RTTOV model
  – Validate with in-situ data loggers
  – Spain: shellfish beds – collab with U Vigo and 3 Shellfisheries Guilds
  – France: mussel and oyster grow-out areas – collab with IFREMER
  – Portugal – UK: rocky shores – collab with CIBIO (U Porto)
  – NEED MORE COASTAL SCENES in Western Spain/Portugal

• Evaporative Stress Index
  – Modified LST from ECOSTRESS
  – Humidity from NASA/GEOS5, WRF forecasts, local weather stations
  – Evaporative Stress from water vapor pressure deficit

• First we need a solution for geolocation problem in coastal zone
LST Validation With Intertidal Sensors

- Spanish Shellfish Bed Logger Sites
- Only 5 usable scenes June – Nov 2019
- ≥500 m geolocation errors in 3 of them
  - Makes the use of AppEEARS risky
- Turn the sensor on before coastline
- Need More Western Spain Coastal Scenes
- Landsat has many more usable scenes
Collaborators
Data Logger Network

• Univ Vigo / Shellfish Guilds
  – Elsa Vázquez
  – Celia Olabarria
  – Cofradías de Mariscadoras de Noia, Combados, Combarro

• Univ Porto / CIBIO
  – Fernando Lima
  – Rui Seabra

• IFREMER
  – Stanislas Dubois
  – Cedric Bacher
Quick Look Logger Temp vs R/S Temp

Spain shellfish bed iButton loggers

ECOSTRESS LST
(atmospheric correction)

Landsat -8 Band 10 Sensor Brightness Temp
(no atmospheric correction)

Many more Landsat-8 scenes are available than ECOSTRESS scenes since Jun 2019.