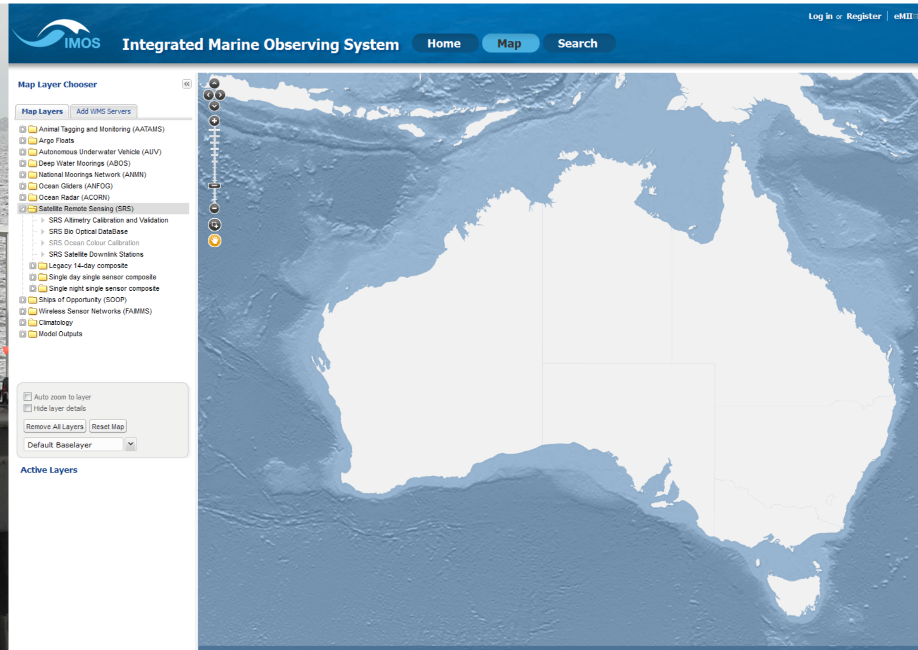

A Systematic approach to maintaining high quality bio-optical data streams in a coastal observing system.

Lesley Clementson[1], Tim Lynch[1], Robert Kay[1], Guillaume Galibert[2] and Irena Zagorskis[3]

07 October 2012

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www.csiro.au

IMOS
Integrated Marine Observing System

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What is IMOS (http://imos.org.au)

Australia's Integrated Marine Observing System (IMOS) was established in 2007 under the National Collaborative Research Infrastructure Strategy (NCRIS), with initial funding of $50M and co-investment of $44M from partners.

It has successfully deployed a range of observing equipment in the oceans around Australia, and is making all of the data freely and openly available through the IMOS Ocean Portal – http://imos.aodn.org.au/webportal/ - for the benefit of Australian marine and climate science as a whole.

With the injection of an additional $52M from the Education Investment Fund (EIF) in 2009, and up to $66M in further co-investment, IMOS will be extended out to mid-2013 and enhance its monitoring in the Southern Ocean and northern Australian waters.

IMOS is designed to be a fully-integrated, national system, observing at ocean-basin and regional scales, and covering physical, chemical and biological variables.

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IMOS Facilities

IMOS Facilities, operated by ten different institutions within the National Innovation System, are funded to deploy equipment and deliver data streams for use by the entire Australian marine and climate science community and its international collaborators.

Argo Floats
Ships of Opportunity
Deep-water Moorings
Ocean Gliders
Autonomous Underwater Vehicles
National Mooring Network
Ocean Radar
Animal Tagging and Monitoring
Wireless Sensor Networks
Marine Information (eMII)
Satellite Remote Sensing (SRS)
Australian Ocean Data Network
Bio-optical Working Group

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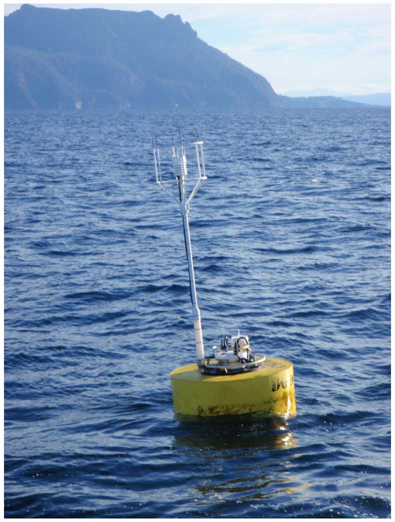
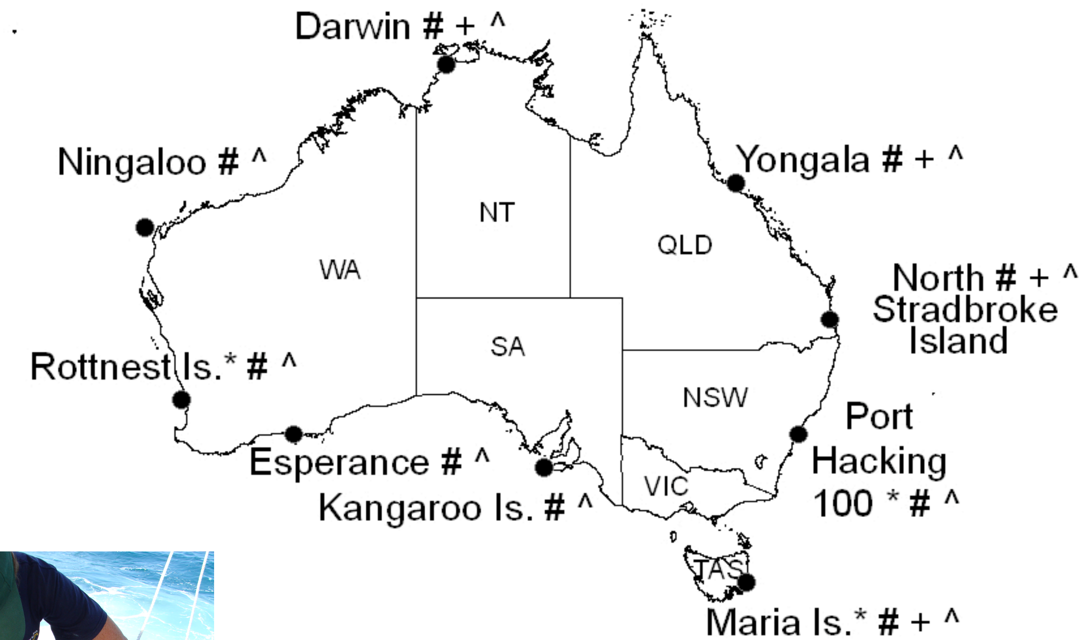
National Reference Stations – time series data
Sensors and Sampling





Key
* - long term site
# - infrastructure deployed
+ - Telemetry
^ BGC sampling

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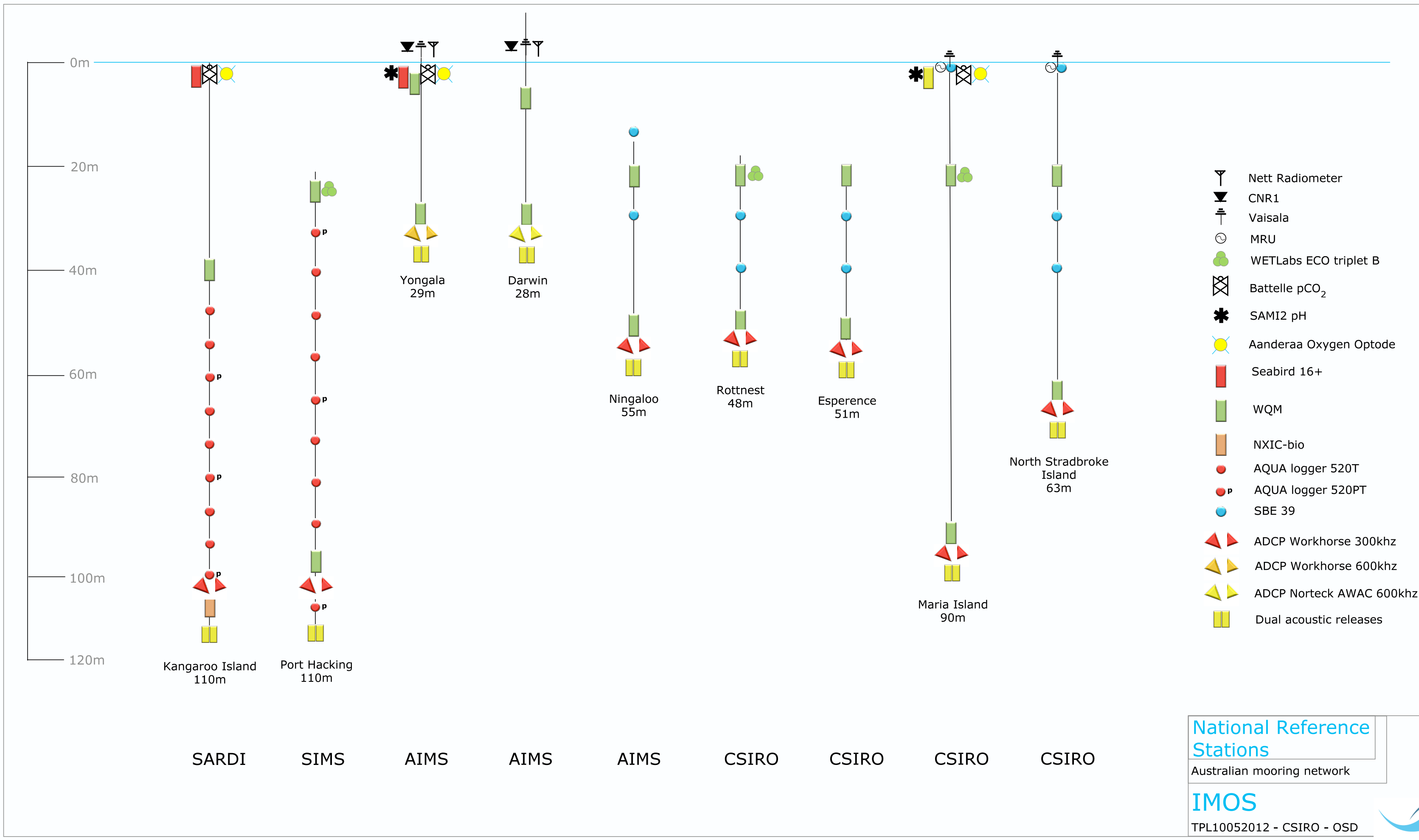
NRS design– Many FLNTUs



QC sensors vs biogeochemical water sampling
- Combine for cross validation

Sensors (T, S, Fl NTU)

9 QC tests

Scientist per site

Matlab toolbox

Methods papers

NATA calibration laboratory

BGC (pigments, nutrients, TSS, flow cytometry, phytoplankton and zooplankton counts)

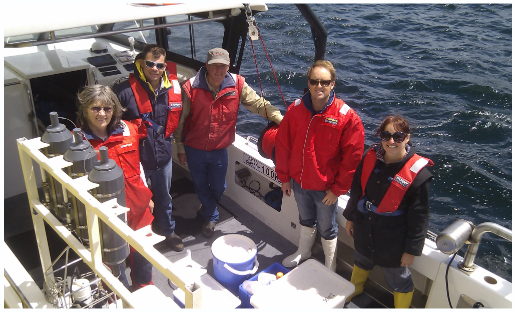
4 central processing laboratories

Scientist per laboratory

Annual training

Sampling/lab manuals

Taxonomic guides



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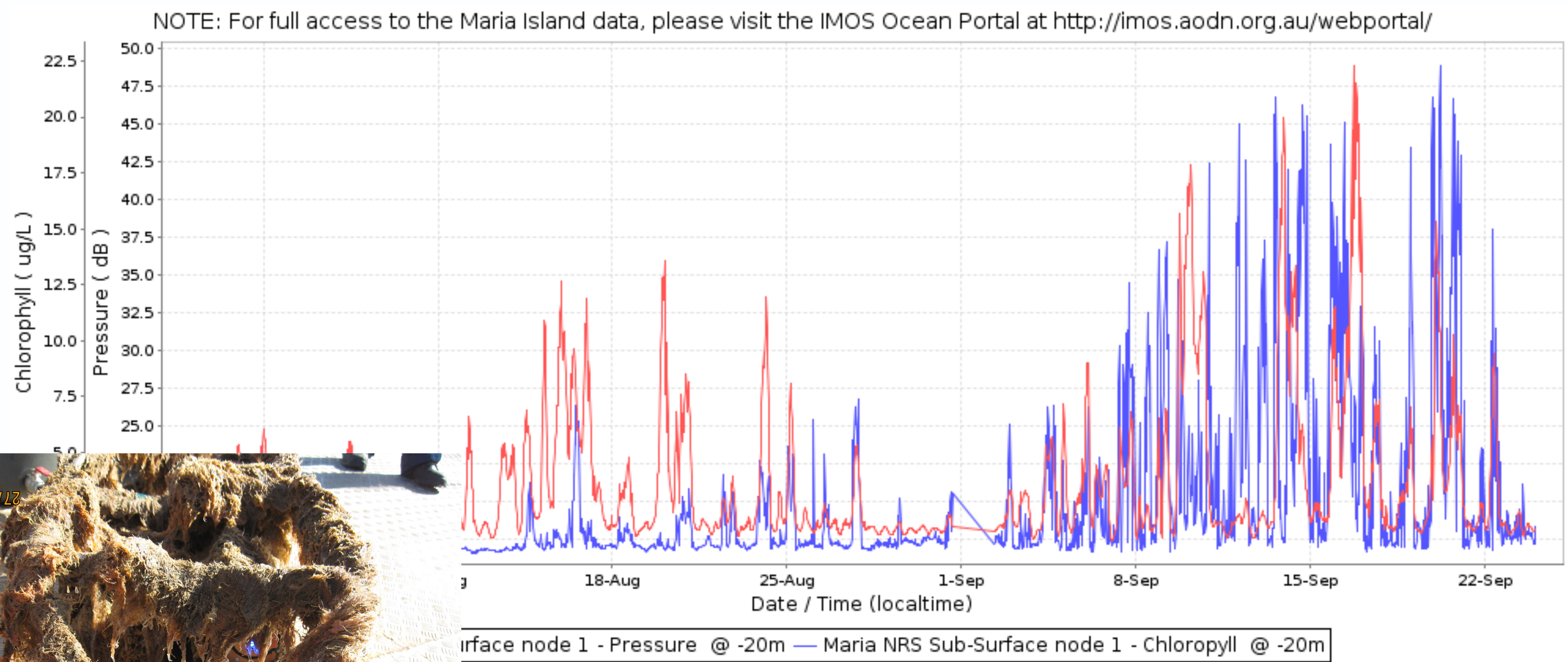
Lesson Learnt – Bio-fouling of sensors after 6 months
- Detected by users via telemetry



Photos of sensors upon retrieval are taken and kept with the sensor history.

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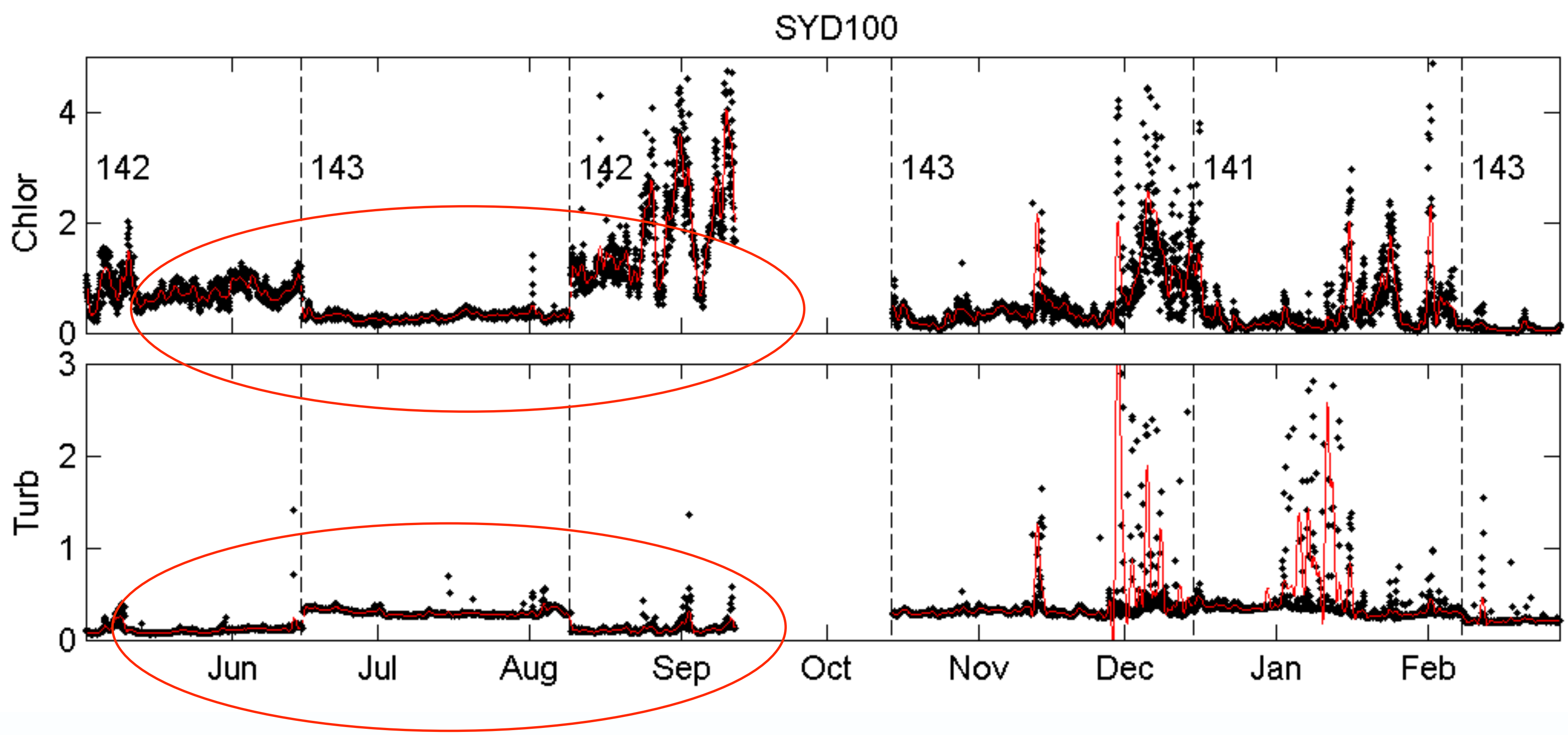
Key lesson learnt for sustained observing QC – inter sensor comparability



Spiking – physicists vs biologists

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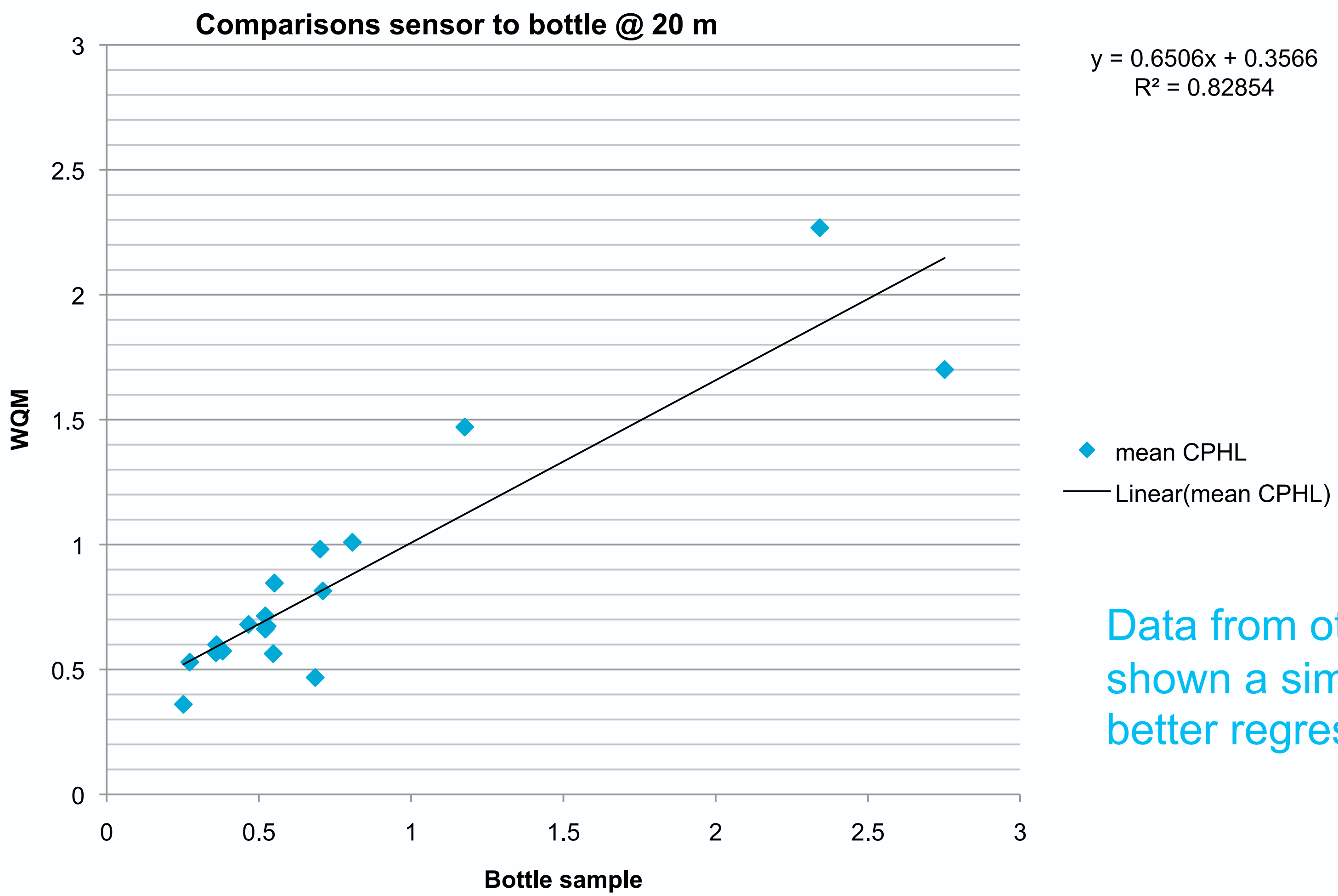
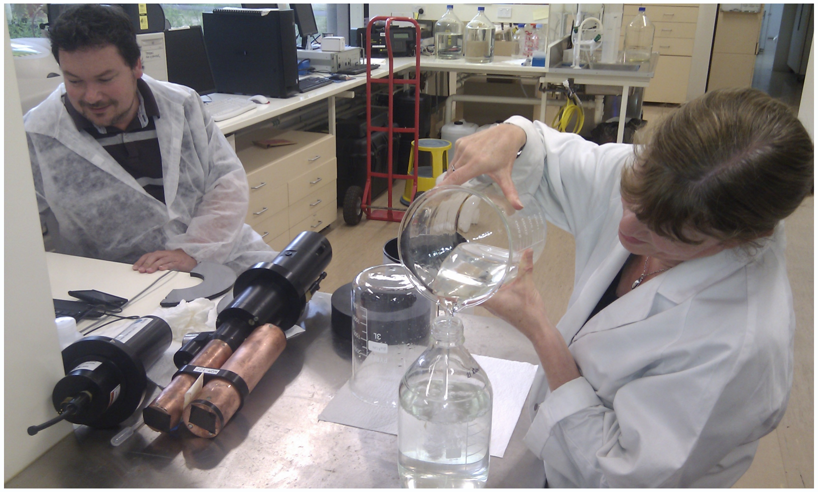
Cross validation of sensor to monthly BGC samples – Chlorophyll (20m) Maria Island NRS



Data from other NRS have shown a similar or slightly better regression

Back to the laboratory



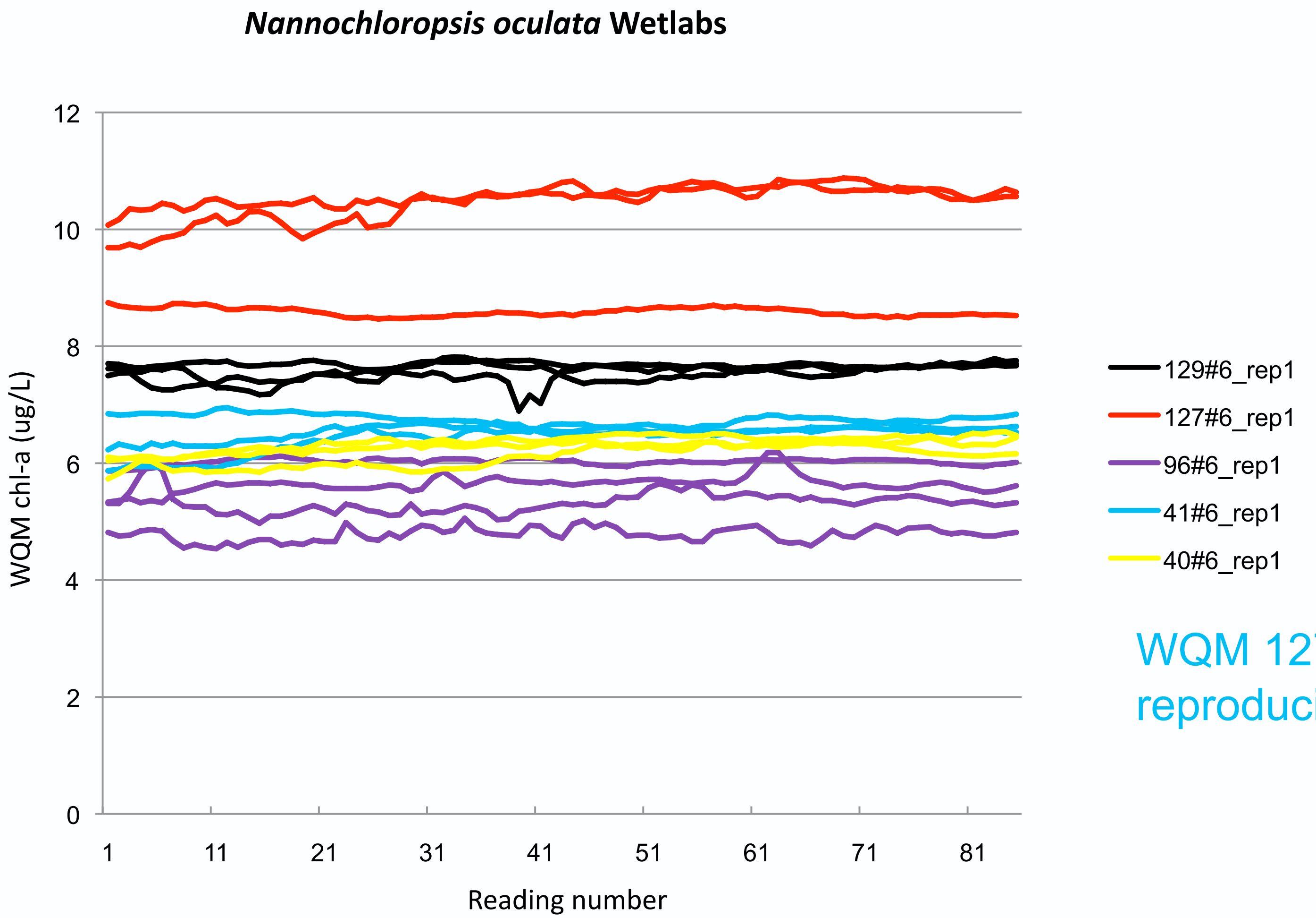
NATA Certified Calibration lab

Australian National Algae Culture Collection (ANACC)

Many FLNTUs available

Highly skilled staff

Key lesson learnt for sustained observing QC – inter sensor comparability



WQM 127 did not give reproducible results

Ratio adjustment with ref samples

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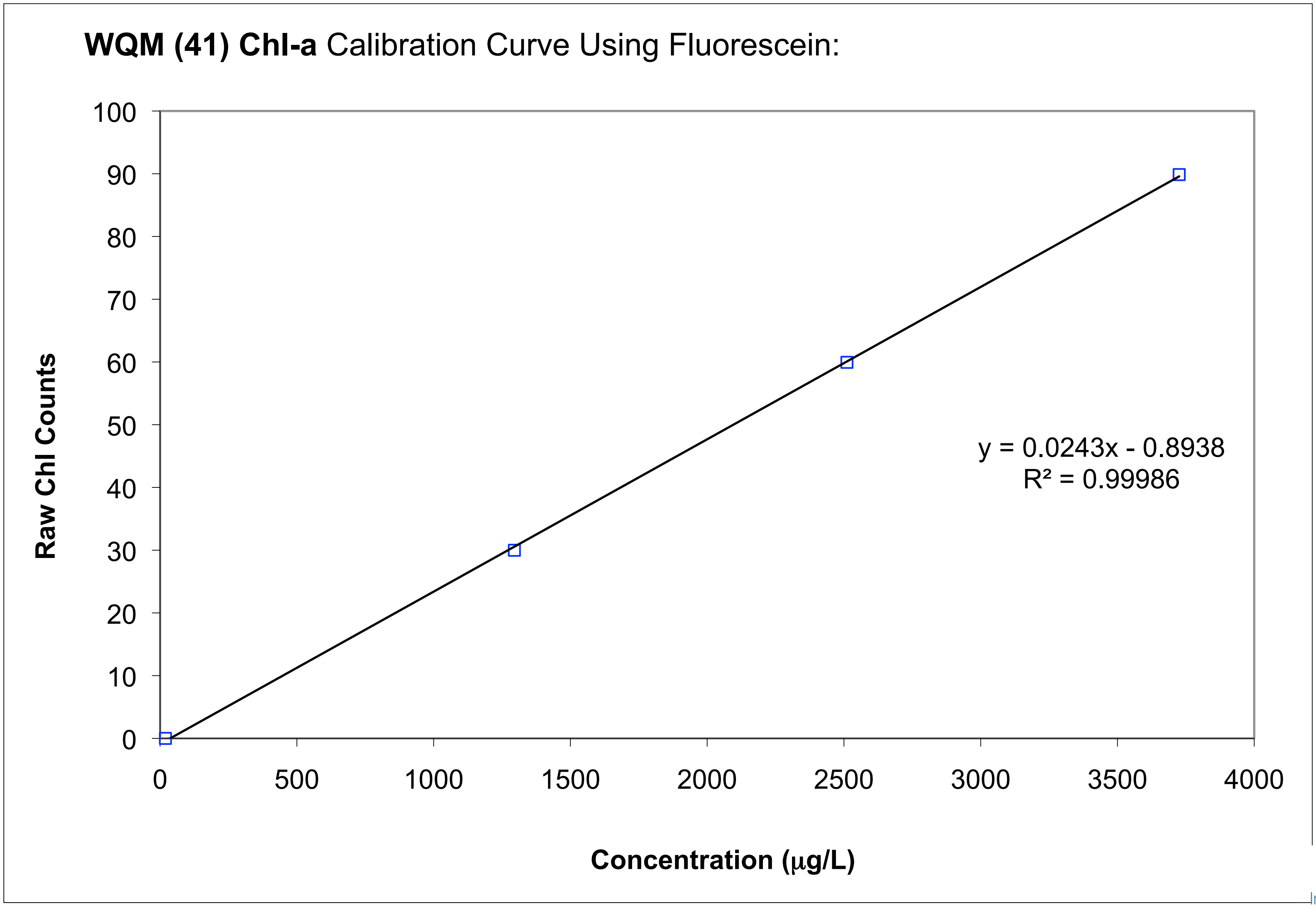
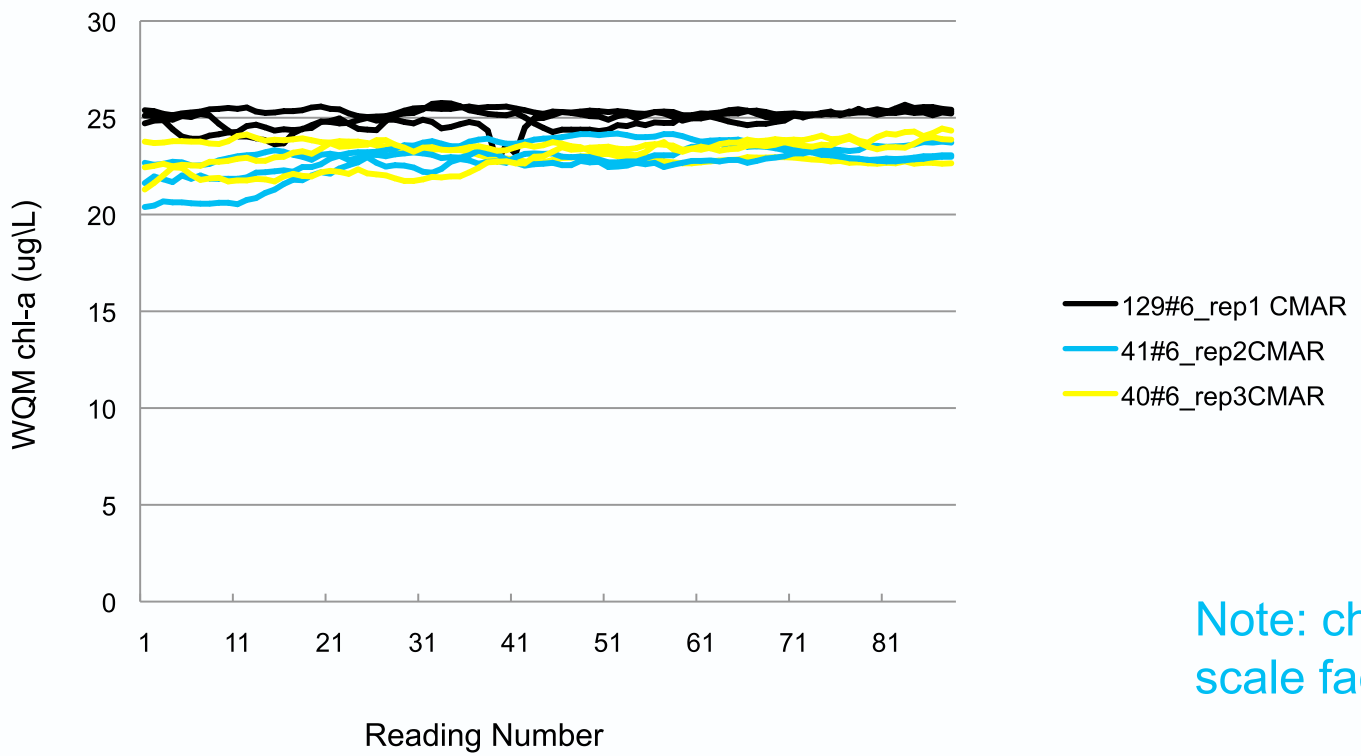
Fluoroscein calibration



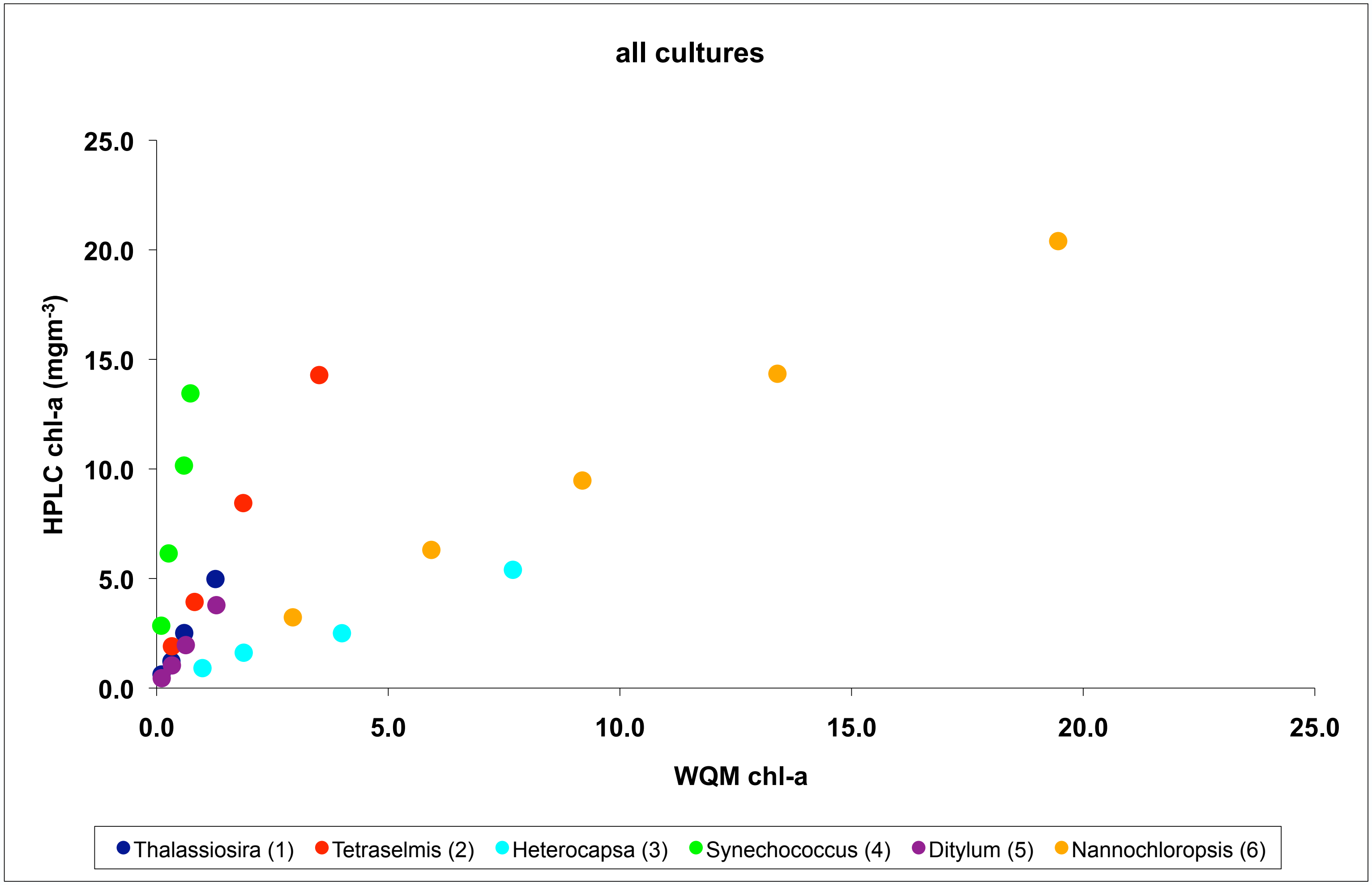
Remove the bogus instruments
– start to get repeatable results

Nannochloropsis oculata **CMAR remove WQM 127 and 96**

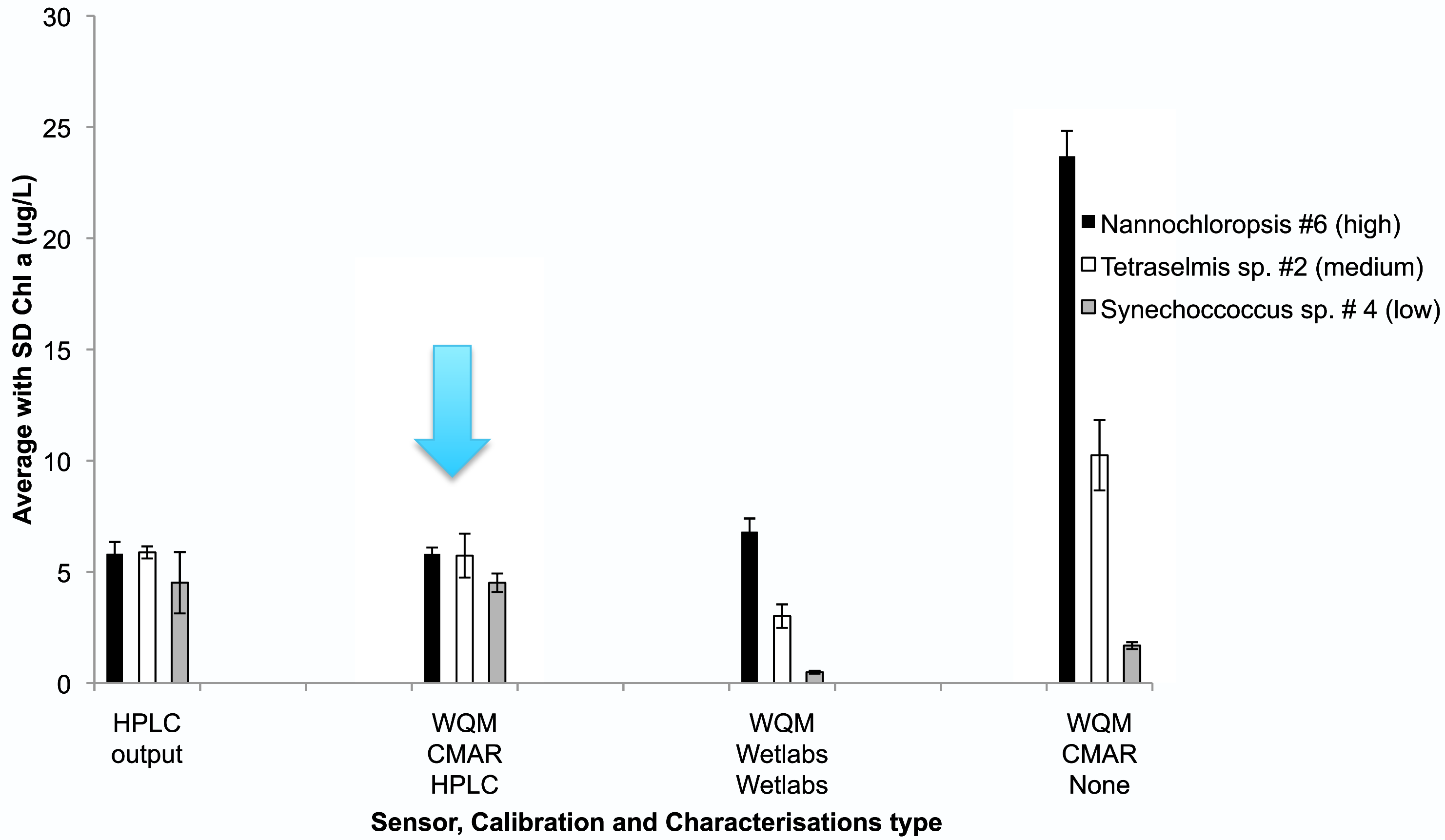


Note: change in scale factor

Algal culture calibration?



Characterize against the HPLC standard and now both precise and accurate across 3 algal species



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Procedures for CTD / WQM on moorings

QC procedure	Variables checked (* can be tuned by user)	Parameterized	Pass flag	Fail flag
Impossible date	TIME	Yes	Good	Bad potentially correctable
Impossible location	LATITUDE, LONGITUDE	Yes, and per site	Good	Bad potentially correctable
In/out water	All	No	Non QC'd	Bad potentially correctable
Global range	TEMP, PSAL, PRES/DEPTH, DO, CHL-A *	Yes	Good	Bad
Regional range	TEMP, PSAL, DO *	Yes, and per site	Good	Bad
Impossible depth	PRES/DEPTH	Yes	Good	Bad
Spike	TEMP, PSAL, PRES/DEPTH, DO, CHL-A *	Yes	Good	Bad
Gradient / Rate of change	TEMP, PSAL, PRES/DEPTH, DO, CHL-A *	Yes	Good	Bad potentially correctable
Stationarity	TEMP, PSAL, PRES/DEPTH, DO, CHL-A *	No	Good	Bad
Climatology	TEMP, PSAL, DO (when possible?)	Yes	Good	Bad

4 – Global range

Each listed parameter has its values compared to global upper and lower valid values :

IMOS parameter	CF title	Unit	Valid min	Valid max	Source
TEMP	Sea water temperature	Celsius	-2.5	40	ARGO Quality control manual v2.7 (Jan. 2012)
PSAL	Sea water salinity	PSU	2.0	41	ARGO Quality control manual v2.7 (Jan. 2012)
PRES	Sea water pressure	dbar	5	12 010	ARGO Quality control manual v2.7 (Jan. 2012)
PRES_REL	Sea water relative pressure	dbar	-5	12 000	ARGO Quality control manual v2.7 (Jan. 2012)
DEPTH	Depth	m	-5	12 000	ARGO Quality control manual v2.7 (Jan. 2012)
DOX1	Mole concentration of dissolved molecular oxygen in sea water	umol/l	0	900 000	MyOcean - Real Time Quality Control of biogeochemical measurements v1.0 (Jan. 2011)
DOX2	Moles of oxygen per unit mass in sea water	umol/kg	0	880 000	MyOcean - Real Time Quality Control of biogeochemical measurements v1.0 (Jan. 2011)
CPHL, CHLU, CHLF	Mass concentration of chlorophyll in sea water	mg/m3	0	100	MyOcean - Real Time Quality Control of biogeochemical measurements v1.0 (Jan. 2011)
...	...	...	...	...	

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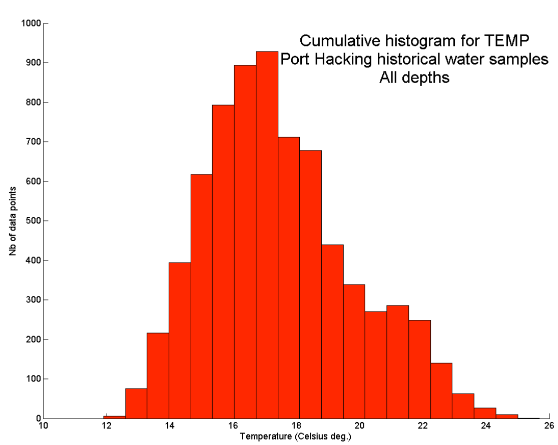
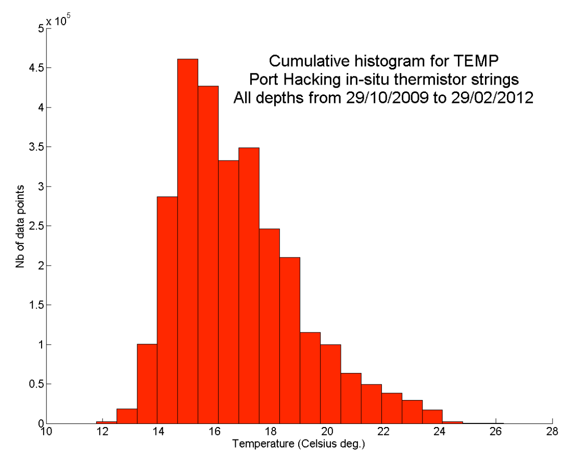
5 – Regional range

Each listed Site and parameter has its values compared to regional upper and lower valid values :

Site	IMOS parameter	CF title	Unit	Valid min	Valid max	Source
NRSPHB	TEMP	Sea water temperature	Celsius	10	28	Port Hacking historical water samples.
NRSPHB	PSAL	Sea water salinity	PSU	31	37	Port Hacking historical water samples.
NRSPHB	DOX2	Moles of oxygen per unit mass in sea water	umol/kg	50	400	Port Hacking historical water samples.
NRSMAI	TEMP	Sea water temperature	Celsius	8	21	Maria Island historical water samples.
NRSMAI	PSAL	Sea water salinity	PSU	33	37	Maria Island historical water samples.
NRSMAI	DOX2	Moles of oxygen per unit mass in sea water	umol/kg	100	400	Maria Island historical water samples.
…	…	…	…	…	…	…





7 – Spike test

Each listed parameter has its own threshold value to be used in the ARGO spike test :

|Vn-(Vn+1 + Vn-1)/2| - |(Vn+1 - Vn-1)/2| <= threshold

IMOS parameter	CF title	Unit	Threshold	Source
TEMP	Sea water temperature	Celsius	6	ARGO Quality control manual v2.7 (Jan. 2012)
PSAL	Sea water salinity	PSU	0.9	ARGO Quality control manual v2.7 (Jan. 2012)
PRES, PRES_REL, DEPTH	Sea water pressure, Sea water relative pressure, Depth	dbar, m	3	
DOX1, DOX2	Mole concentration of dissolved molecular oxygen in sea water, Moles of oxygen per unit mass in sea water	umol/l, umol/kg	PABIM	MyOcean - Real Time Quality Control of biogeochemical measurements v1.0 (Jan. 2011)
CPHL, CHLU, CHLF	Mass concentration of chlorophyll in sea water	mg/m3	PABIM	MyOcean - Real Time Quality Control of biogeochemical measurements v1.0 (Jan. 2011)
...	...	...	...	

PABIM white book v1.3 (Feb. 2010) threshold :

|median(Vn-2,Vn-1,Vn,Vn+1,Vn+2)| + |stDev(Vn-2,Vn-1,Vn,Vn+1,Vn+2)|

8 – Gradient Vs Rate of change

Gradient

Each listed parameter has its own threshold value to be used in the ARGO gradient test :

|Vn-(Vn+1 + Vn-1)/2| <= threshold

Rate of change

Each listed parameter has its own threshold value to be used in the MyOcean rate of change test :

|Vn – Vn-1| + |Vn – Vn+1| <= 2*threshold

IMOS parameter	CF title	Unit	Gradient threshold	Rate of change threshold
TEMP	Sea water temperature	Celsius	9	2*stDev(first month)
PSAL	Sea water salinity	PSU	1.5	2*stDev(first month)
PRES, PRES_REL, DEPTH	Sea water pressure, Sea water relative pressure, Depth	dbar, m	3	2*stDev(first month)
DOX1, DOX2	Mole concentration of dissolved molecular oxygen in sea water, Moles of oxygen per unit mass in sea water	umol/l, umol/kg	90	2*stDev(first month)
CPHL, CHLU, CHLF	Mass concentration of chlorophyll in sea water	mg/m3	3	2*stDev(first month)
…	…	…	…	…

-Points with more than 1h apart are not considered as neighbours and current point is flagged as “Non QC’d”.

-Tests only flag current point Vn.

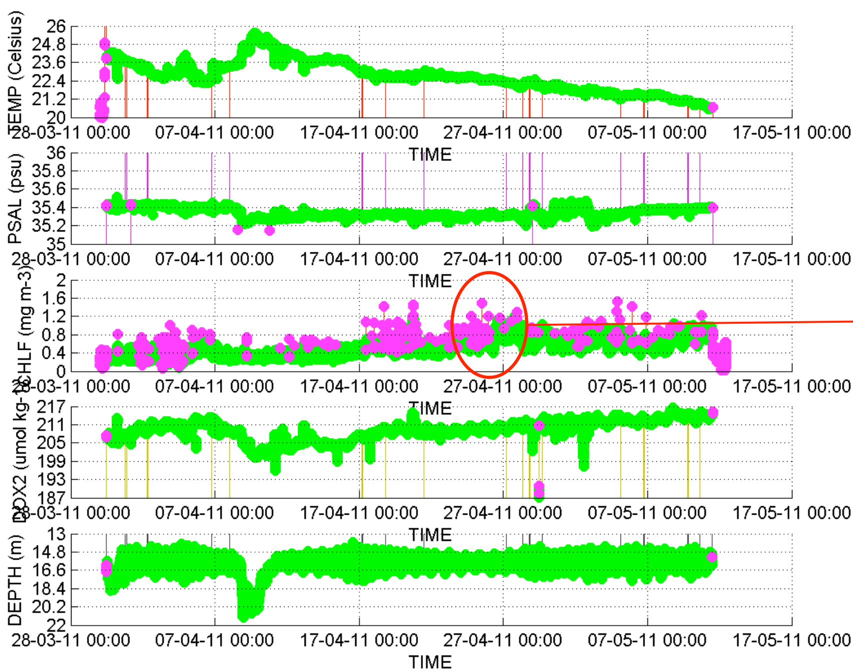
8 – Gradient Vs Rate of change

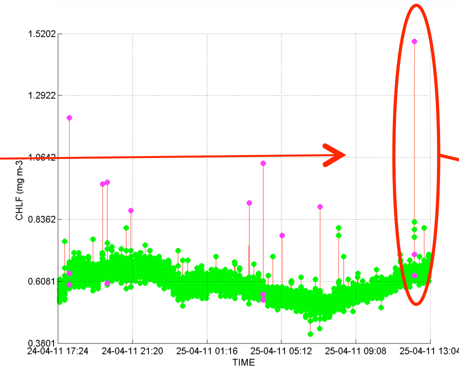
Gradient

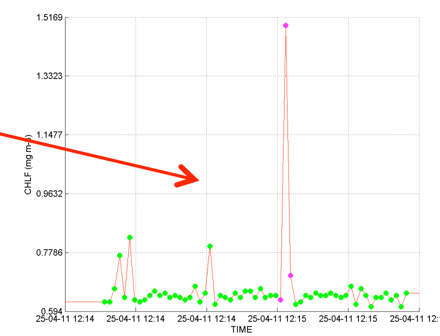
|Vn-(Vn+1 + Vn-1)/2| <= constant

Rate of change

|Vn – Vn-1| + |Vn – Vn+1| <=
2* 2*stDev(first month)







Actual value is “real”

Summary

We have taken a three prong approach to achieving consistent quality controlled data from the moored sensors.

Fieldwork - consistent sensor deployment/retrieval procedures over all sites
- consistent BGC sampling procedures over all sites
- maintain sensor history

Laboratory - consistent one operator analyses for samples from all sites
- routine multi-point calibration of sensors
- extra experimental work to characterize sensors

Data - 9 QC tests applied to sensor data
- manual checks of some flagged data – eg: chl-a

All data is freely available http://imos.aodn.org.au/webportal

Acknowledgements

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Data Team

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Thank you

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