Tracking Dynamics of Freshwater and Marine Water Mixing using Satellite and Flyover Thermal Imaging combined with In-Situ Sensing

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INSIGHT Centre for Data Analytics, National Centre for Sensor Research, Dublin City University
****National Centre for GeoComputation, NUI Maynooth***

Invited Lecture presented at

'Innovation in Environmental Monitoring' University of York

September 21-22, 2016

SFI – Minister Bruton launches €88 million SFI research centre, bringing new insights to Data Analytics

www.sfi.ie/news-resources/press-releases/minister-bruton-launches-€88-million-sfi-research-centre,-br

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MINISTER BRUTON LAUNCHES €88 MILLION SFI RESEARCH CENTRE, BRINGING NEW INSIGHTS TO DATA ANALYTICS

- Insight, the Centre for Data Analytics, will position Ireland at the heart of global Data Analytics research
- The largest investment in a single research centre in the history of the state
- Uniting 4 universities, 30 industry partners and 200 researchers in one multi-location research centre
- Creating 300 direct jobs through 12 funded spin outs, as well as creating indirectly thousands of other job opportunities

‘Insight Centre for Data Analytics’

- Biggest single research investment ever by Science Foundation Ireland
- Biggest coordinated research programme in the history of the state
- Focused on ‘big data’

12th December 2013: The Minister for Jobs, Enterprise and Innovation, Mr Richard Bruton T.D. and Minister for ... **Ireland** (SFI) Research Centre for Data Analytics. In a joint initiative between DCU, NUI Galway, UCC and UCD, Insight, and other partner institutions, brings together more than 200 researchers from these and other Higher Education institutions, with 30 industry partners, to position Ireland at the heart of global data analytics research.

The Centre will receive funding of €58 million from the Department of Jobs, Enterprise and Innovation through SFI’s Research Centres Programme, along with a further contribution of €30 million from 30 industry partners. Insight represents a new approach to research and development in Ireland, by connecting the scientific research of Ireland’s leading data analytics researchers with the needs of industry and enterprise.

Remote (Continuous) Sensing Challenges: Platform and Deployment Hierarchies

Physical Transducers –low cost, reliable, low power demand, long life-time

Thermistors (temperature), movement, location, power,, light level, conductivity, flow, sound/audio, ……

Chemical Sensors – more complicated, need regular calibration, more costly to implement

Electrochemical, Optical, .. For metal ions, pH, organics…

Biosensors – the most challenging, very difficult to work with, die quickly, single shot (disposable) mode dominant use model

Due to the delicate nature of biomaterials enzymes, antibodies….

Increasing difficulty & cost

Increasing scalability

Gas/Air Sensing – easiest to realise

Reliable sensors available, relatively low cost

Integrate into platforms, develop IT infrastructure, GIS tools, Cloud Computing

On-land Water/ Monitoring

More accessible locations

Target concentrations tend to be higher

Infrastructure available

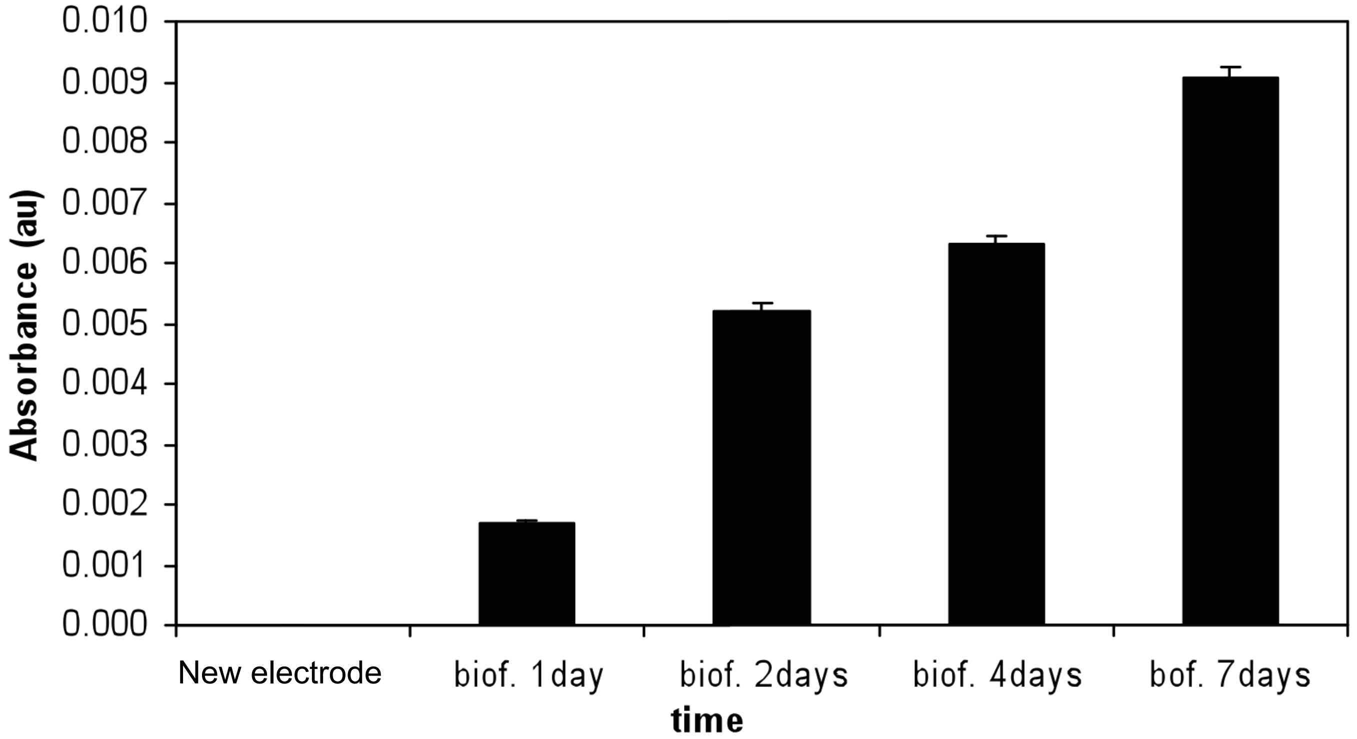
Marine Water

Challenging conditions

Remote locations & Limited infrastructure

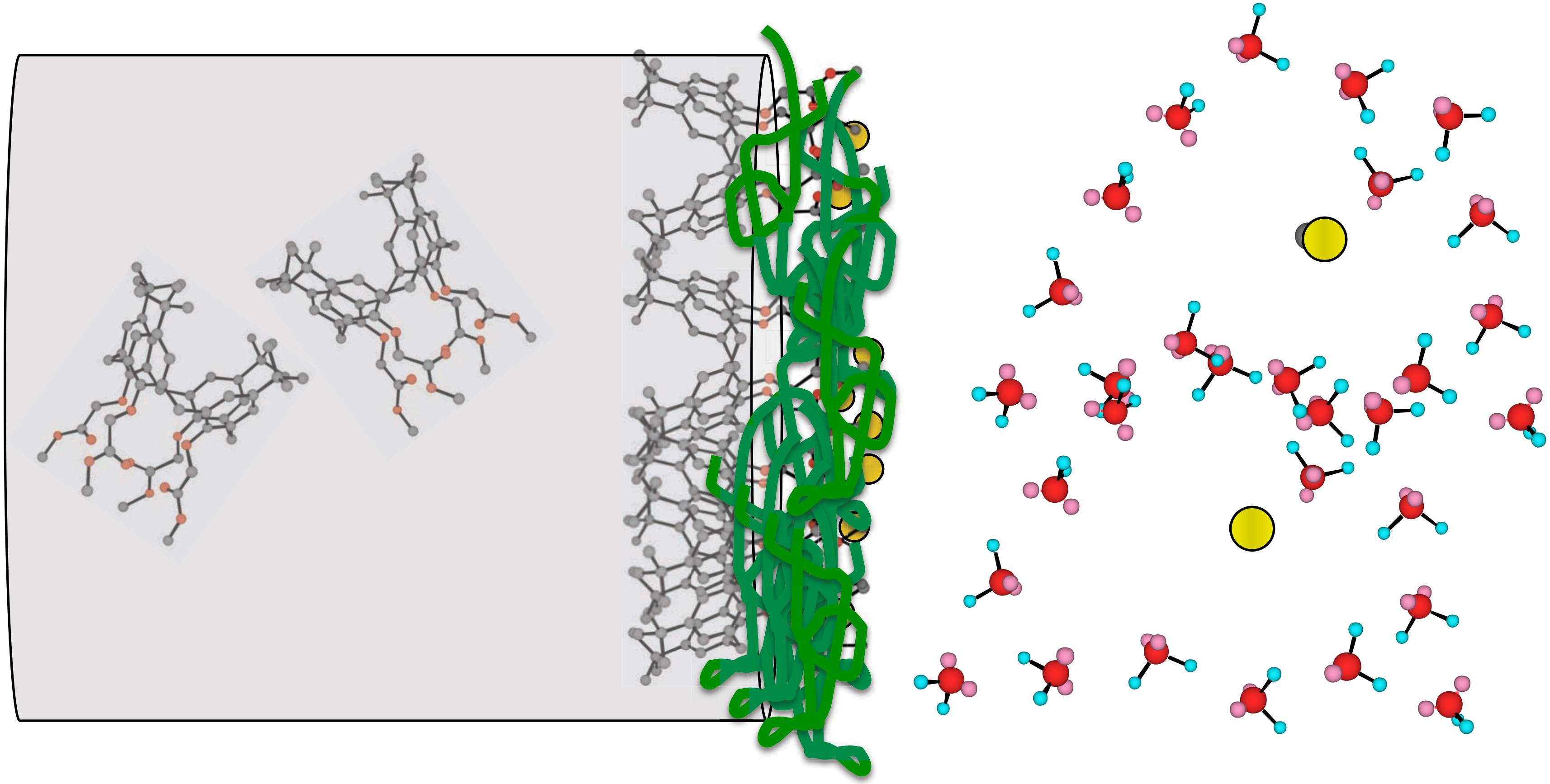
Concentrations tend to be lower and tighter in range

Biofilm Formation on Sensors



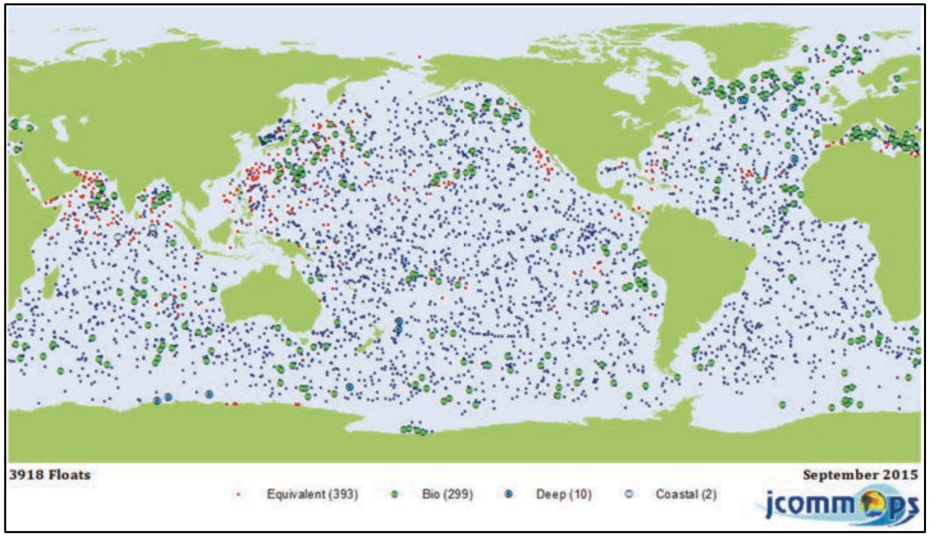
- **Electrodes exposed to local river water (Tolka)**
- **'Slime test' shows biofilm formation happens almost immediately and grows rapidly**

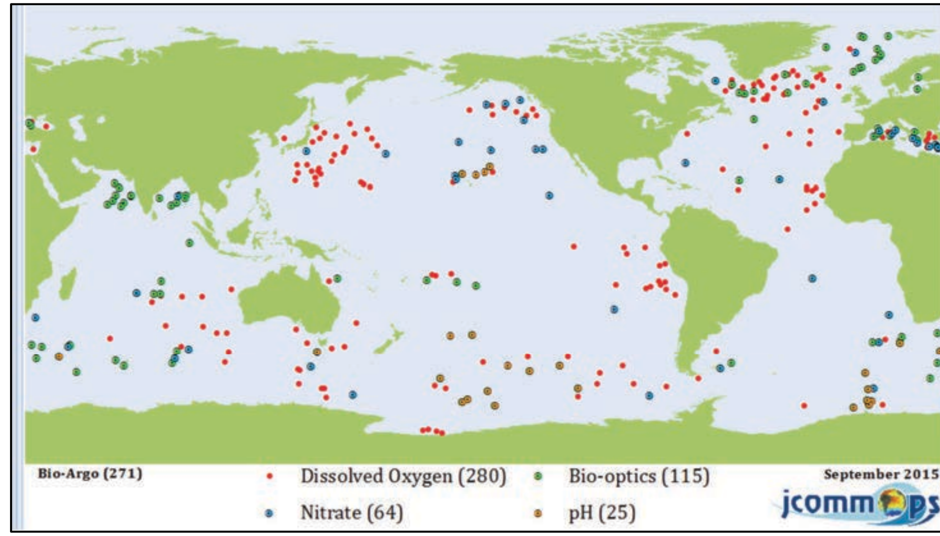
Control of membrane interfacial exchange & binding processes



Remote, autonomous chemical sensing is a tricky business!

Argo Project (accessed March 20 2016)





- **Ca. 4,000 (3918) floats: temperature and salinity**
- **Bio/Chem: Nitrate (64), DO (280), Bio-optics (115), pH (25)**

DO is by Clark Cell (Sea Bird Electronics) or Dynamic fluorescence quenching (Aanderaa)

@€60K ea!

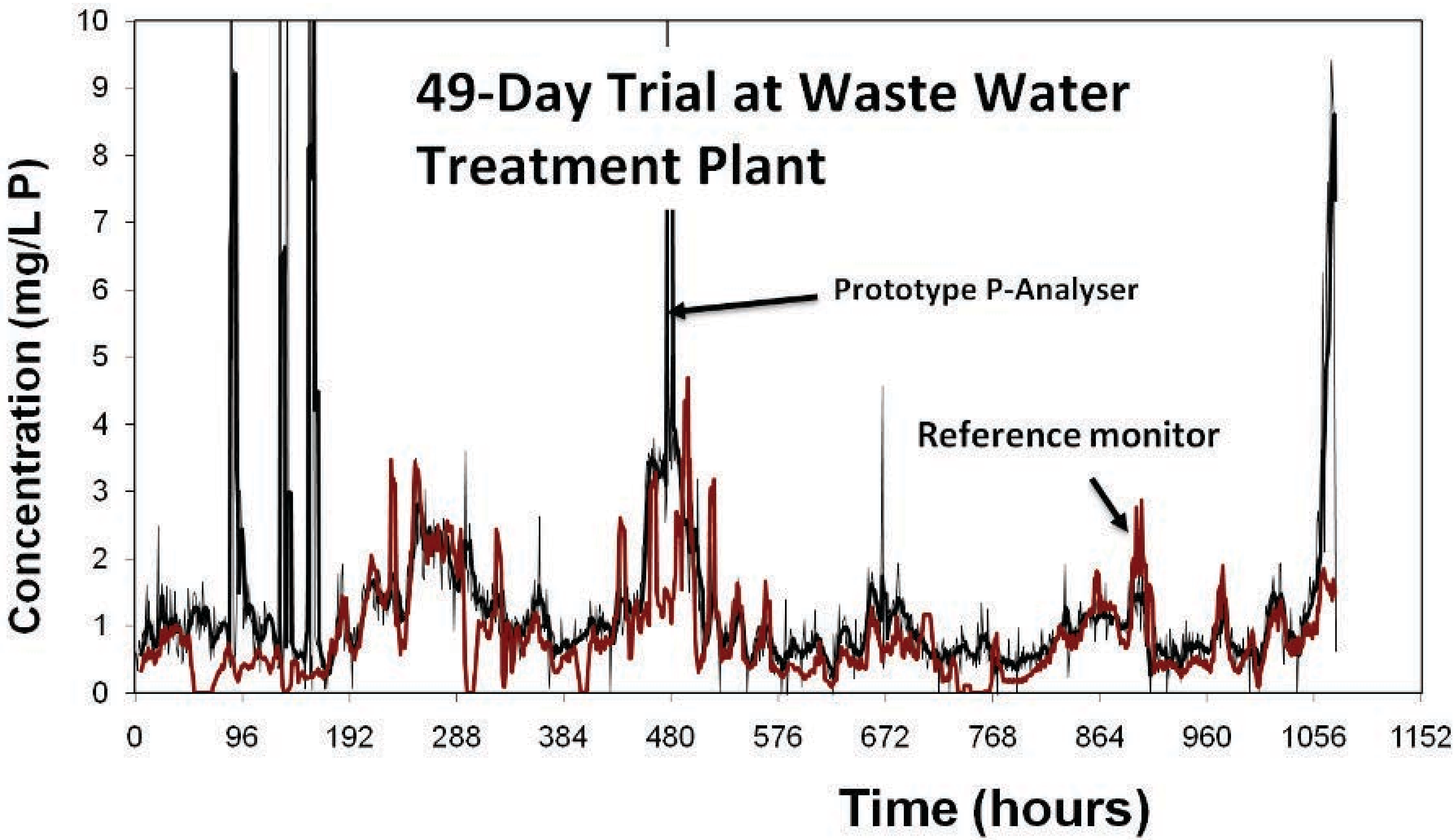
See https://picasaweb.google.com/JCOMMOPS/ArgoMaps?authuser=0&feat=embedwebsite

'calibration of the DO measurements by the SBE sensor remains an important issue for the future', Argo report 'Processing Argo OXYGEN data at the DAC level', September 6, 2009, V. Thierry, D. Gilbert, T. Kobayashi

Deployment at Osberstown WWTP

- Phosphate monitoring unit deployed
- System is fully immersed in the treatment tank
- Wireless communications unit linked by cable
- Data transmitted to cloud

Autonomous Chemical Analyser

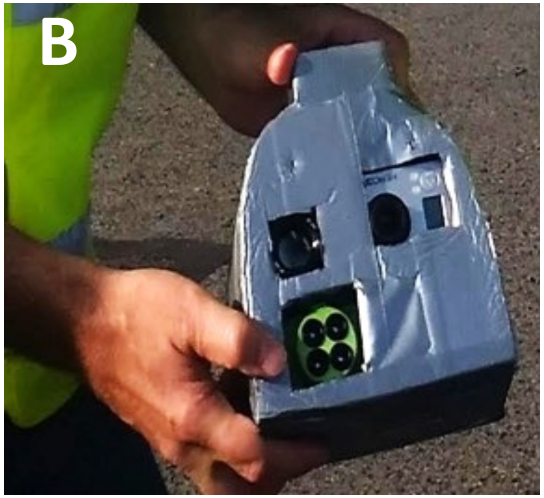


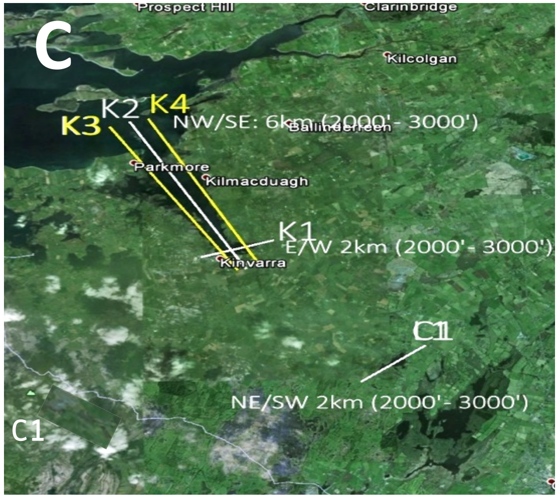
Osberstown – 3 week deployment

Biofouling of sensor surfaces is a major challenge for remote chemical sensing – both for the environment and for implantable sensors


Inver
Screebe
Camus
Oughter
Corrandulla
Annaghdown
Lough Corrib
Monivea
Tiquin
Briarhill
Lackaghbeg
Loughgeorge
Derrydonnell
Salalee
Cloghaun
Moycullen
Claregalway
Bengarra
Shraugh
Kilkieran
Bealadangan
Galway
Technology
Park
Athenry
Moycullen
Bogs
Costelloe
Derroe
Rossaveel
Ballybane
Galway
Oranmore
Kiltullagh
Carraroe
Salthill
Cathair
Spiddal
Furbogh
Barna
Carrarea
Lettermullan
Trabane
Inverin
Coral Strand
Cahercastle
Clarinbridge
Killeeneen
Craughwell
Carrabane
Tawin
Aggard
Kilcolgan
Caherpeak
Rathcosgrove
Ballinderreen
Kilchreest
Doorus
Flaggy Shore
Furbo
Shrawn
North Atlantic
Ocean
Kinvarra
Labane
Mainistir
Kilronan
Murroogh
Formoyle
Ballyvaughan
Bealaclugga
Peterswell
Fanore
Gort Na
gCapall
Inishmaan
Deelin
An Tra
Tierneevin
Gort
Leaha
Kilmoon
Lisdoonvarna
Meggagh
Carran
Boston
Doolin
Shanaglish
Cloon
Kilkeedy
Tubber
Flagmount
Kilfenora
Leamaneh
Blakemount
Killinaboy
Caher
Ballyportry
Moyree
Ballinruan
St bridget's
Well
Liscannor
Corofin
Ennistimon
Lahinch
Crusheen
Aylevaun
Rannagh
Ruan
Inchicronan
Feakle
Google

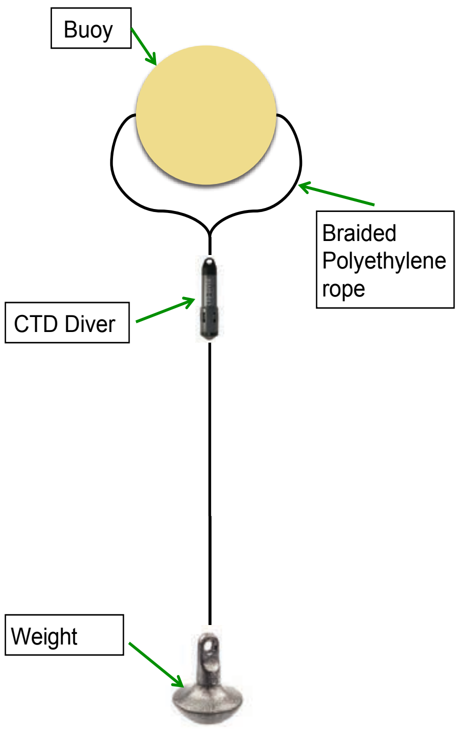
Fly-Over Sensing

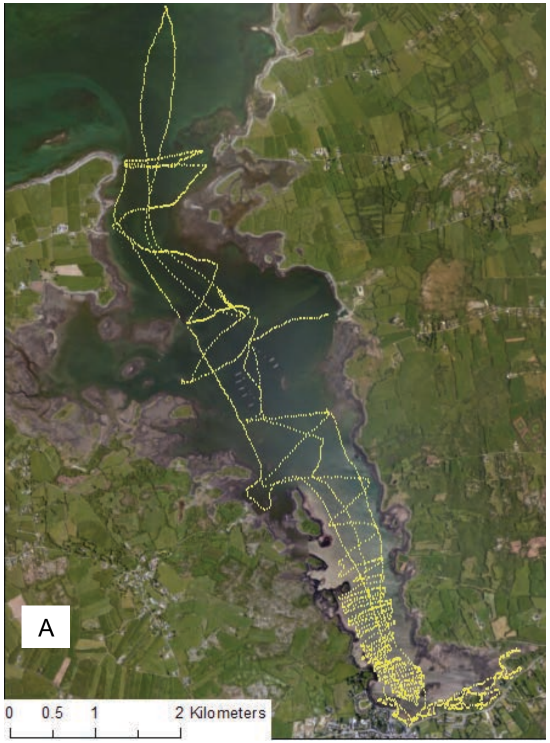


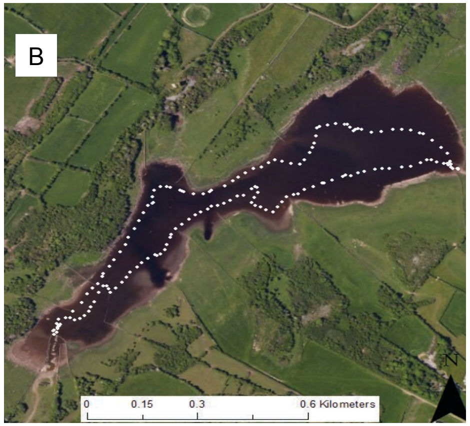


A) Sensor pod mounted on the wing strut of a Cessna 172 light aircraft; (B) The NCG sensor pod used to acquire data; (C). Flight paths for aerial flyovers of Kinvara bay and catchment area. K1 covers the inner bay while K2, K3 and K4 map the length of the bay from Kinvara to the mouth of the bay

In-Situ Sensing – Rig and Sampling Points

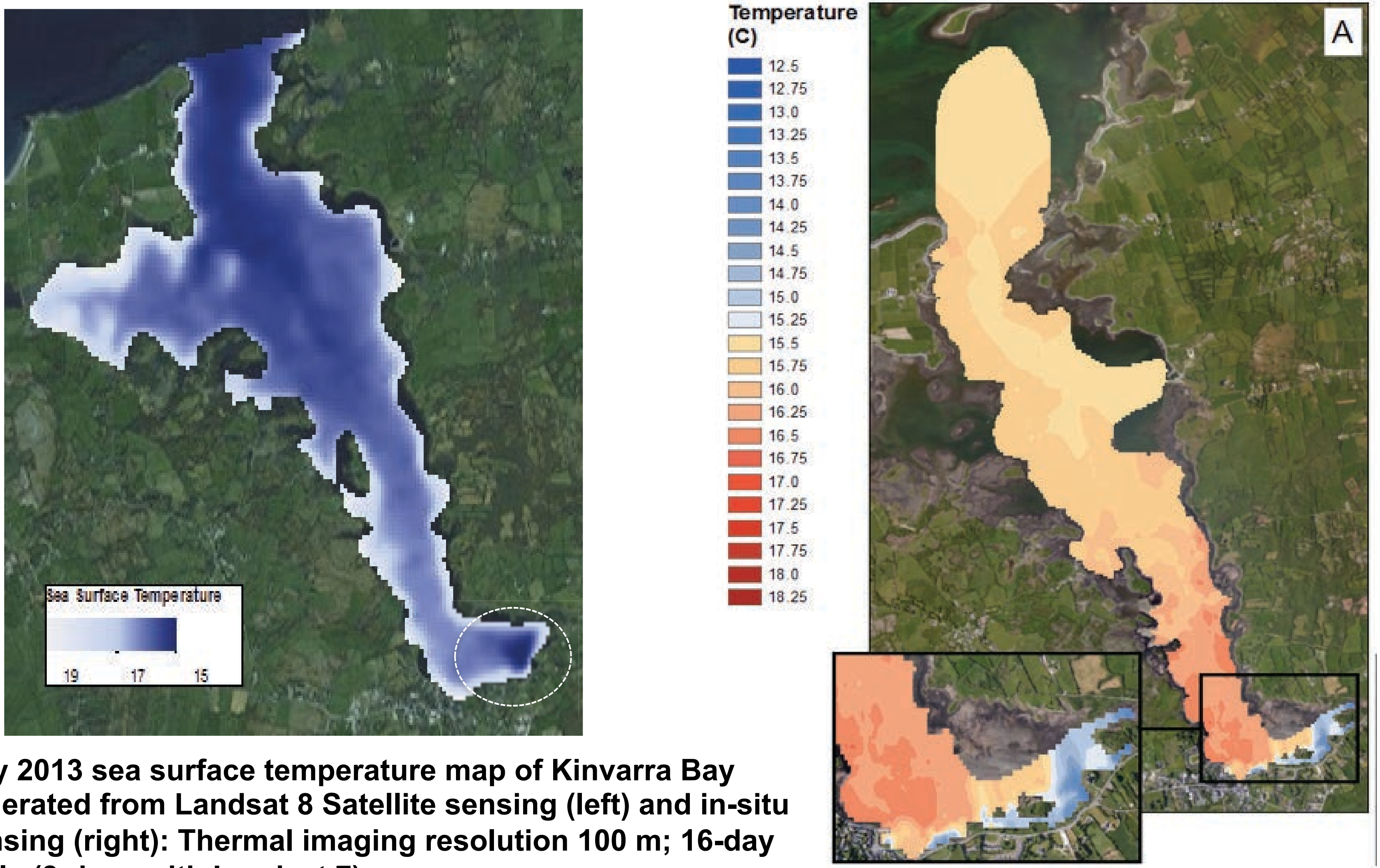






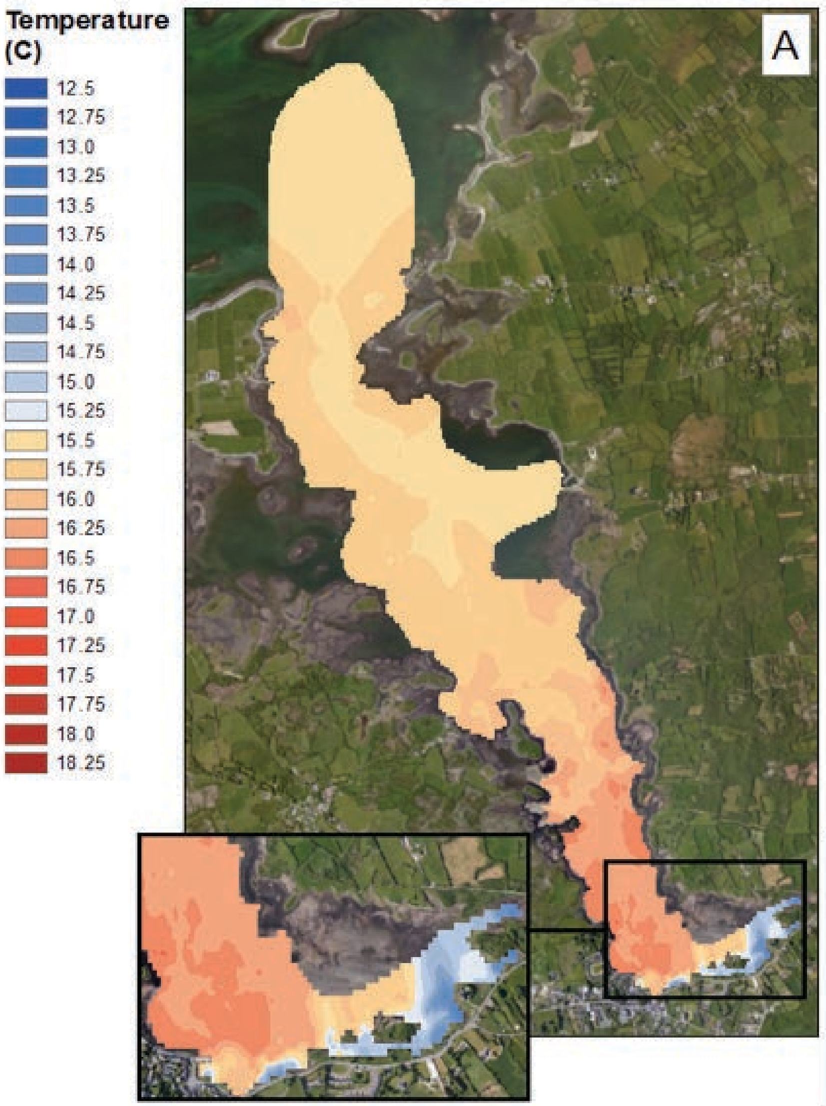
Location of in-situ data points collected over a four-day sampling campaign in (A) Kinvara Bay and (B) Cahergluassuan Turlough

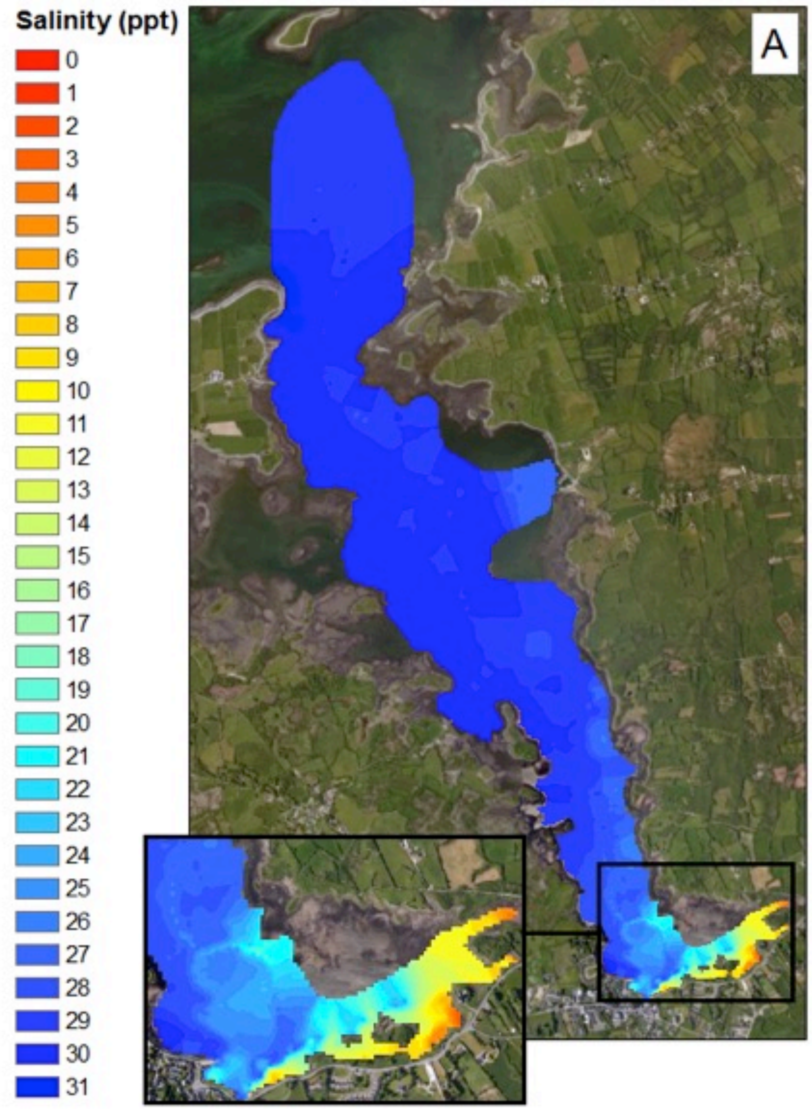
Comparing In-Situ and Satellite SST Measurements



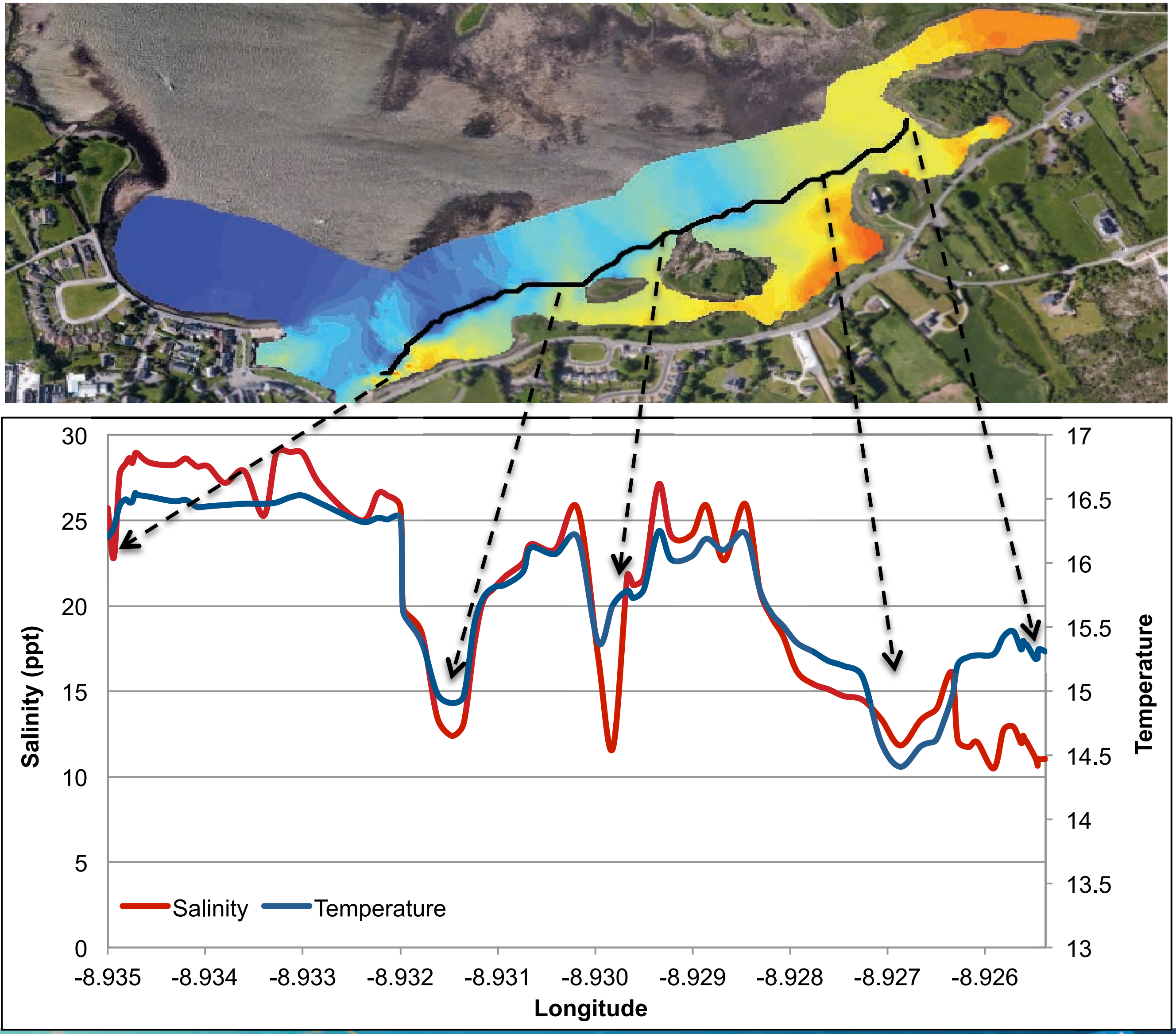
July 2013 sea surface temperature map of Kinvarra Bay generated from Landsat 8 Satellite sensing (left) and in-situ Sensing (right): Thermal imaging resolution 100 m; 16-day cycle (8-days with Landsat 7)

In-Situ Temp (L) vs Salinity (R)





Correlation of In-Situ Temperature and Salinity Measurements (East-West Transect)

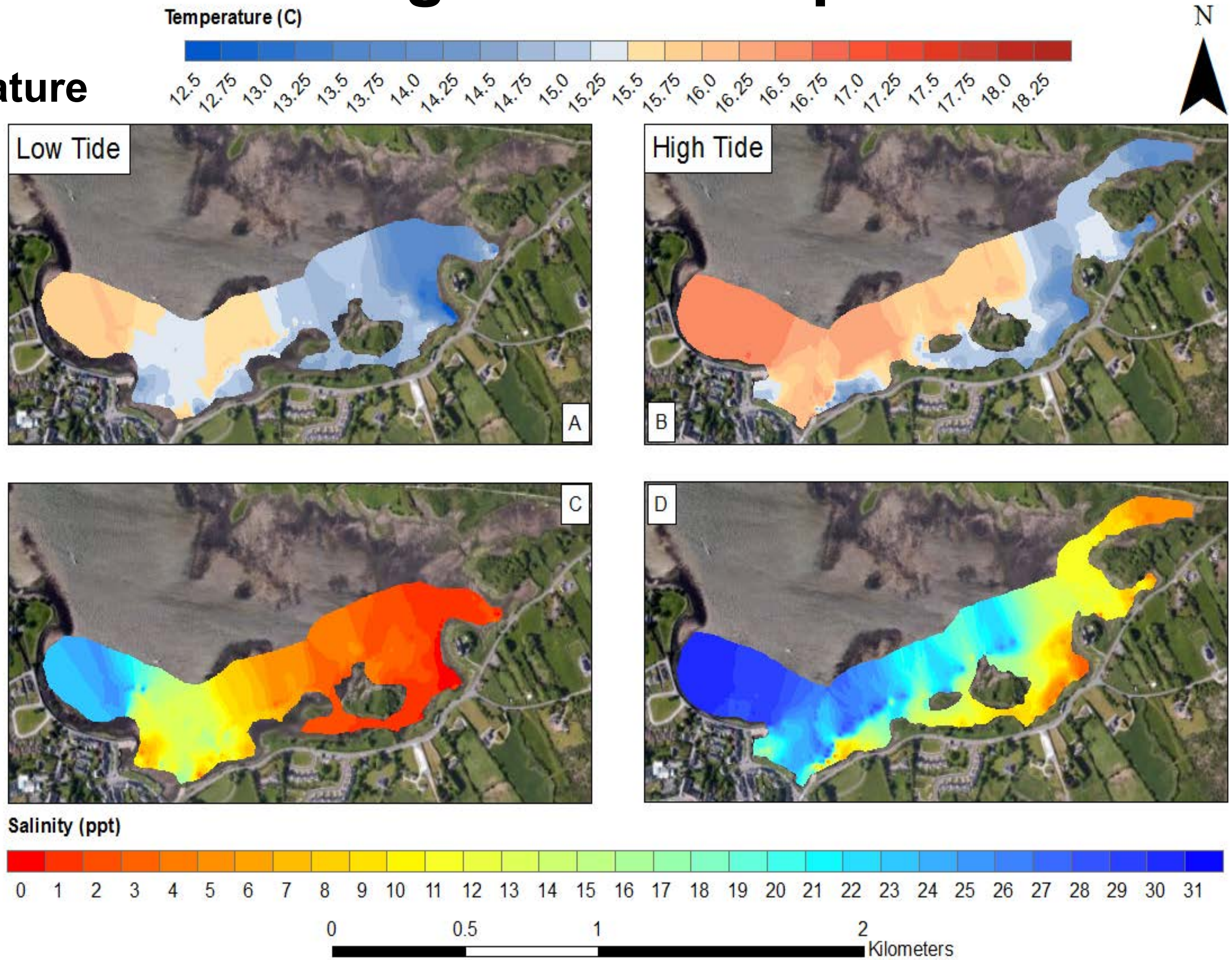


Temperature and salinity transect, stretching left to right from Kinvara pier (west) to Dunguaire castle (east); with salinity contour plot from in-situ bay survey

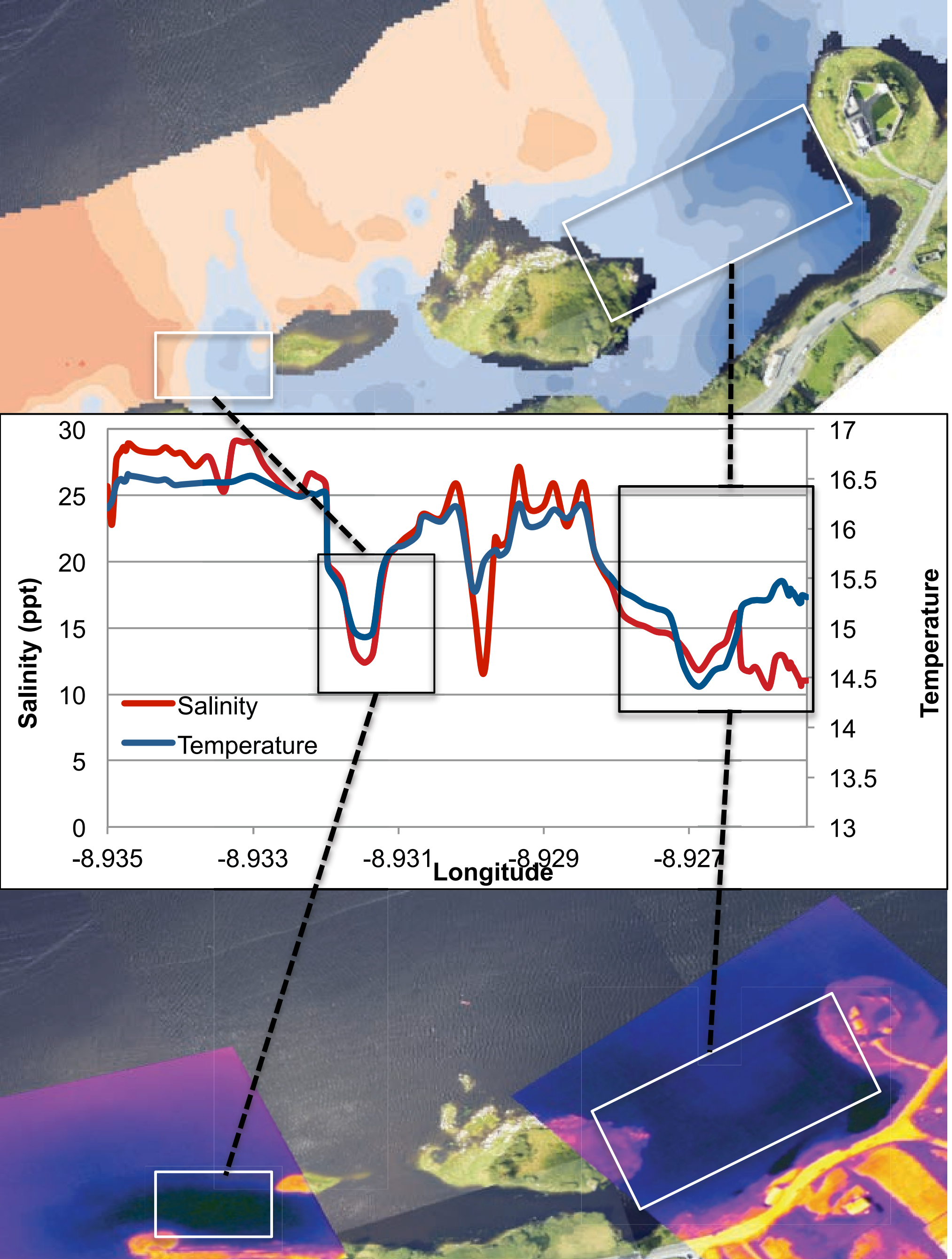
The effect of individual cold-water plumes is clearly evident in the salinity and temperature data.

Low Tide/High Tide Comparison

Temperature



Salinity



Correlation between In-Situ Temperature (top)

In-Situ Salinity & Temperature Transect (middle)

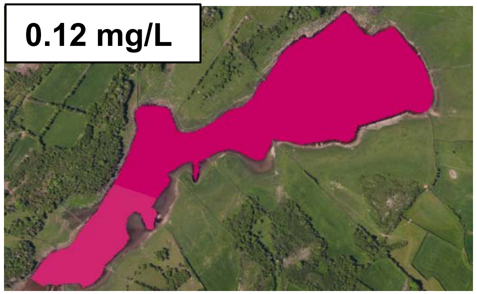
and Remote Thermal IR Fly-Over Data (bottom)

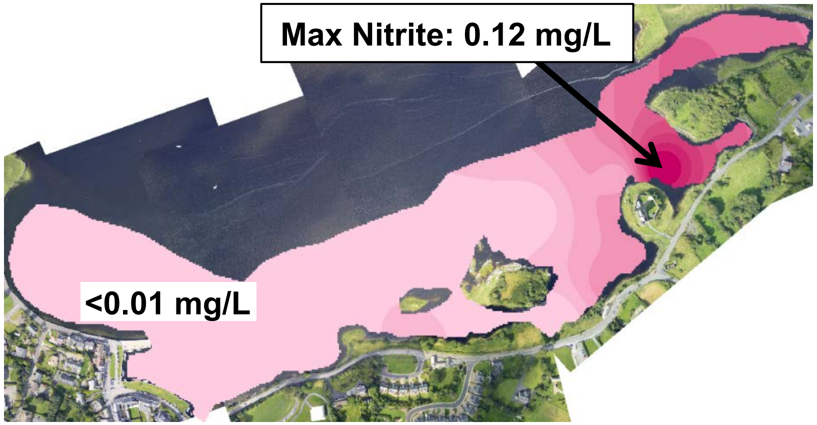
Nutrient Measurements

Nutrient levels at high tide

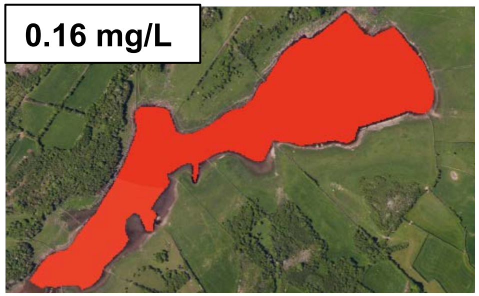
Caherglaussan Turlough

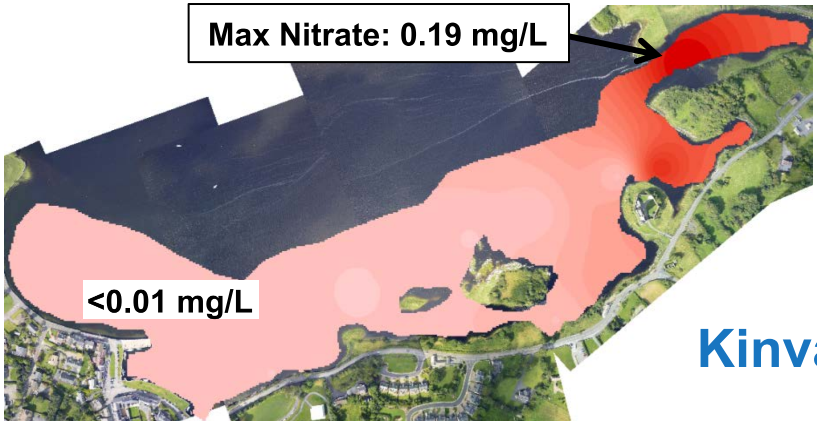
Nitrite



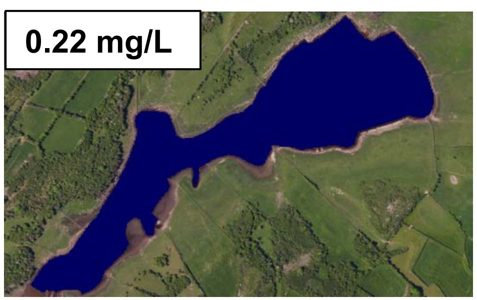


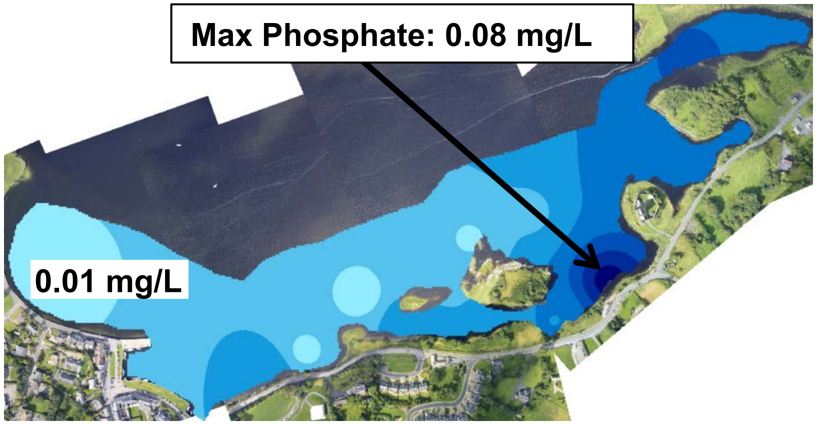
Nitrate





Phosphate





Kinvara Bay

Thoughts….

- **Remote SST temperature can be used as a surrogate for in-situ salinity to track dynamics of fresh/sea-water mixing in coastal areas**
- **Assuming that the composition of each water type is relatively well conserved, then we can track the distribution of their chemistries in the bay e.g. track where the nutrients go with minimal in-situ measurements**
- **This is turn can dramatically change our sensing and sampling strategy**
  - Fewer in-situ measurements needed (Ground Truth system)
  - Much lower cost
- **Wide spatial and Temporal coverage**

Thanks to…..

- Members of my research group
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MASK
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Materials and Advanced Sensor Knowledge Exchange

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DCU

SMARTBAY
IRELAND



COMMON SENSE
MARINE SENSORS - MARINE MONITORING

The COMMONSENSE consortium

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www.commonsenseproject.eu

Thanks to Michael for the invite!

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Project no: 269302
Materials and Advanced Sensor Knowledge Exchange
NAPES
NEXT GENERATION ANALYTICAL PLATFORMS FOR ENVIRONMENTAL SENSING
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