Tropical Water Quality Hub

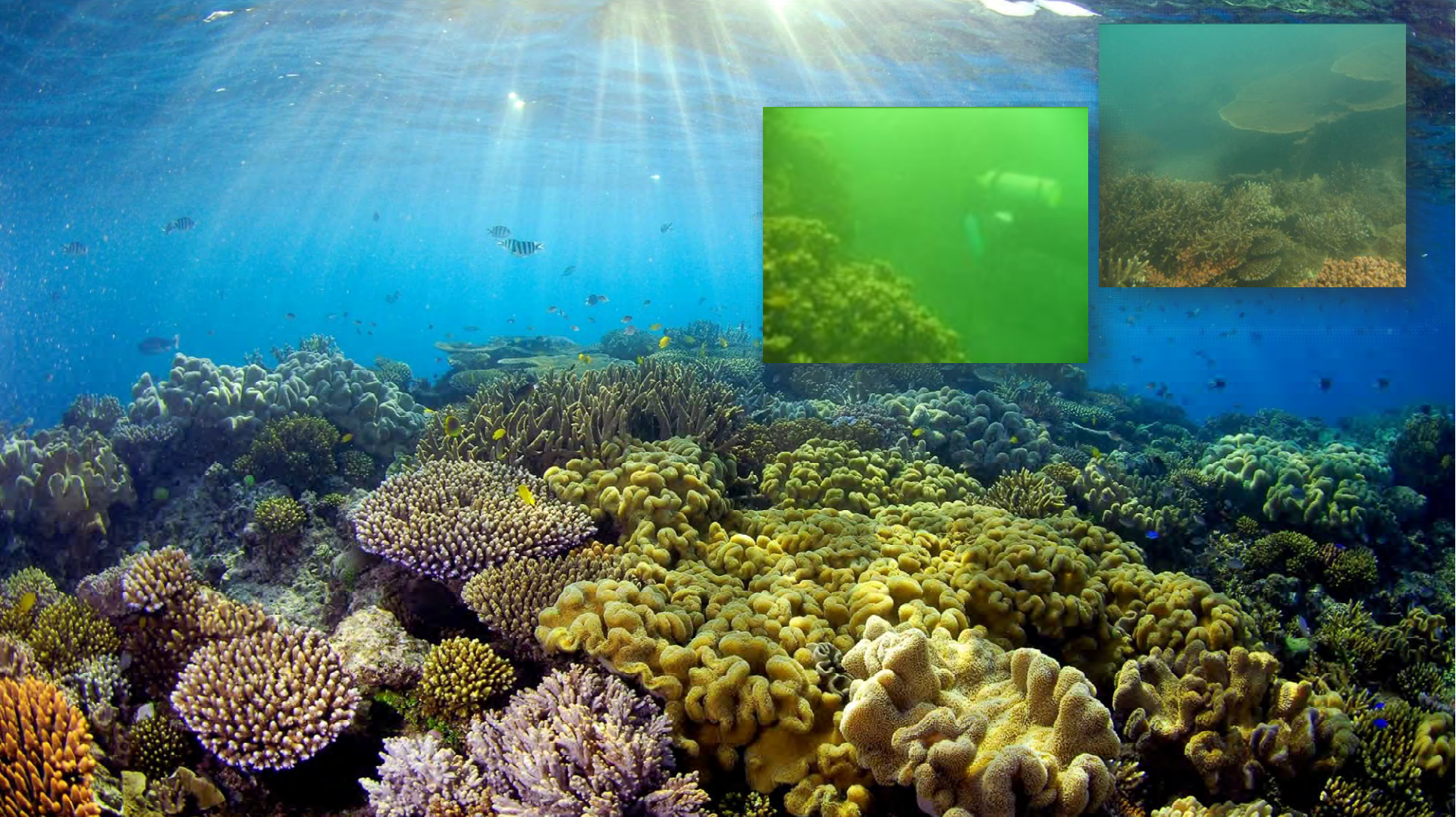
National Environmental Science Programme

# Benthic light as an ecologically-validated water quality indicator

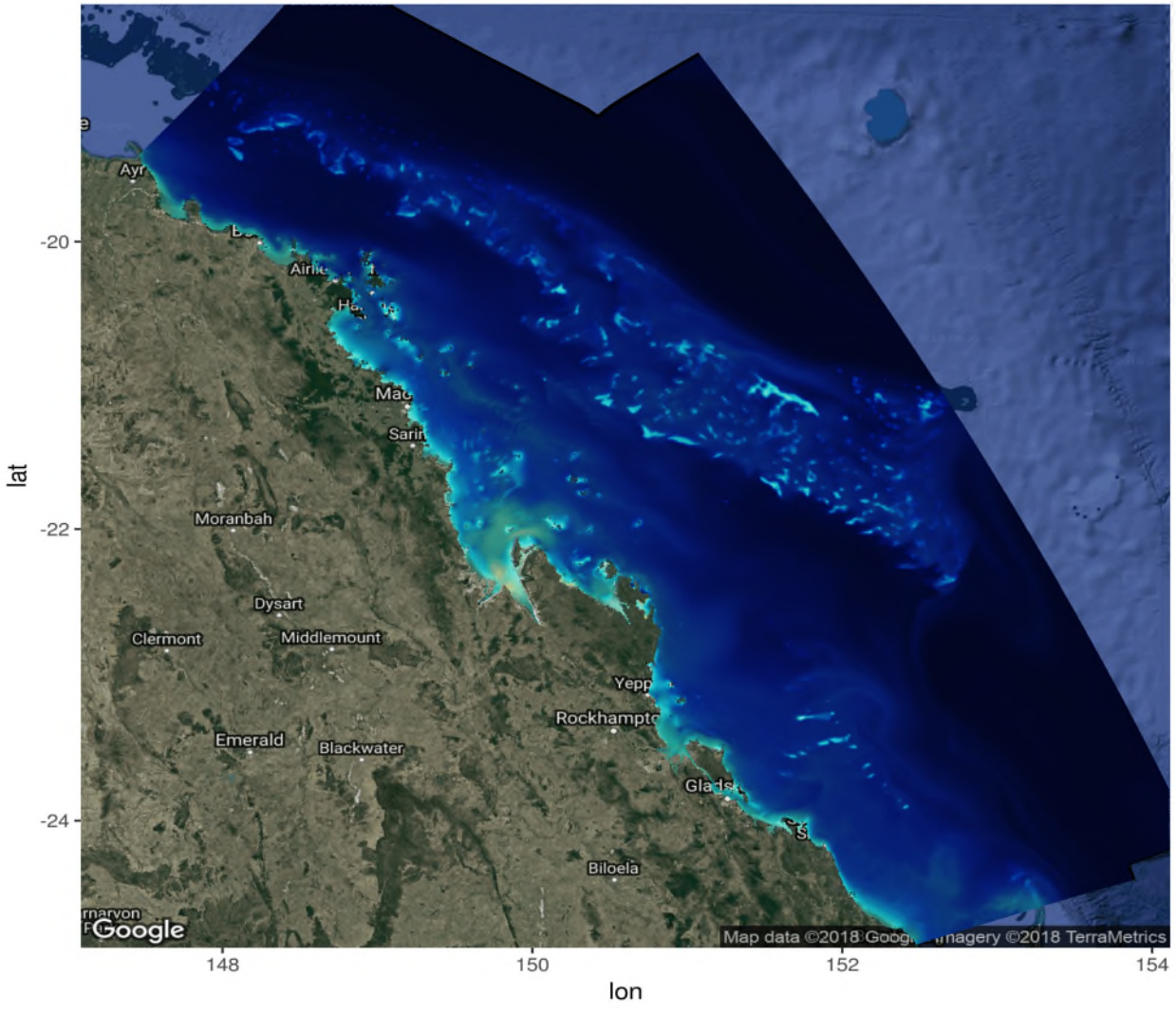
Dr. Barbara Robson
Australian Institute of Marine Science

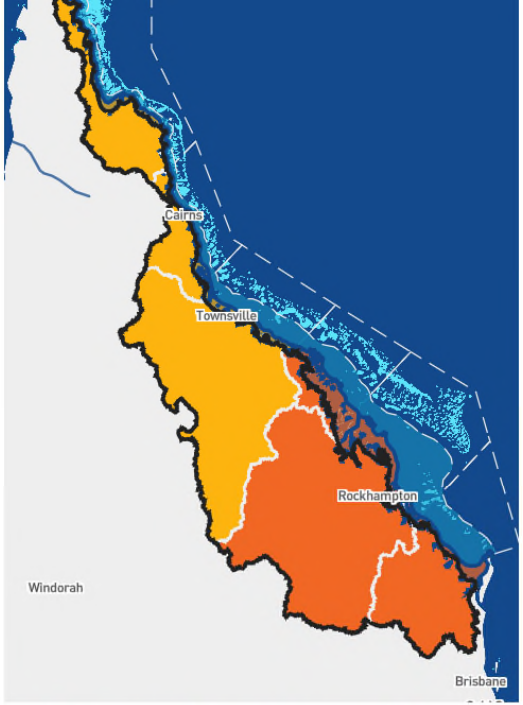
Australian Government

Australian Institute of Marine Science



# eReefs marine models
# -- Cyclone Yasi 2011






A Very good B Good C Moderate D Poor
E Very poor N No data/NA

## Great Barrier Reef catchments

**Area:** 42,400,000 hectares

### Results

Grade

D

Poor

Data confidence ●●●●○

Decline in score

Reef resilience indicators through time

Seagrass abundance Coral cover change

Score (1-100)

2007-08 2008-09 2009-10 2010-11 2011-12 2012-13 2013-14 2014-15 2015-16 2016-17 2017-18

### Contributing to the results

Seagrass

Reproductive effort → Abundance → Nutrient status → D

Data confidence ●●●●○

Coral

Juvenile → Algae → Change → Composition → Cover → C

Data confidence ●●●●○

Water quality

Secchi depth → Chlorophyll a → D

Data confidence ●●●○○

Since last report card: → No change ↑ Improvement ↓ Decline

https://reportcard.reefplan.qld.gov.au/



# Goal

To develop a new Water Quality Index (WQI) that:

- Can be applied over the whole GBR
- Relates directly to ecological impacts
- Considers *chronic* effects of light stress

# Steps in developing a bPAR-based Water Quality Indicator

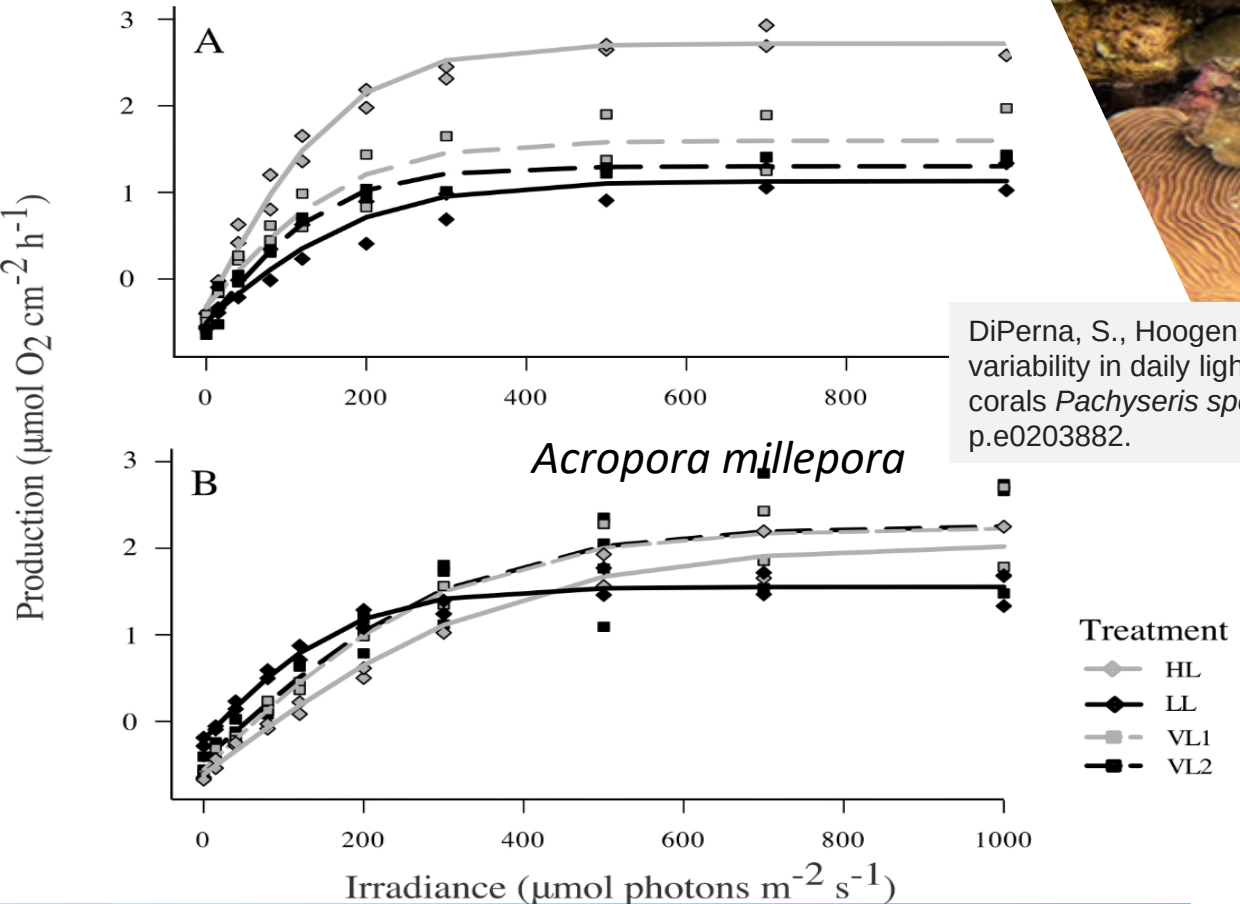
1. Determine light responses and thresholds for key coral and seagrass species
2. Develop a remote sensing algorithm to estimate bPAR across the whole GBR
3. Combine to produce a Water Quality Index

# Steps in developing a bPAR-based Water Quality Indicator

1. Determine light responses and thresholds for key coral and seagrass species



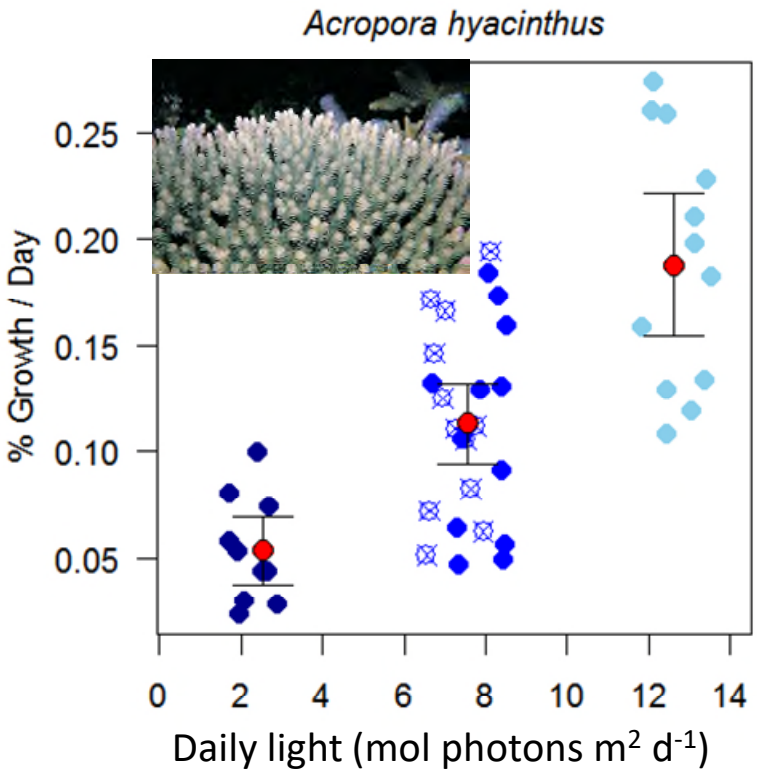
*Pachyseris speciosa*

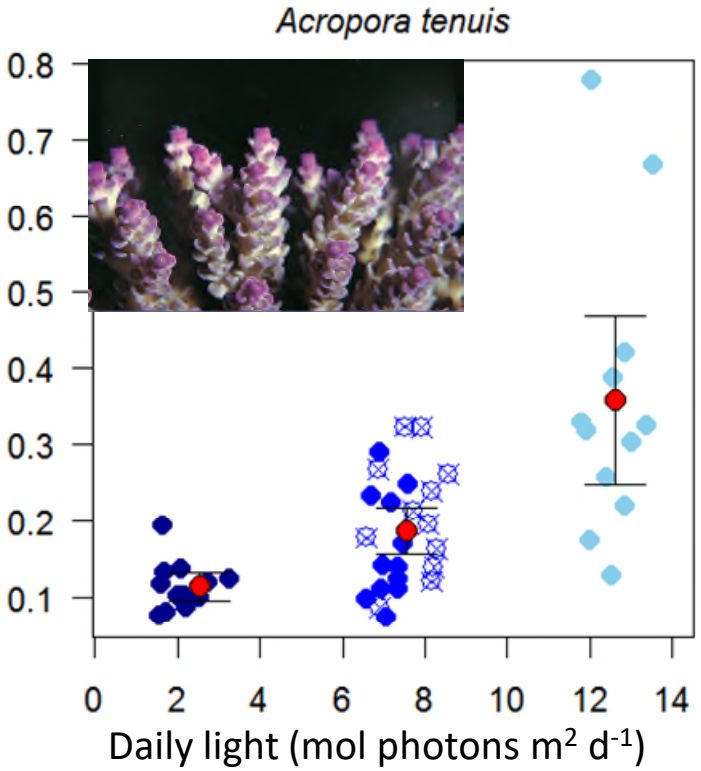



*Acropora millepora*



DiPerna, S., Hoogen, Noonan, S. and Fabricius, K., 2018. Effects of variability in daily light integrals boom, M., on the photophysiology of the corals *Pachyseris speciosa* and *Acropora millepora*. *PloS one*, *13*(9), p.e0203882.

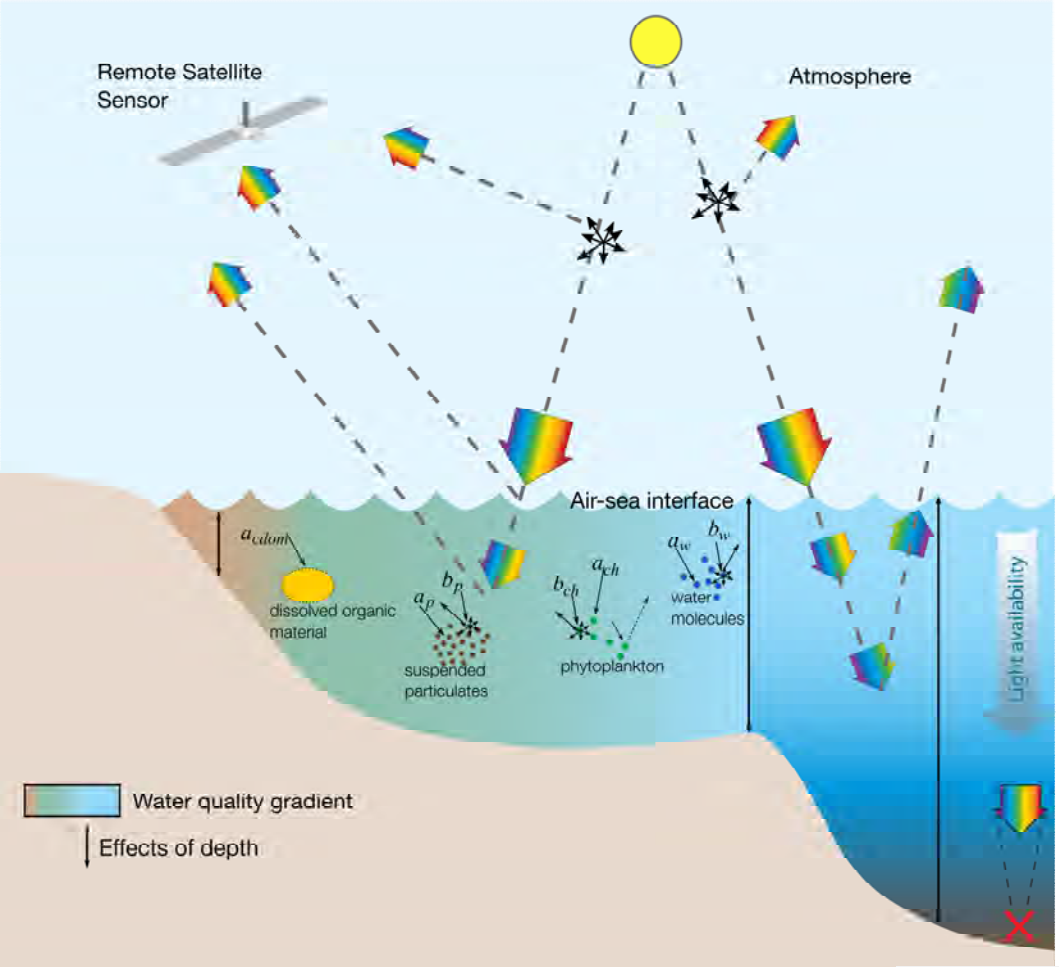


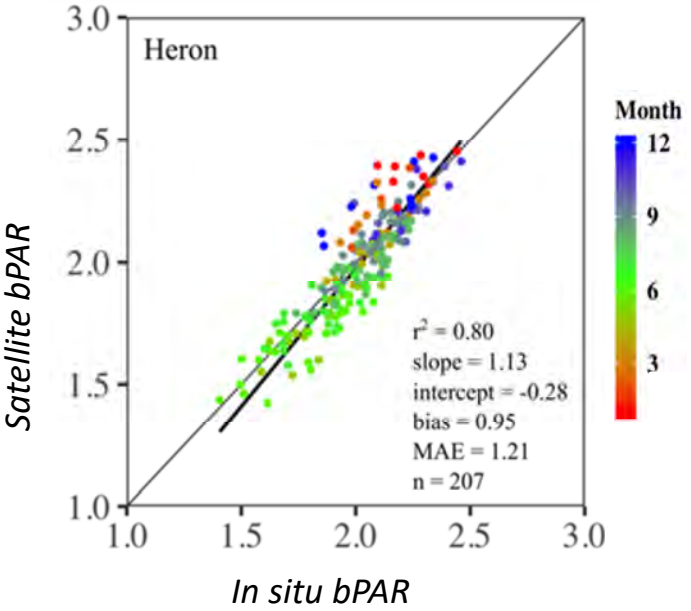




Noonan et al., Effects of light variability and elevated pCO2 on the adult and juvenile stages of two *Acropora* corals. Submitted.

# Steps in developing a bPAR-based Water Quality Indicator

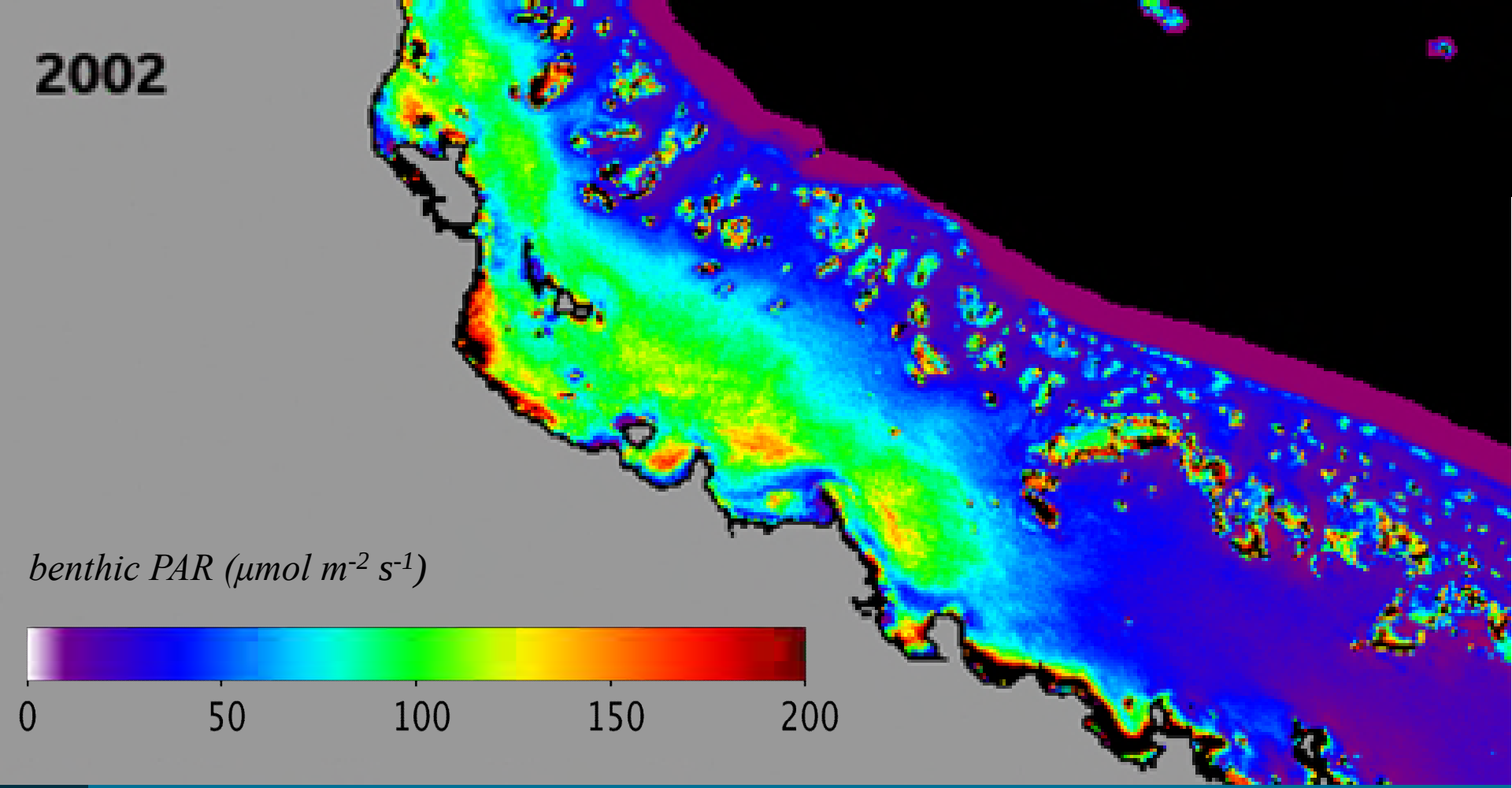
1. Determine light responses and thresholds for key coral and seagrass species
2. Develop a remote sensing algorithm to estimate bPAR across the whole GBR



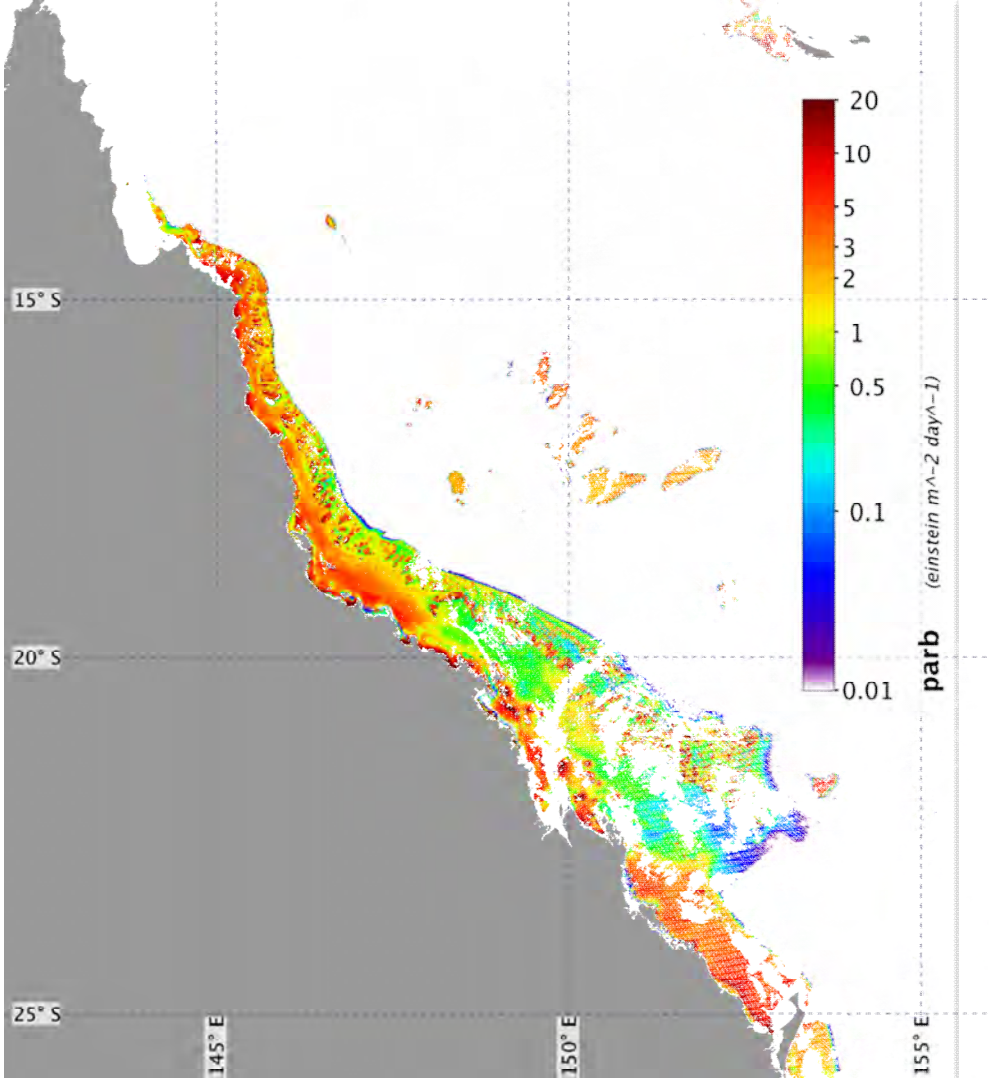



Magno-Canto, M.M., McKinna, L.I., Robson, B.J. and Fabricius, K.E., 2019. Model for deriving benthic irradiance in the Great Barrier Reef from MODIS satellite imagery. *Optics express*, *27*(20), pp.A1350-A1371.

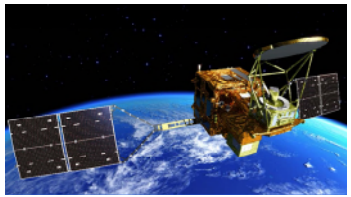

2002
benthic PAR (µmol m-2 s-1)
0
50
100
150
200

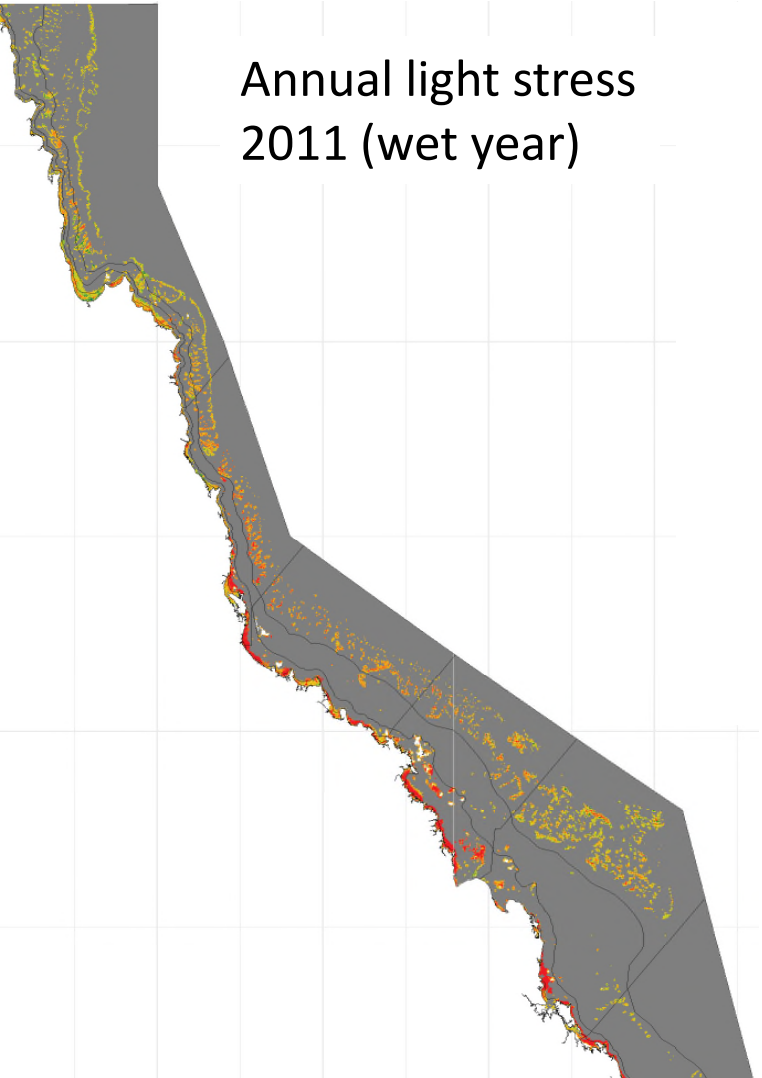
# Steps in developing a bPAR-based Water Quality Indicator

1. Determine light responses and thresholds for key coral and seagrass species
2. Develop a remote sensing algorithm to estimate bPAR across the whole GBR
3. Combine to produce a Water Quality Index




# Daily Integrated Benthic Light (bPAR)





Annual light stress
2011 (wet year)

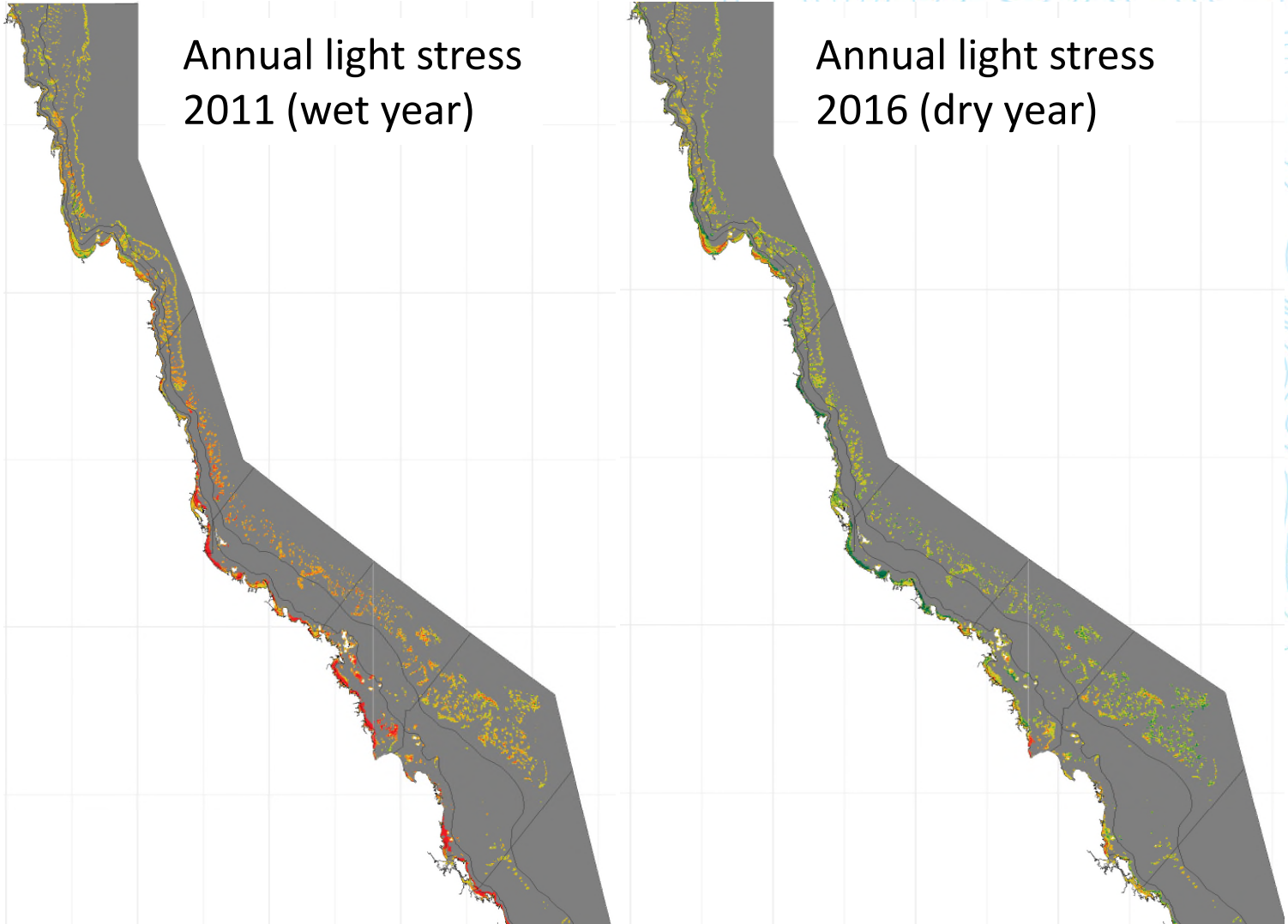
# Chronic light stress

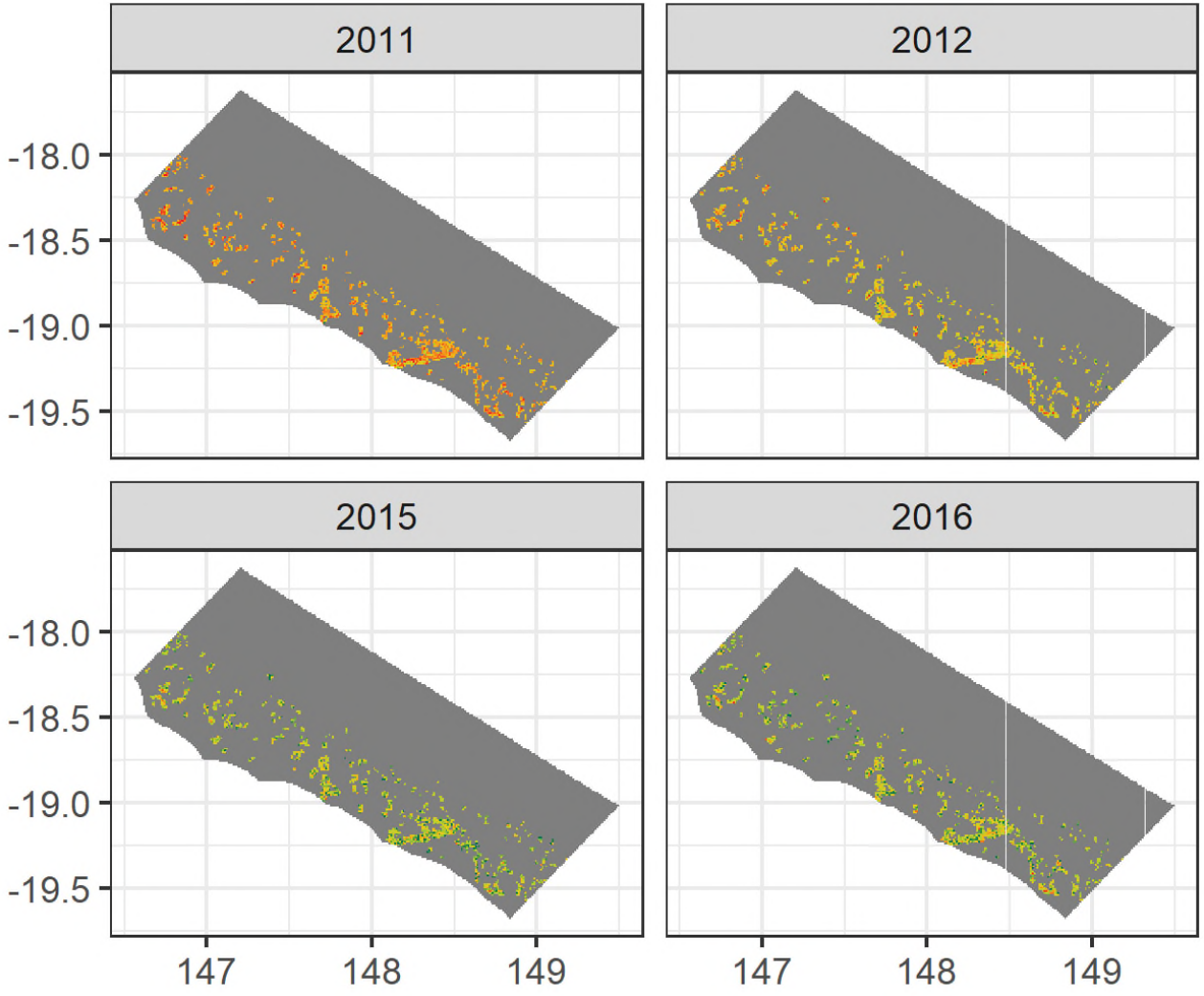
*On any given day, if daily light <14 mol photons $m^{-2}$, corals and seagrasses are not growing as fast as they possibly could.*

Daily light stress = 14 – daily light dose

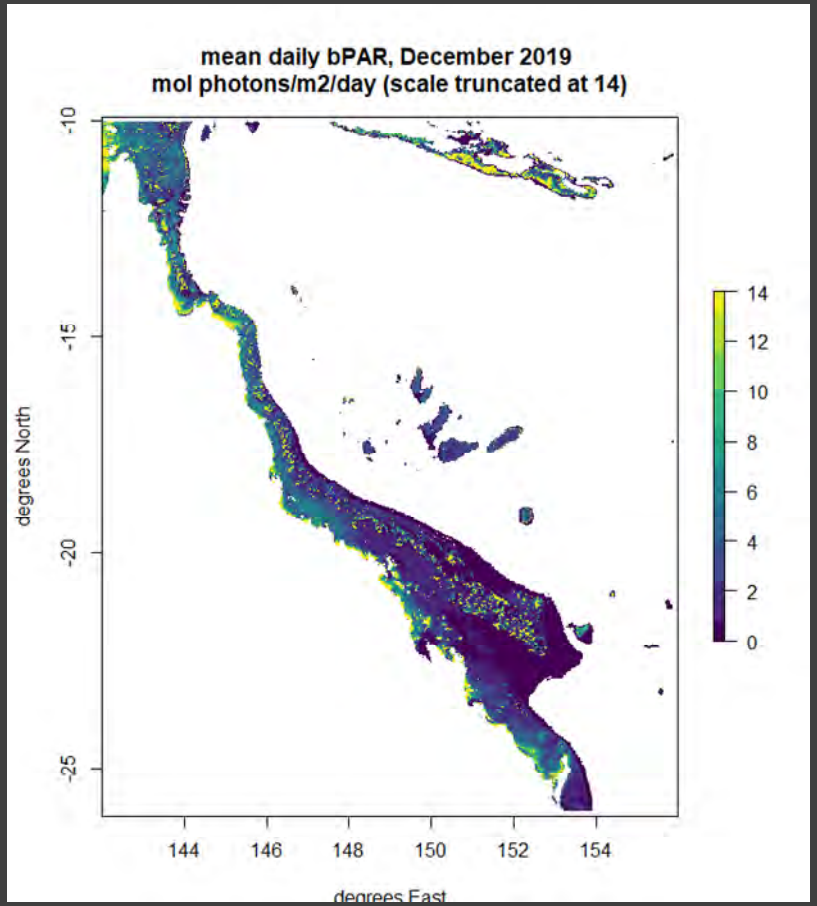
*Relative* daily light stress =
max(14, 95$^{th}$%-ile light) – daily light dose

Annual or seasonal light stress = ∑daily relative light stress


Annual light stress
2011 (wet year)
Annual light stress
2016 (dry year)

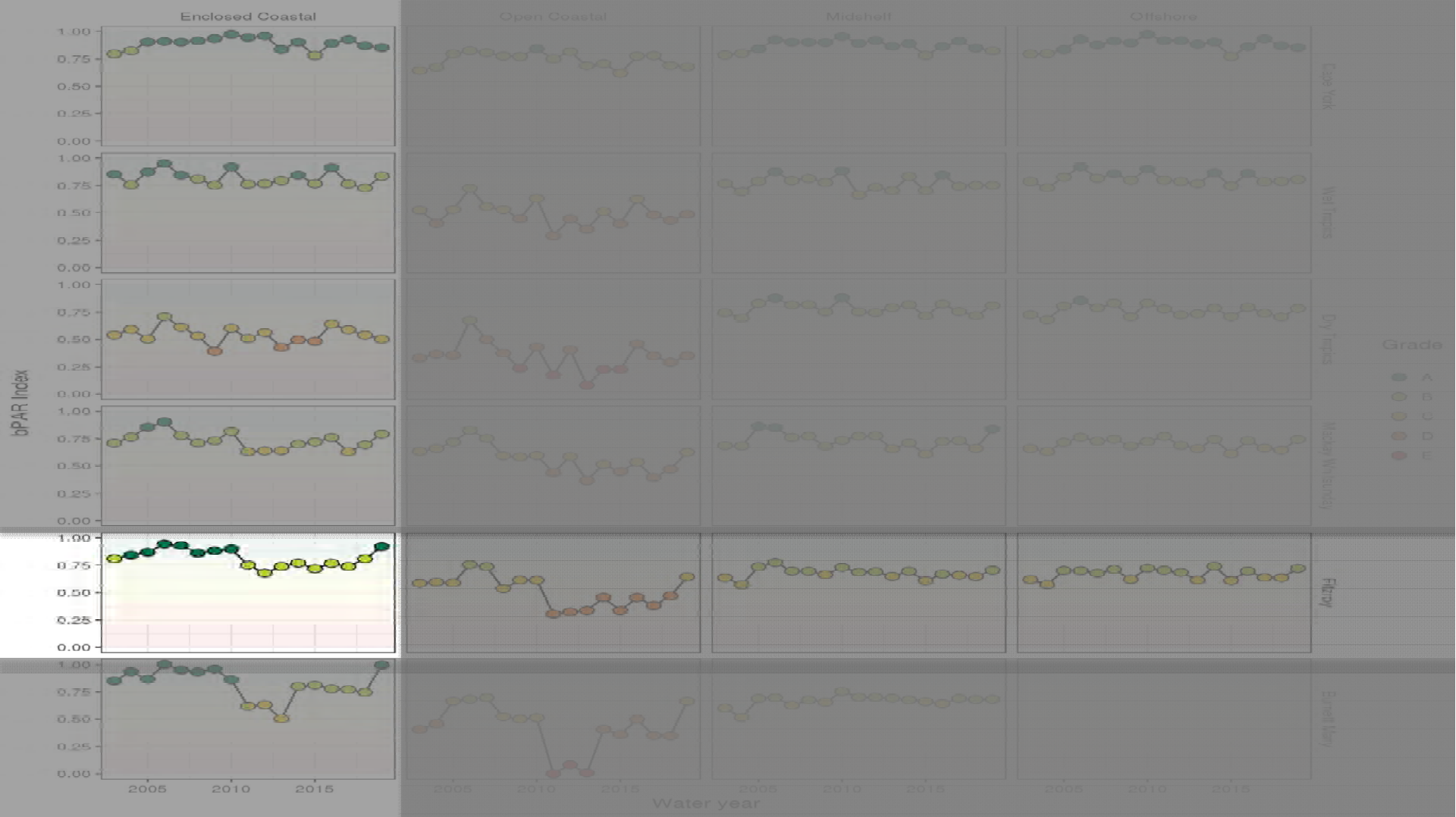


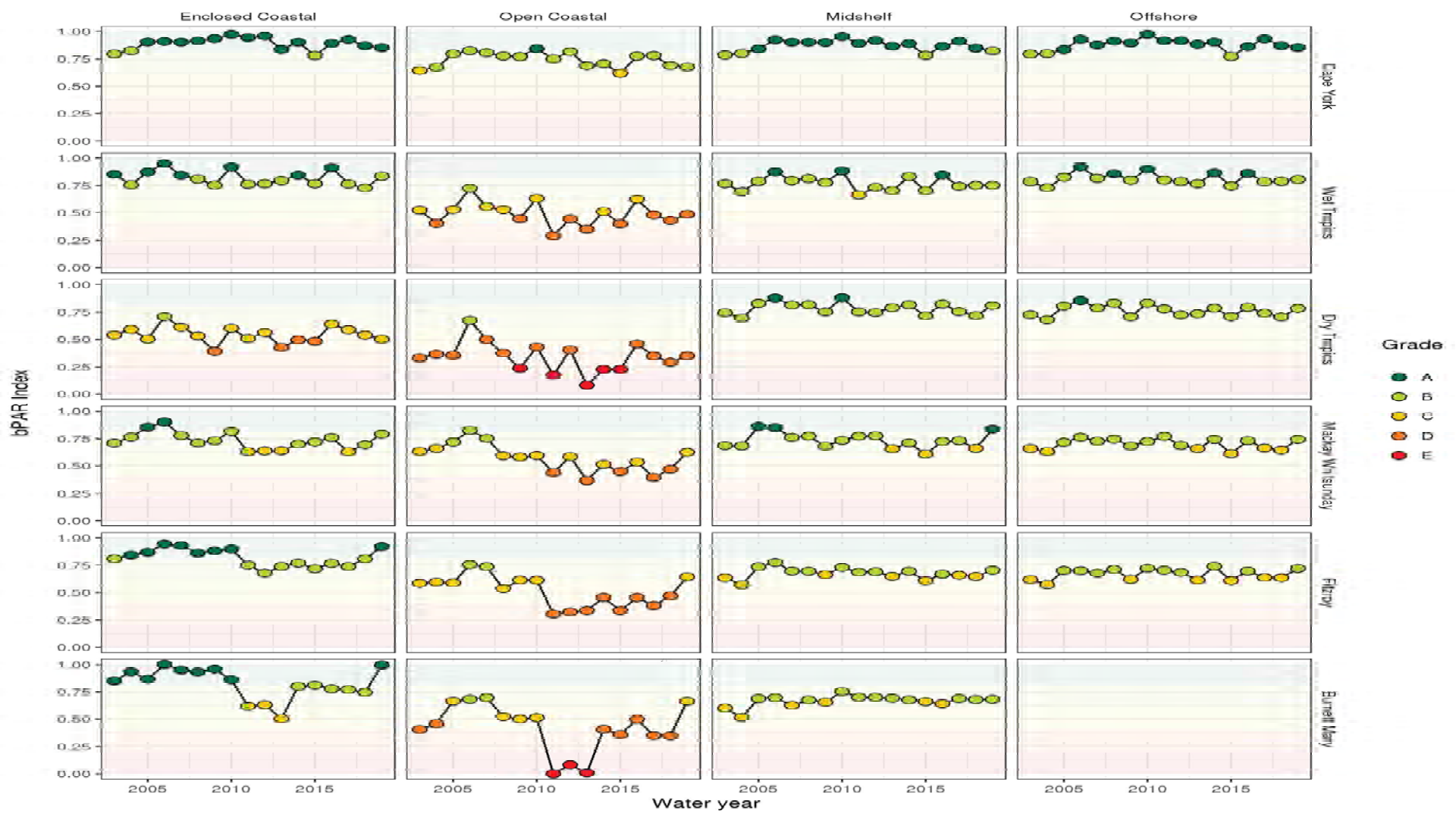

**Annual light stress**
**Offshore Dry Tropics**

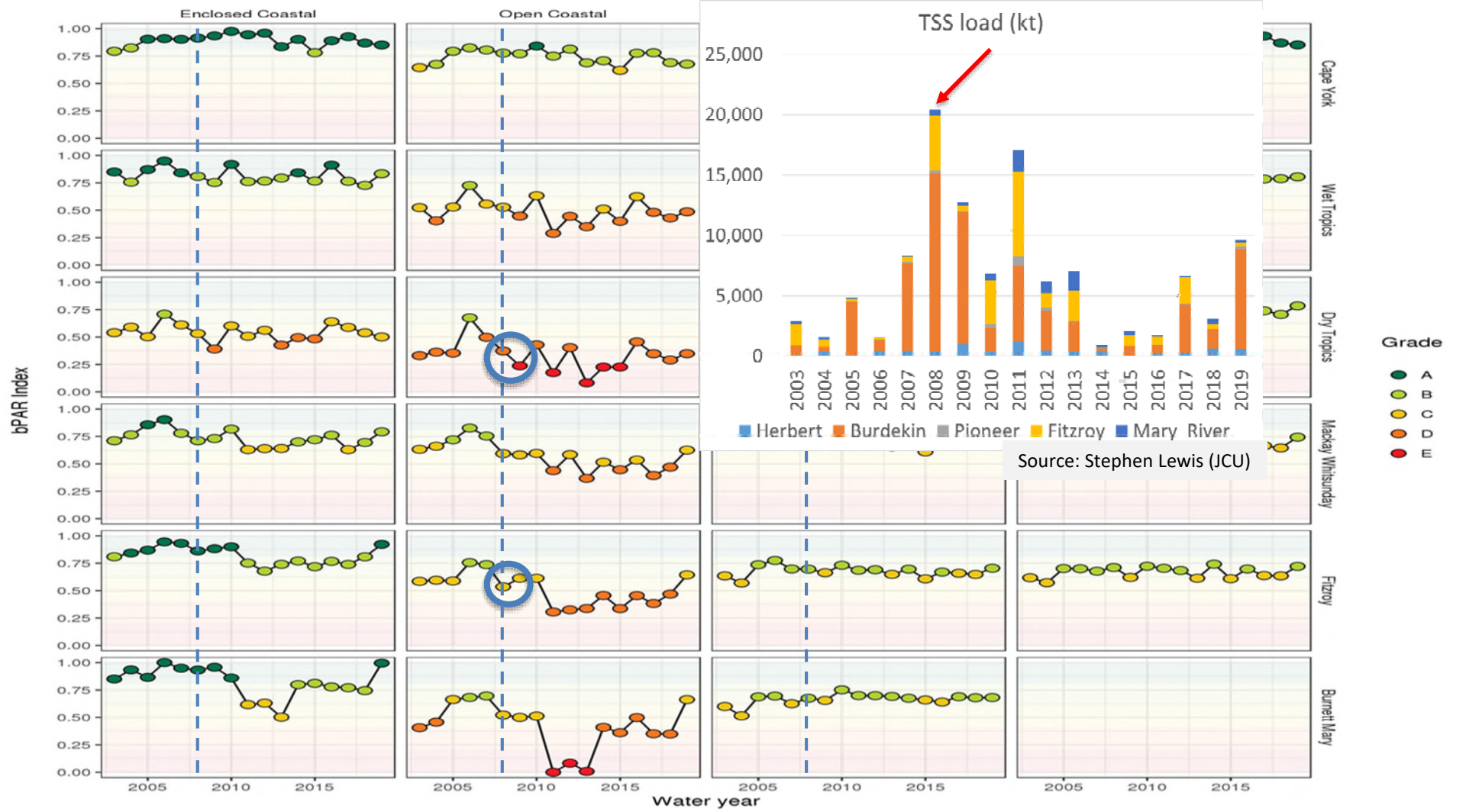


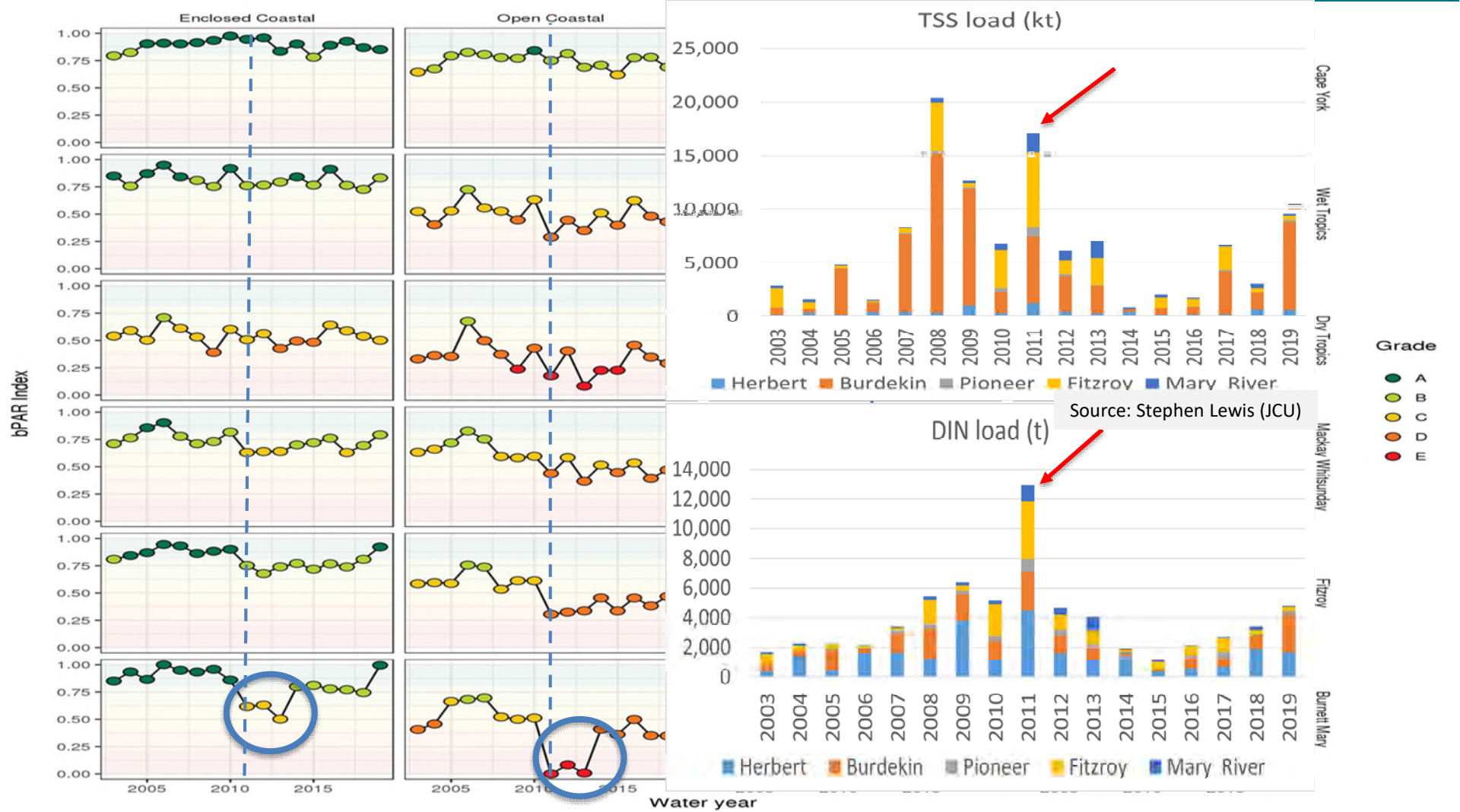

# Calculation of bPAR Water Quality Index

1. Calculate the total annual relative light stress for each pixel
2. Sum over each management region
3. Scale to provide a value between 0 (worst case) and 1 (no light stress)
4. Assign letter grades

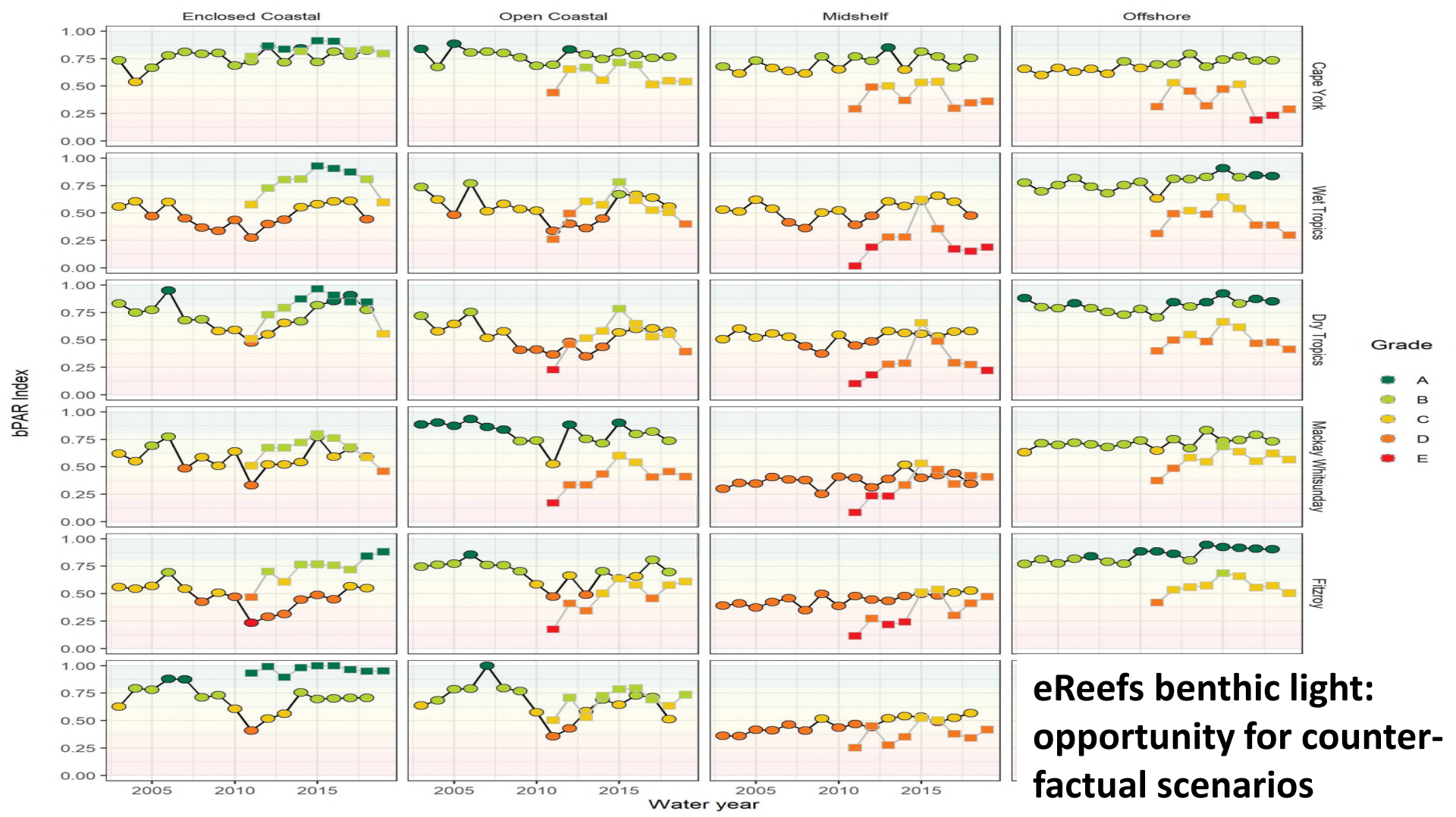

Enclosed Coastal
Open Coastal
Midshelf
Offshore
Cape York
Wet Tropics
Dry Tropics
Mackay Whitsunday
Fitzroy
Burnett Mary
bPAR Index
1.00
0.75
0.50
0.25
0.00
2005
2010
2015
Water year
Grade
A
B
C
D
E


Enclosed Coastal
Open Coastal
Midshelf
Offshore
Cape York
Wet Tropics
Dry Tropics
Mackay Whitsunday
Fitzroy
Burnett Mary
bPAR Index
1.00
0.75
0.50
0.25
0.00
2005
2010
2015
Water year
Grade
A
B
C
D
E


Enclosed Coastal
Open Coastal
bPAR Index
Water year
Cape York
Wet Tropics
Dry Tropics
Mackay Whitsunday
Fitzroy
Burnett Mary
Grade
A
B
C
D
E
TSS load (kt)
25,000
20,000
15,000
10,000
5,000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Herbert
Burdekin
Pioneer
Fitzroy
Mary River
Source: Stephen Lewis (JCU)




Source: Stephen Lewis (JCU)




**eReefs benthic light: opportunity for counter-factual scenarios**

# NEXT STEPS



- Benthic light data product is being made available via Digital Earth (Geoscience Australia) and eAtlas
- We’d like to incorporate this WQI into Reef Report Cards

# THANK YOU

*Contributors*

Katharina Fabricius (project proponent, 2.3.1)

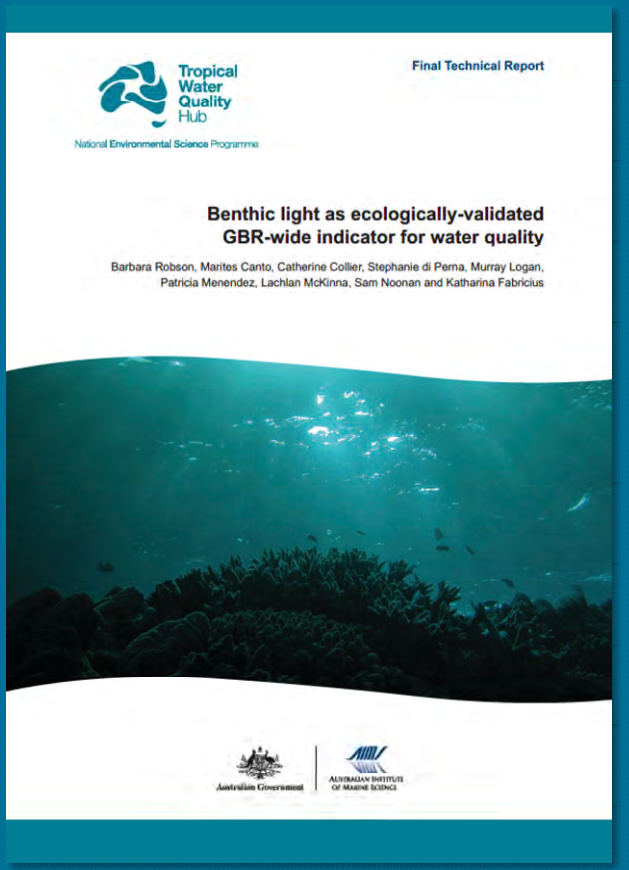
Barbara Robson (project leader)

Marites Canto & Lachlan McKinna (remote sensing)

Stephanie di Perna & Sam Noonan (coral experiments)

Catherine Collier (seagrass thresholds)

Murray Logan (report cards)




AIMS: Australia's tropical marine research agency.

Australian Government

National Environmental Science Programme

For more information please contact:
Barbara Robson
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07 4753 4324

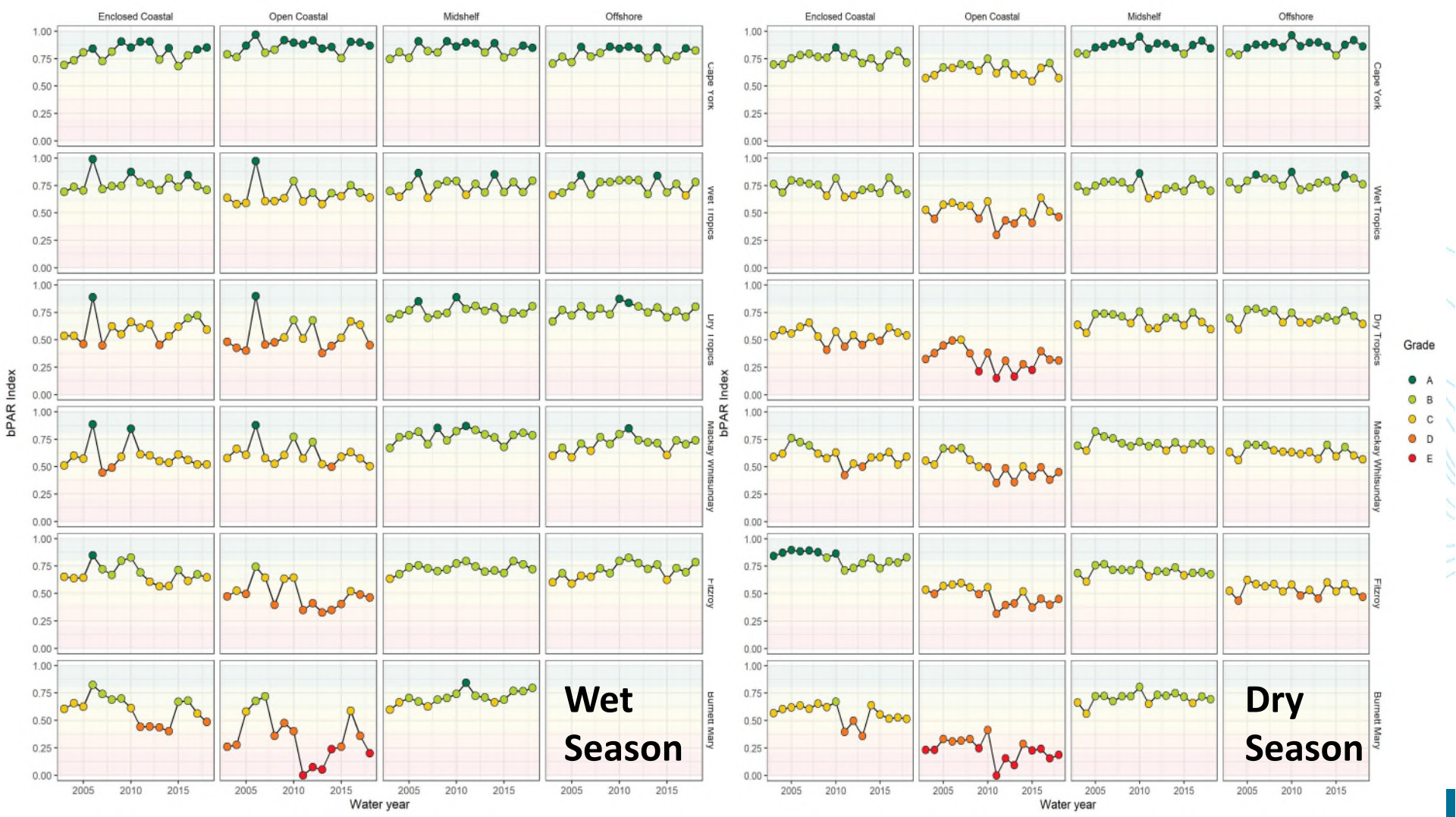
JAMES COOK UNIVERSITY AUSTRALIA
Celebrating 50 YEARS 1970 - 2020

Reef & Rainforest RESEARCH CENTRE

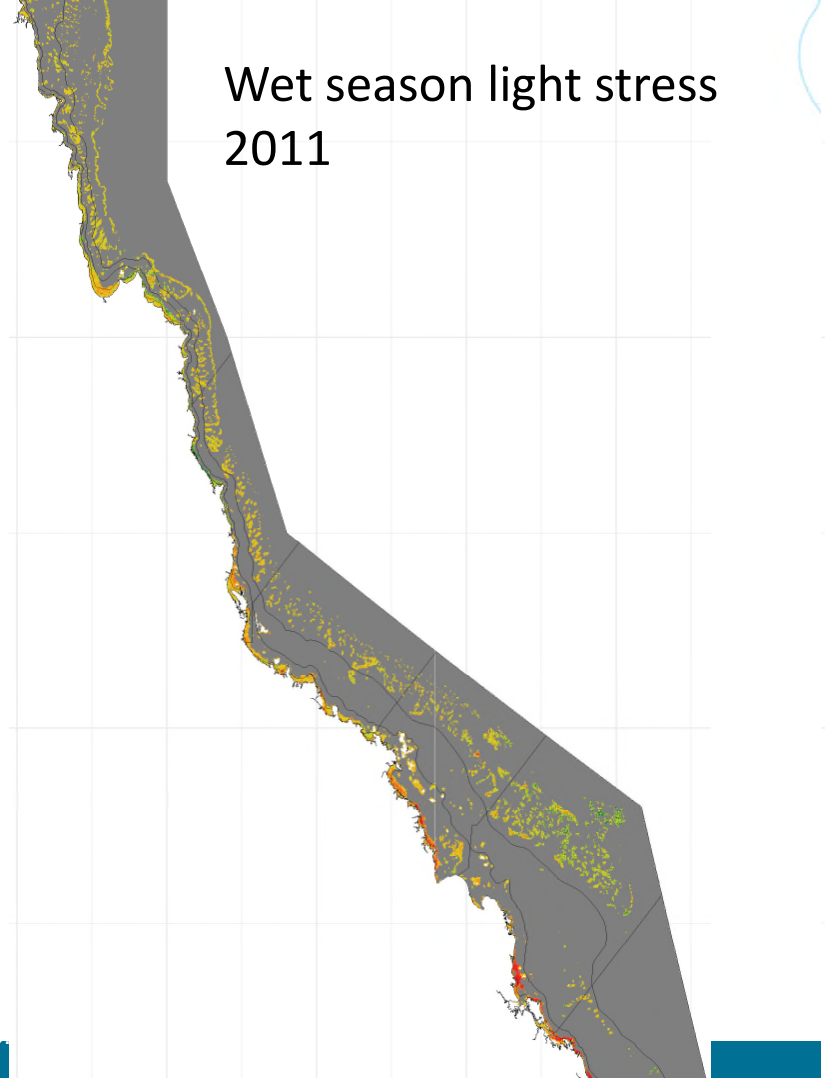
Australian Government
AUSTRALIAN INSTITUTE OF MARINE SCIENCE

# (Additional slides for discussion)

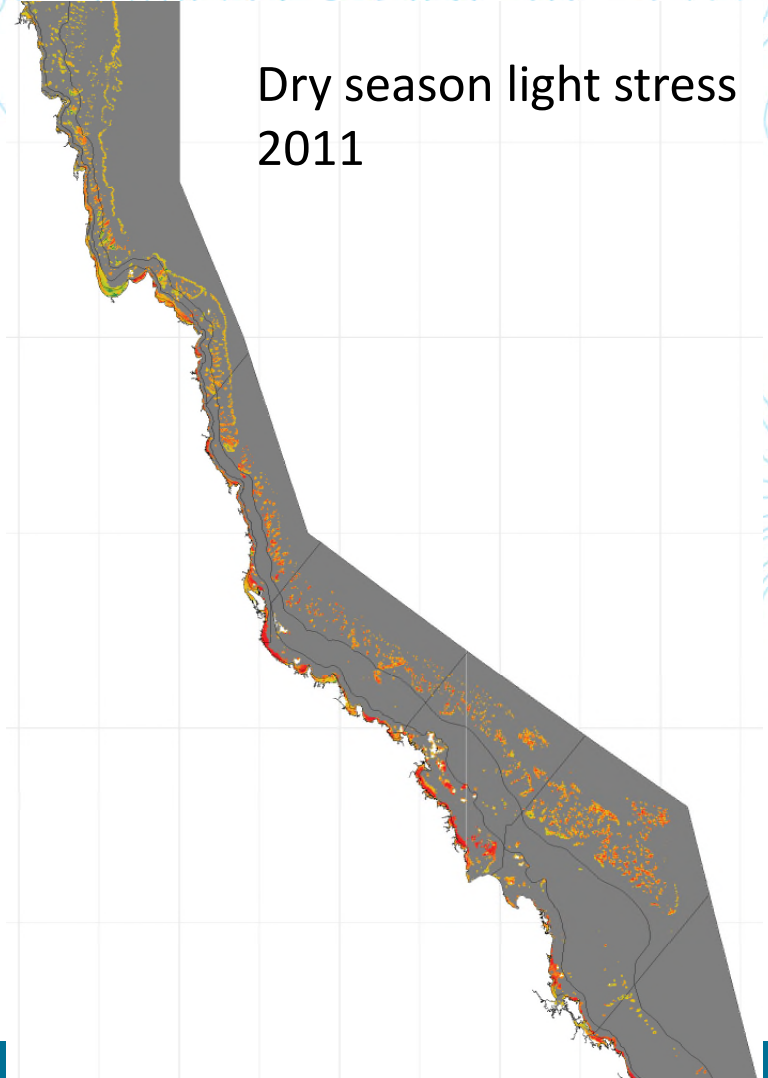
# Seasonal WQI


Enclosed Coastal
Open Coastal
Midshelf
Offshore
Cape York
Wet Tropics
Dry Tropics
Mackay Whitsunday
Fitzroy
Burnett Mary
bPAR Index
Water year
Grade
A
B
C
D
E
Wet Season
Dry Season

Wet season light stress 2011



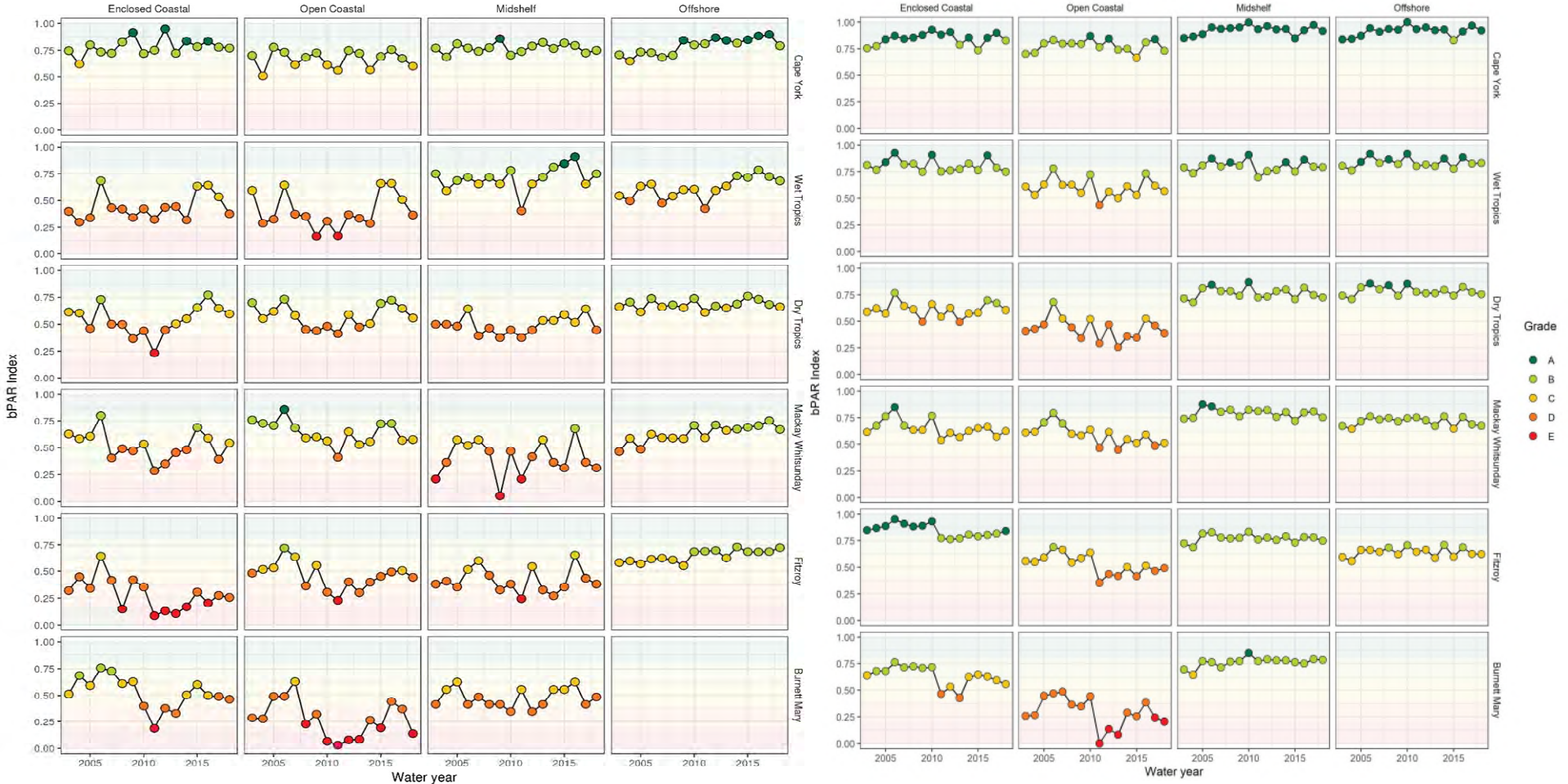
Dry season light stress 2011

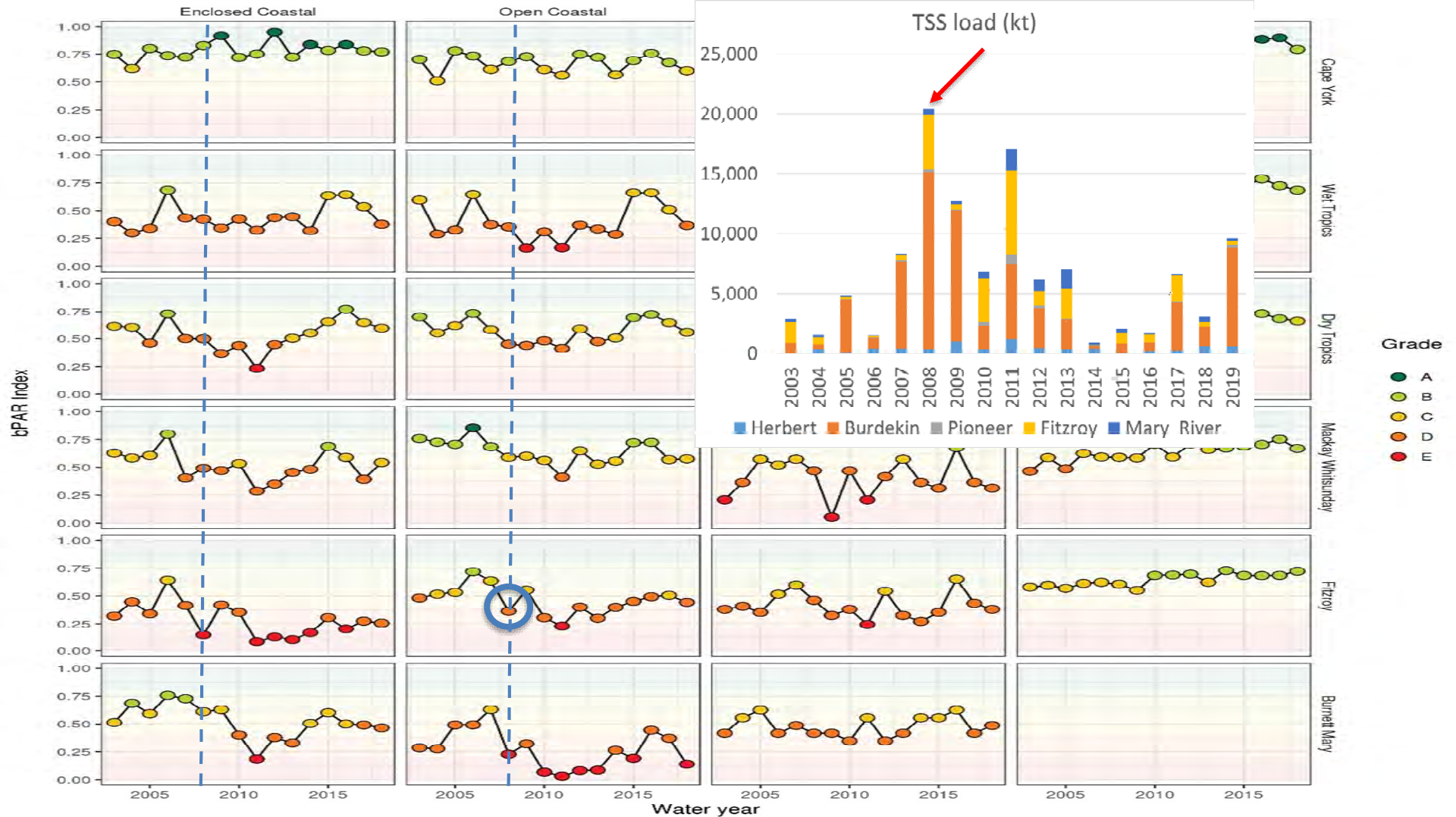


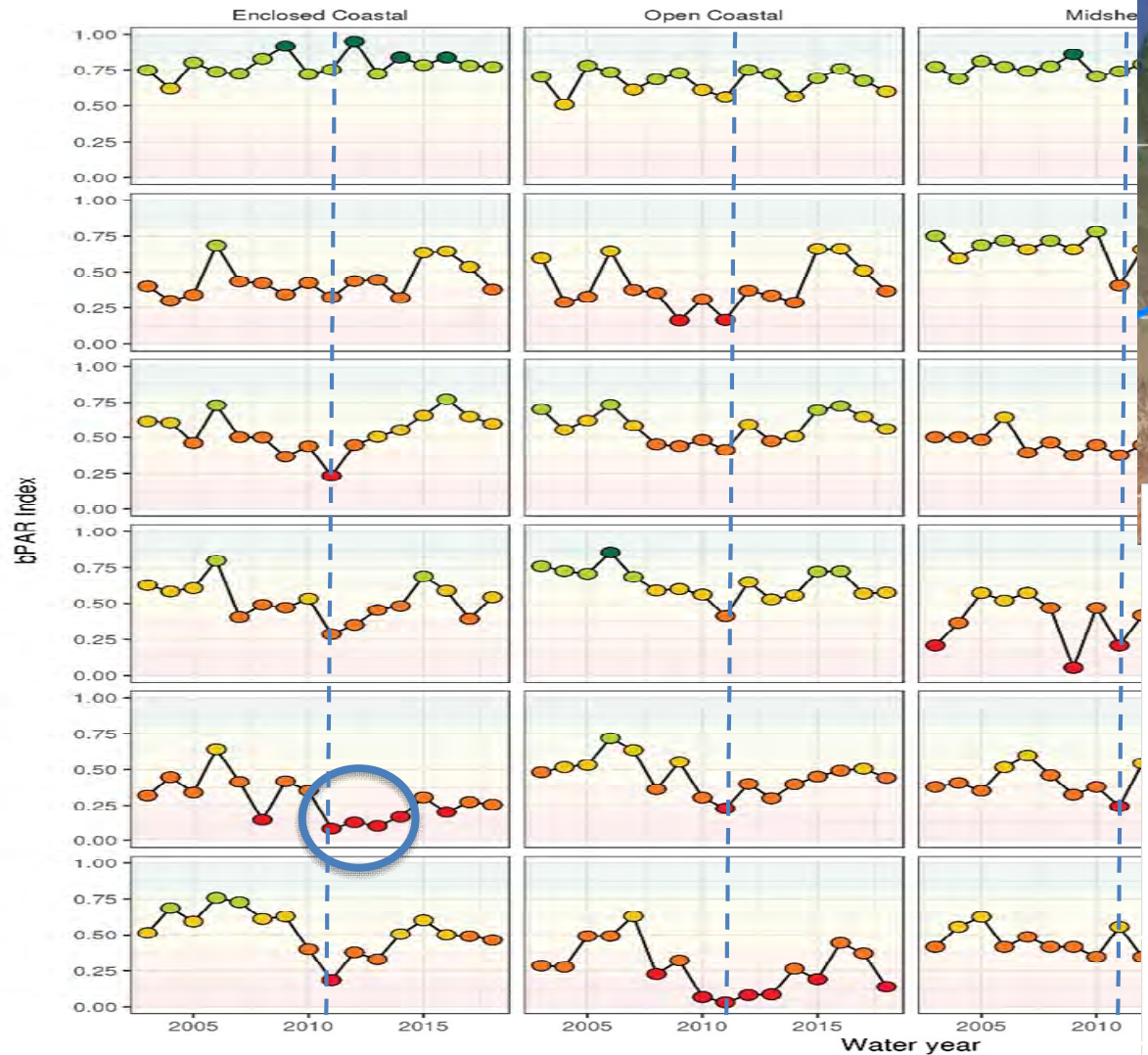
# Original WQI

Original WQI (variation in area of good benthic light)

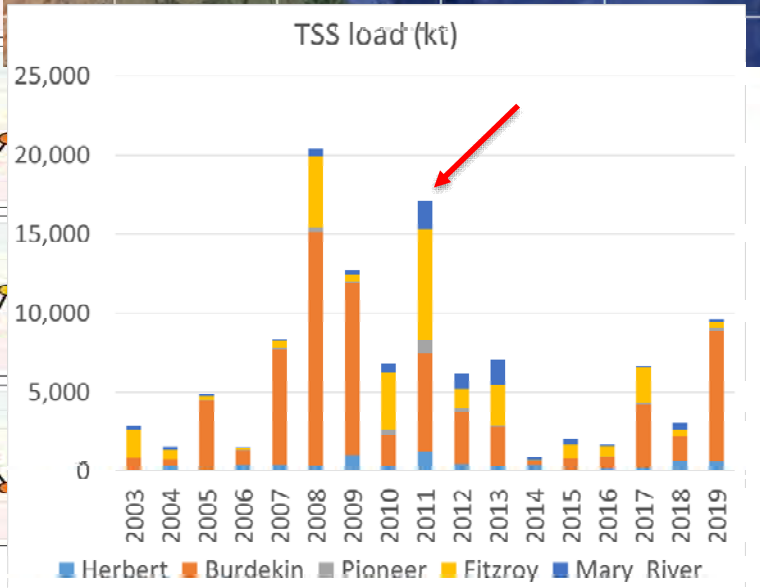
New WQI (total light stress for unmasked areas in each region cf 95th percentile)

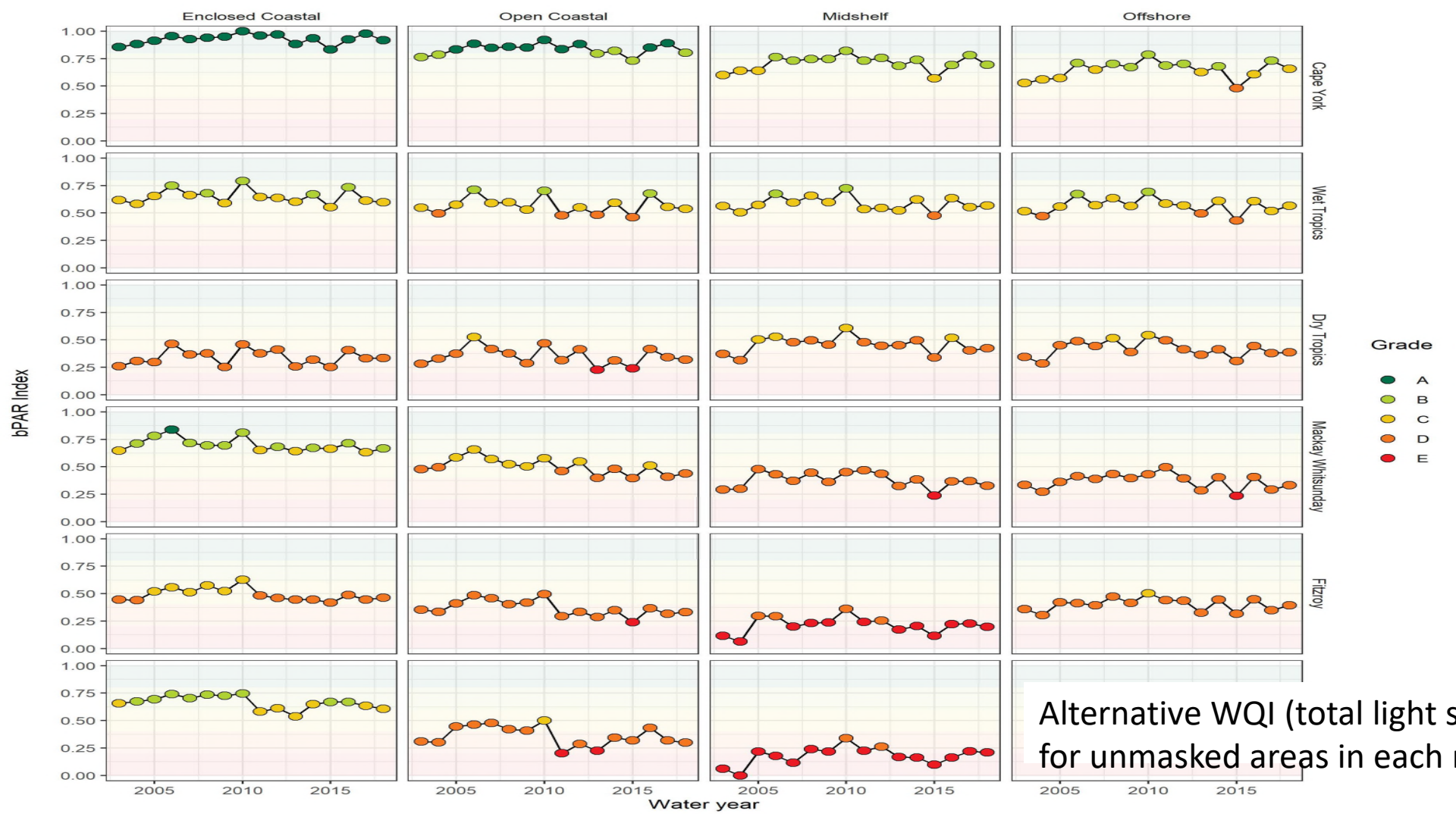



Enclosed Coastal
Open Coastal
bPAR Index
Water year
Cape York
Wet Tropics
Dry Tropics
Mackay Whitsunday
Fitzroy
Burnett Mary
TSS load (kt)
Herbert
Burdekin
Pioneer
Fitzroy
Mary River
Grade
A
B
C
D
E


Enclosed Coastal
Open Coastal
Midshe
bPAR Index
1.00
0.75
0.50
0.25
0.00
2005
2010
2015
Water year

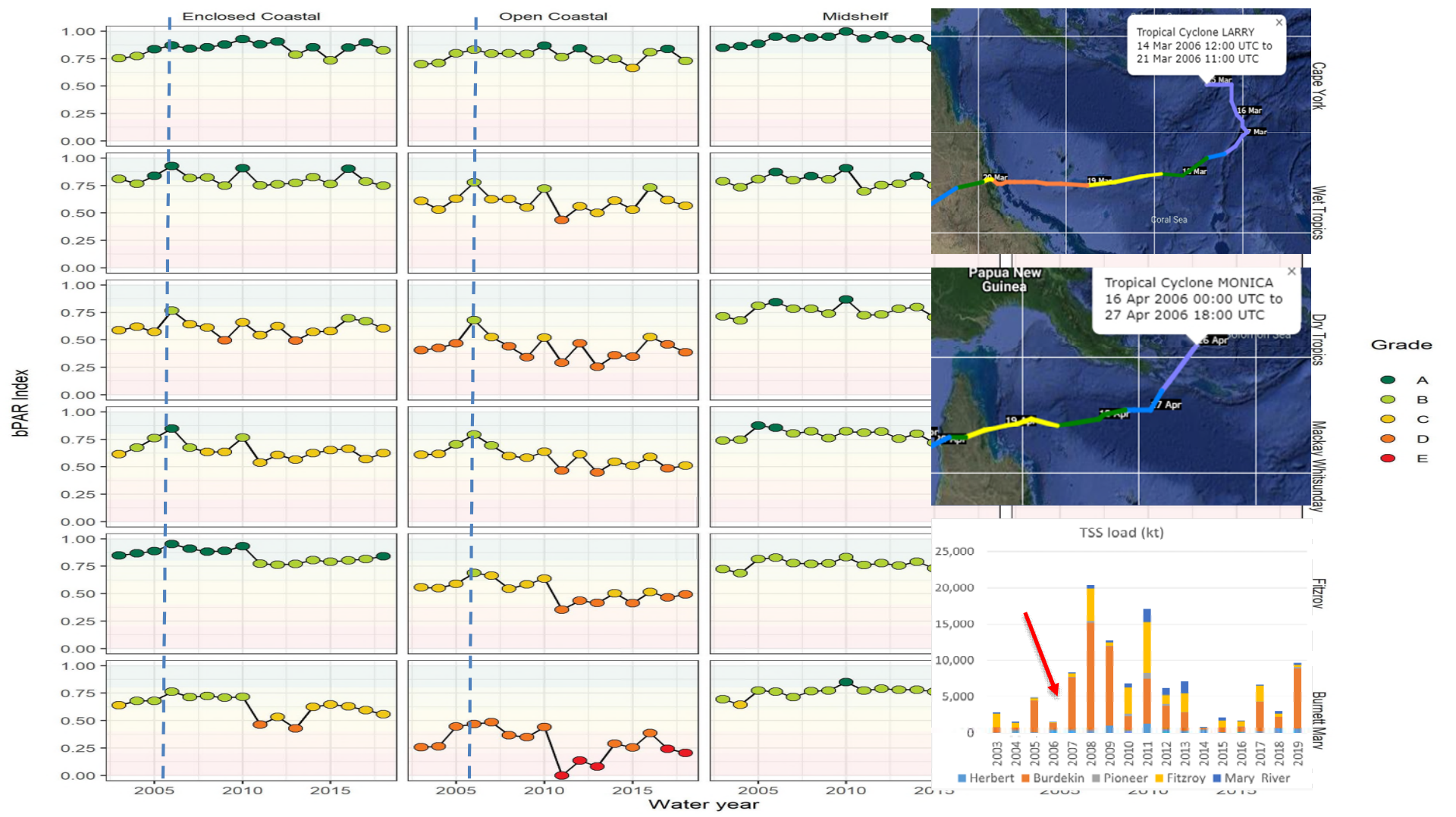

Tropical Cyclone YASI
31 Jan 2011 12:00 UTC to
03 Feb 2011 12:00 UTC
Coral Sea
QUEENSLAND

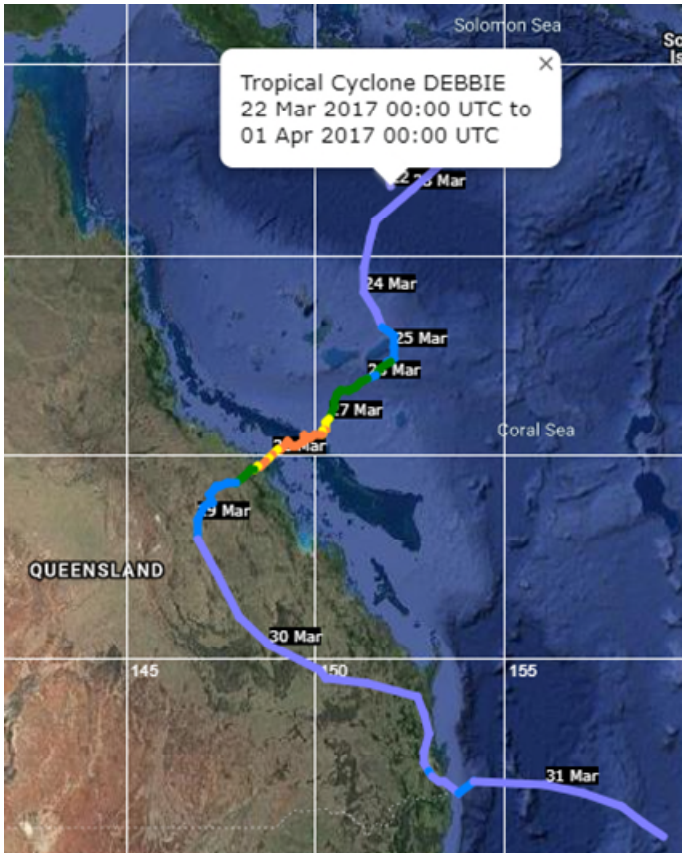

TSS load (kt)
25,000
20,000
15,000
10,000
5,000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Herbert
Burdekin
Pioneer
Fitzroy
Mary River

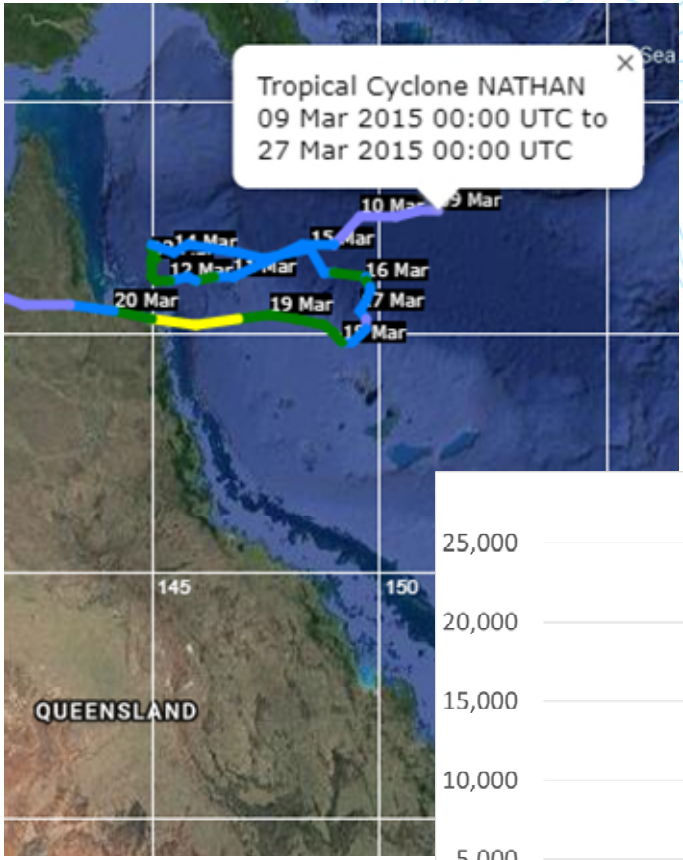


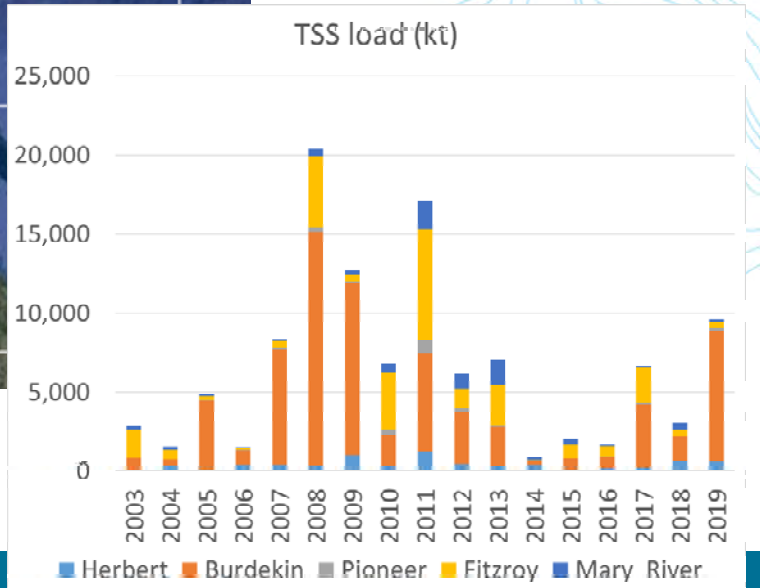

Alternative WQI (total light s
for unmasked areas in each

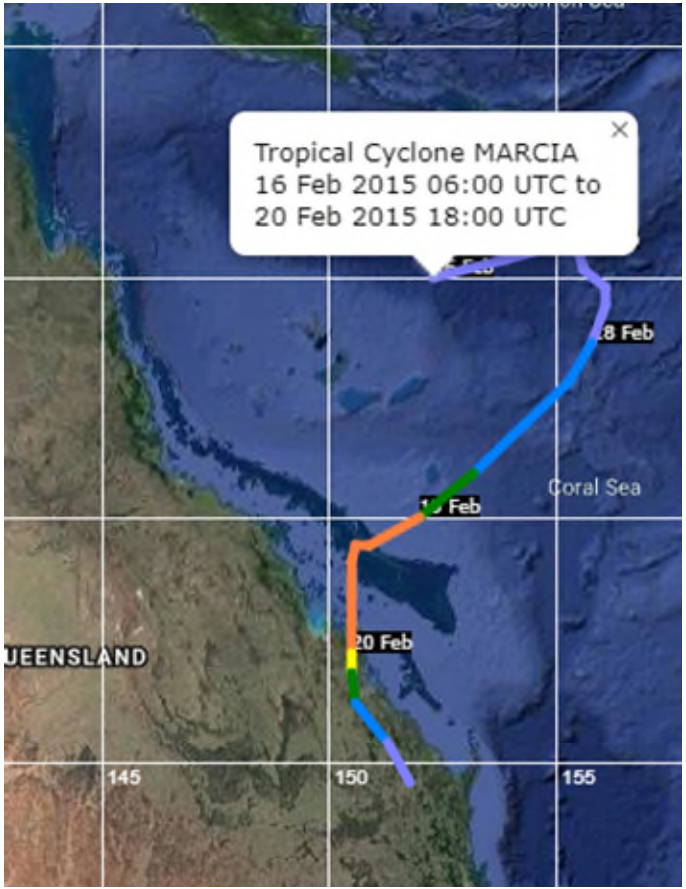
# Past storms

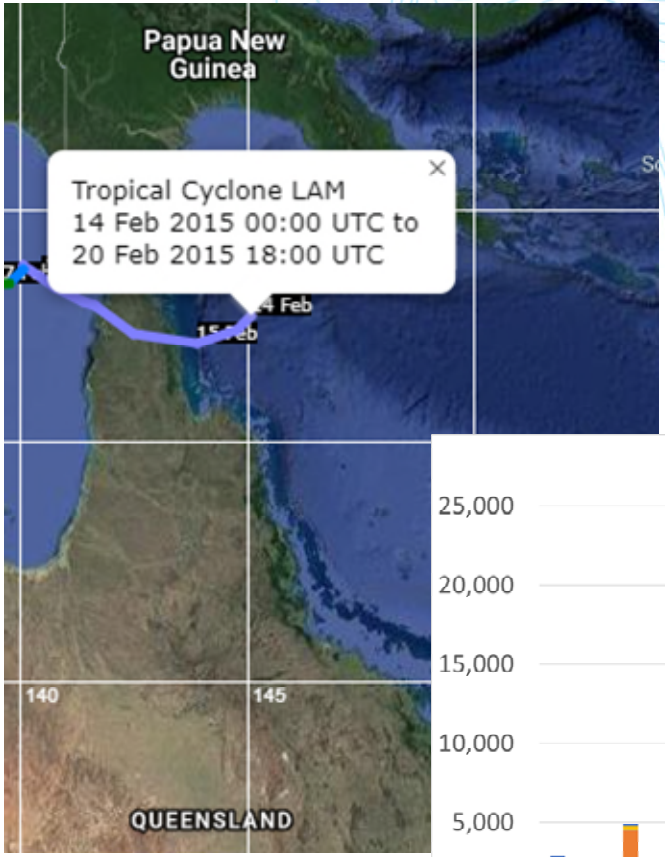

Enclosed Coastal
Open Coastal
Midshelf
bPAR Index
1.00
0.75
0.50
0.25
0.00
2005
2010
2015
Water year
Tropical Cyclone LARRY
14 Mar 2006 12:00 UTC to
21 Mar 2006 11:00 UTC
Coral Sea
Cape York
Wet Tropics
Papua New Guinea
Tropical Cyclone MONICA
16 Apr 2006 00:00 UTC to
27 Apr 2006 18:00 UTC
Dry Tropics
Mackay Whitsunday
TSS load (kt)
25,000
20,000
15,000
10,000
5,000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Herbert
Burdekin
Pioneer
Fitzroy
Mary River
Fitzroy
Burnett Mary
Grade
A
B
C
D
E

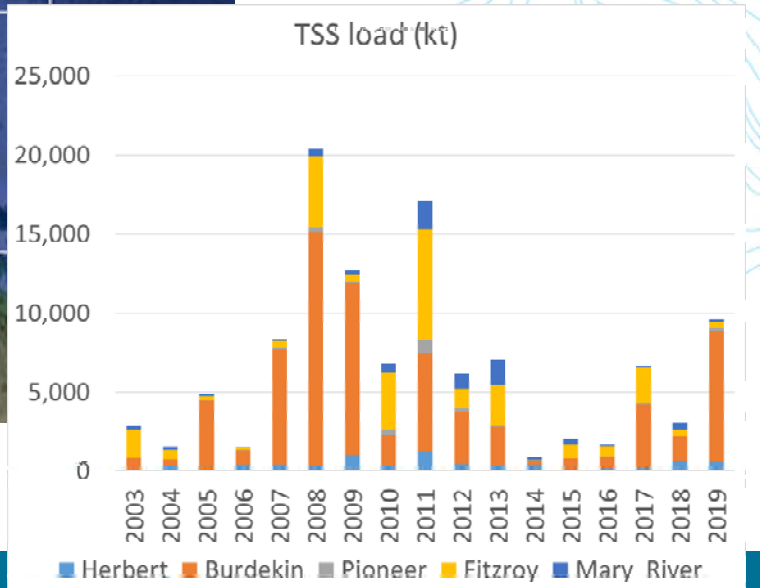

Solomon Sea
Tropical Cyclone DEBBIE
22 Mar 2017 00:00 UTC to
01 Apr 2017 00:00 UTC
24 Mar
25 Mar
Coral Sea
QUEENSLAND
30 Mar
31 Mar
145
150
155

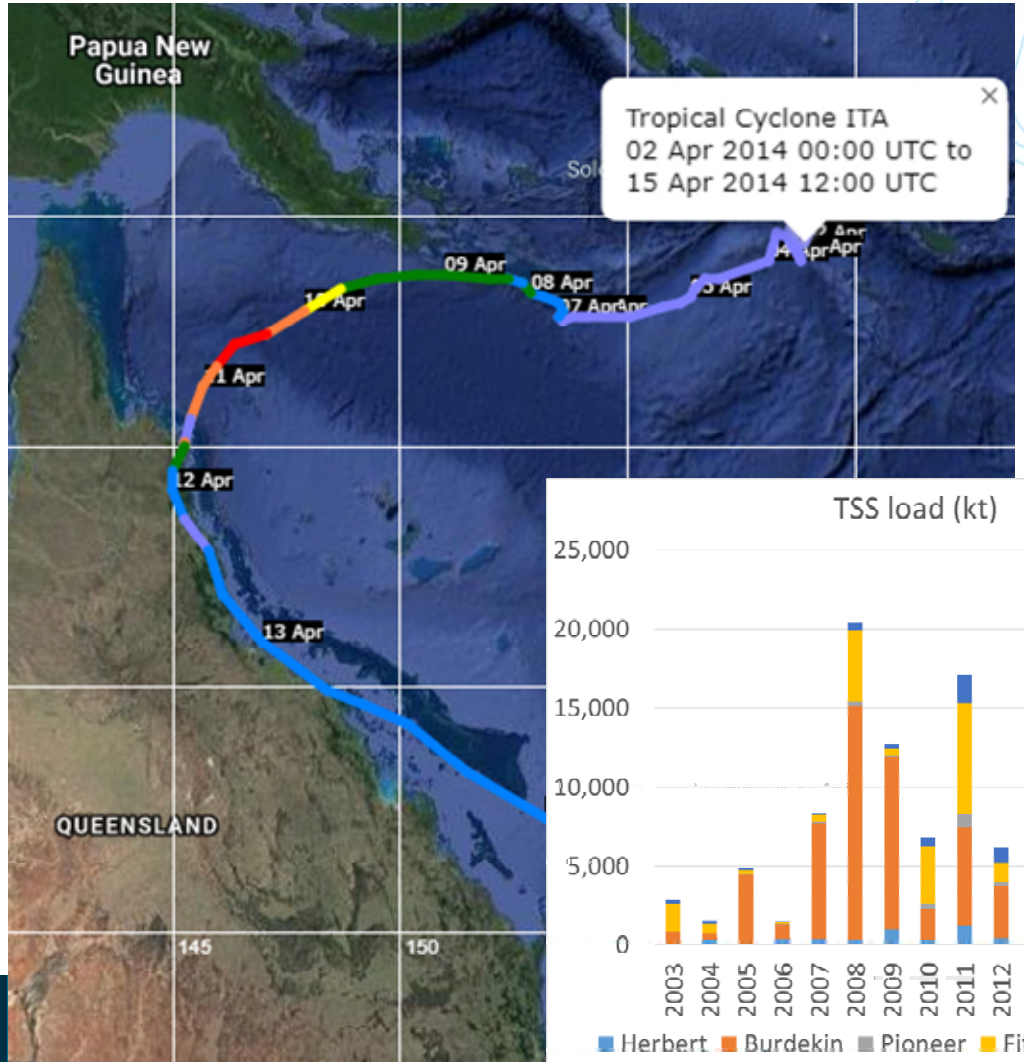

Tropical Cyclone NATHAN
09 Mar 2015 00:00 UTC to
27 Mar 2015 00:00 UTC
16 Mar
20 Mar
19 Mar
QUEENSLAND
145
150

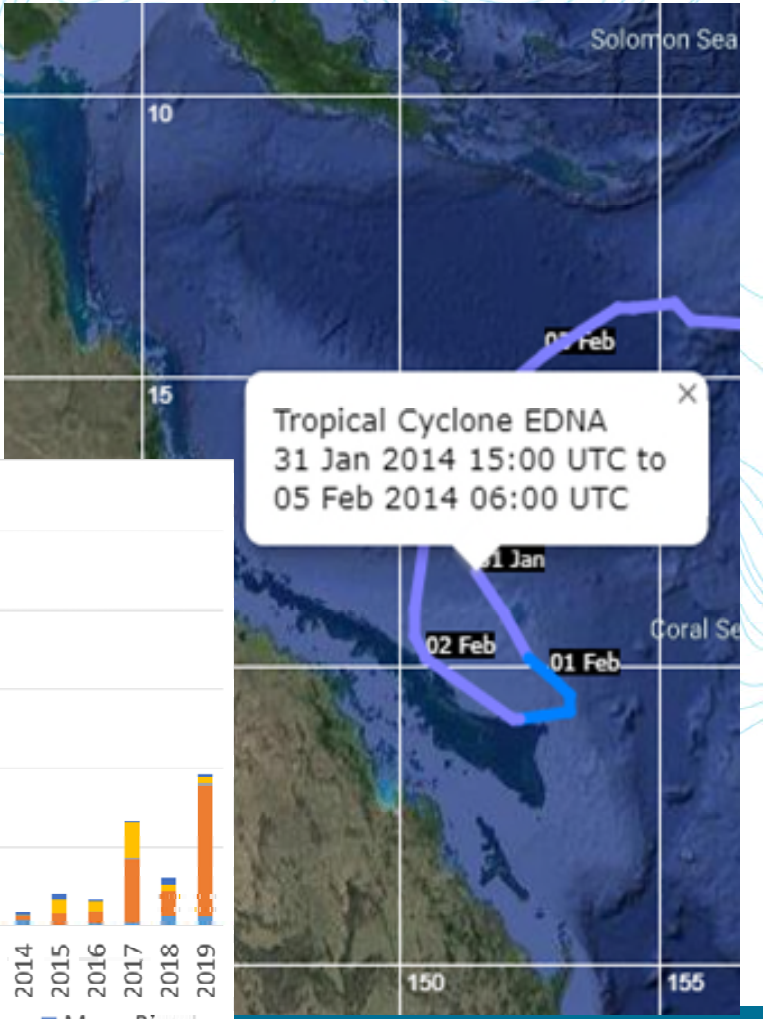

TSS load (kt)
25,000
20,000
15,000
10,000
5,000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Herbert
Burdekin
Pioneer
Fitzroy
Mary River


Tropical Cyclone MARCIA
16 Feb 2015 06:00 UTC to
20 Feb 2015 18:00 UTC
Coral Sea
20 Feb
145
150
155


Papua New Guinea
Tropical Cyclone LAM
14 Feb 2015 00:00 UTC to
20 Feb 2015 18:00 UTC
140
145
QUEENSLAND

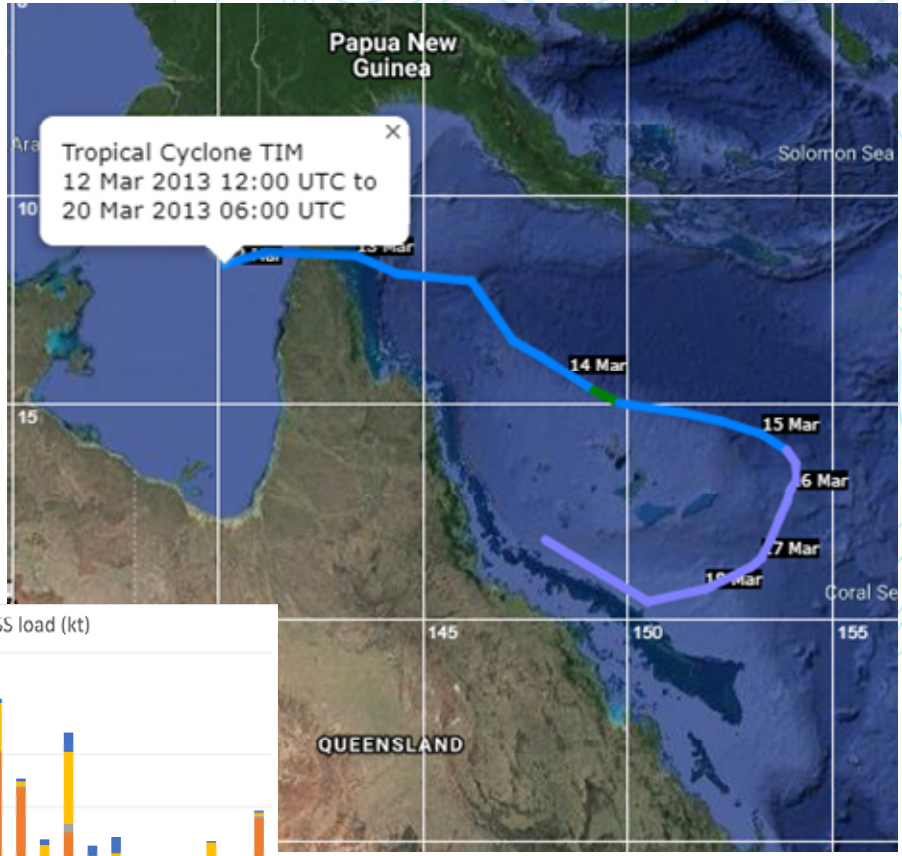

TSS load (kt)
25,000
20,000
15,000
10,000
5,000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Herbert
Burdekin
Pioneer
Fitzroy
Mary River

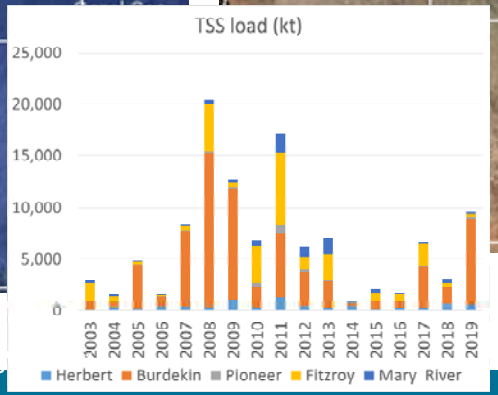

Papua New Guinea
Tropical Cyclone ITA
02 Apr 2014 00:00 UTC to
15 Apr 2014 12:00 UTC
09 Apr
08 Apr
13 Apr
QUEENSLAND
145
150


Solomon Sea
10
15
Tropical Cyclone EDNA
31 Jan 2014 15:00 UTC to
05 Feb 2014 06:00 UTC
02 Feb
01 Feb
Coral Se
150
155


TSS load (kt)
25,000
20,000
15,000
10,000
5,000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Herbert
Burdekin
Pioneer
Fitzroy
Mary River

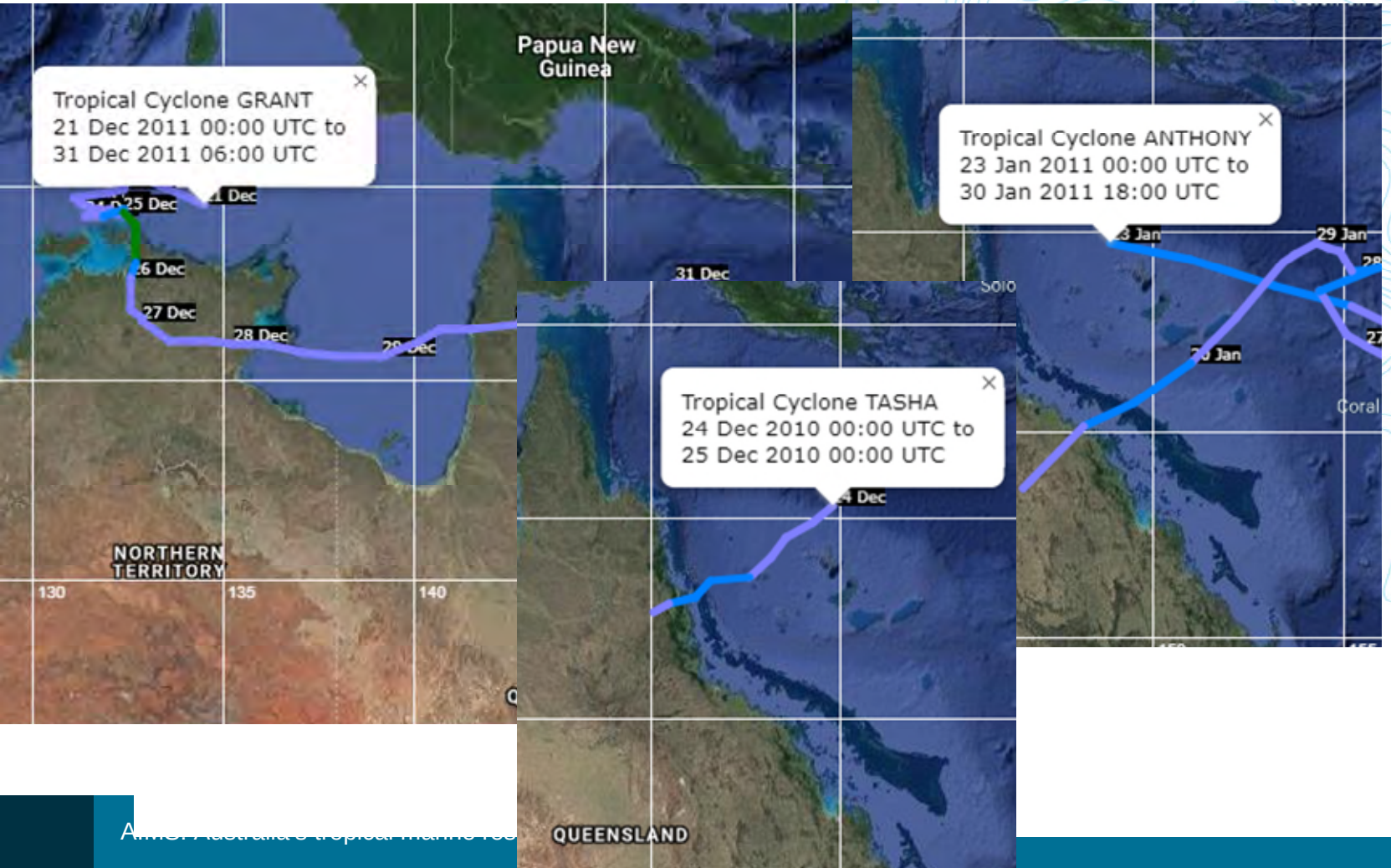

Papua New Guinea
Tropical Cyclone ZANE
28 Apr 2013 12:00 UTC t
02 May 2013 00:00 UTC
01 May
145
150
QUEENSLAND

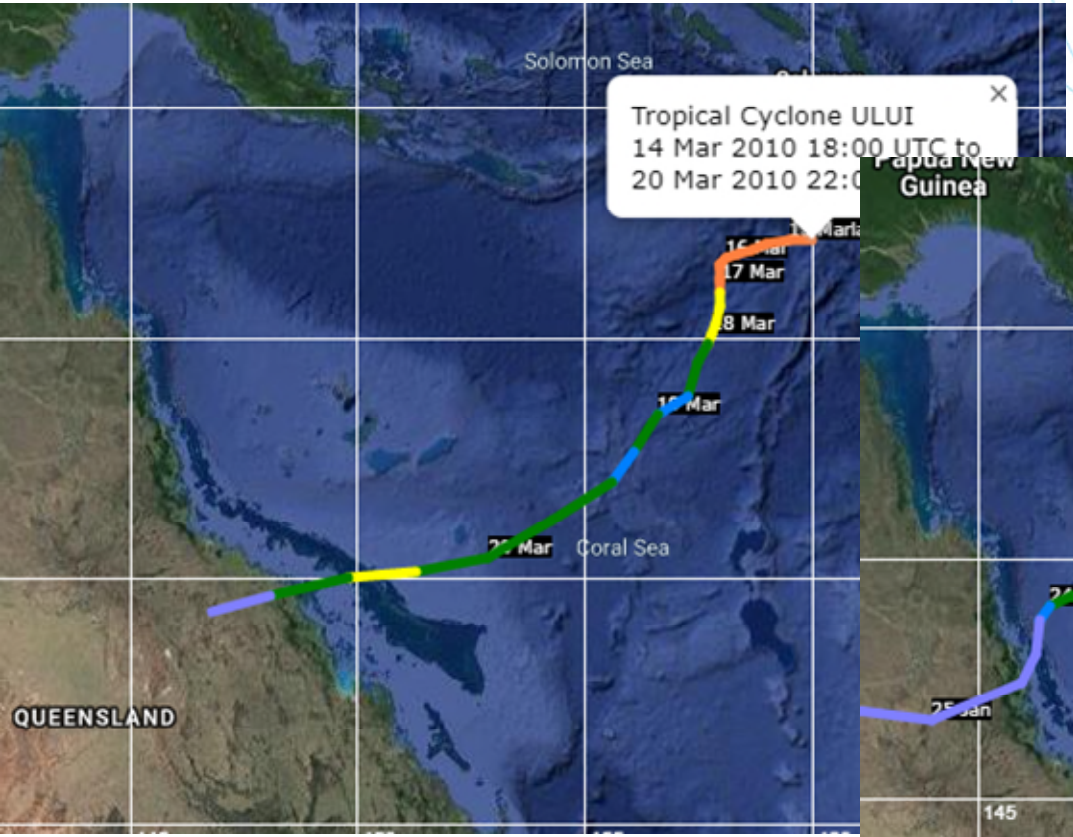

Papua New Guinea
Tropical Cyclone TIM
12 Mar 2013 12:00 UTC to
20 Mar 2013 06:00 UTC
Solomon Sea
14 Mar
15 Mar
15
145
150
155
QUEENSLAND
Coral Se


TSS load (kt)
25,000
20,000
15,000
10,000
5,000
0
2003
2004
2005
2005
2007
2008
2009
2010
2011
2012
2013
2014
2015
2015
2017
2018
2019
Herbert
Burdekin
Pioneer
Fitzroy
Mary River

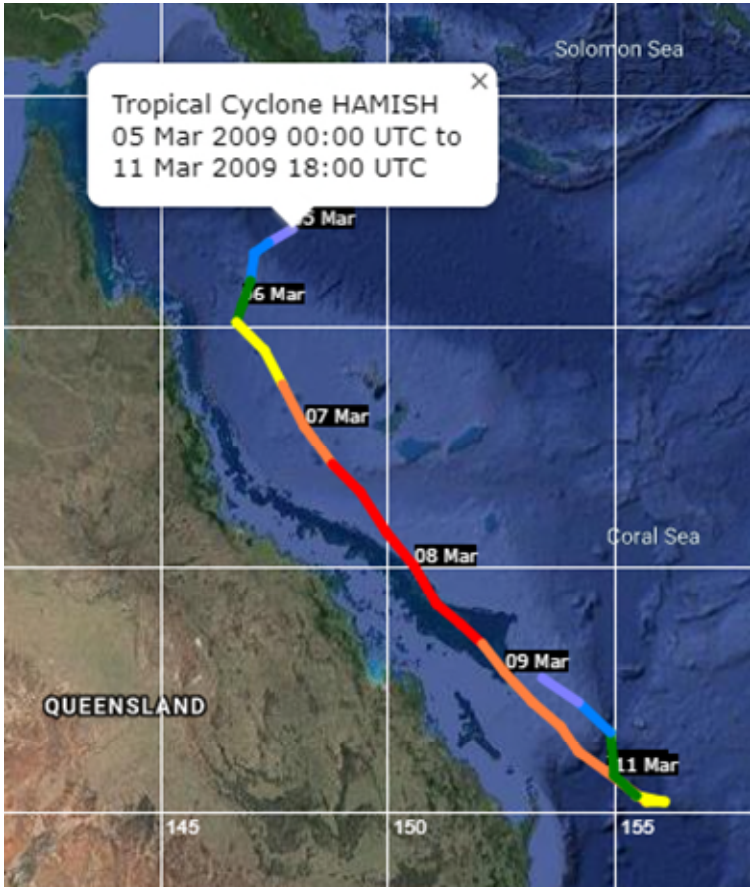

Tropical Cyclone OSWALD
17 Jan 2013 12:00 UTC to
28 Jan 2013 12:00 UTC
18 Jan
23 Jan
24 Jan
25 Jan
QUEENSLAND
27 Jan
28 Jan


Tropical Cyclone JASMINE
31 Jan 2012 18:00 UTC to
06 Feb 2012 12:00 UTC
03 Feb
05 Feb
QUEENSLAND


Papua New Guinea
Tropical Cyclone GRANT
21 Dec 2011 00:00 UTC to
31 Dec 2011 06:00 UTC
25 Dec
31 Dec
6 Dec
27 Dec
28 Dec
NORTHERN TERRITORY
130
135
140
Tropical Cyclone TASHA
24 Dec 2010 00:00 UTC to
25 Dec 2010 00:00 UTC
4 Dec
QUEENSLAND
Tropical Cyclone ANTHONY
23 Jan 2011 00:00 UTC to
30 Jan 2011 18:00 UTC
3 Jan
29 Jan
Coral


Solomon Sea
Tropical Cyclone ULUI
14 Mar 2010 18:00 UTC to
20 Mar 2010 22:0
17 Mar
Coral Sea
QUEENSLAND

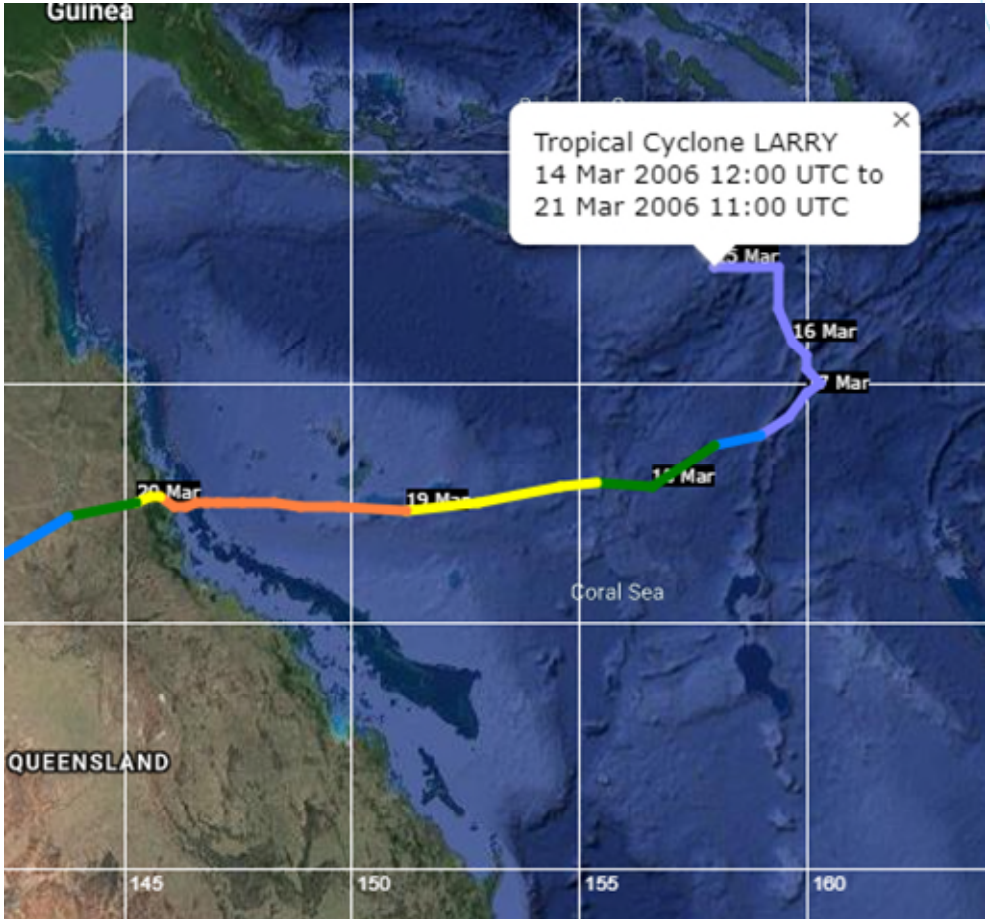

Papua New Guinea
Tropical Cyclone OLGA
21 Jan 2010 18:00 UTC to
30 Jan 2010 00:00 UTC
23 Jan
Coral Sea
145
150
155
160
QUEENSLAND


Tropical Cyclone HAMISH
05 Mar 2009 00:00 UTC to
11 Mar 2009 18:00 UTC
Solomon Sea
07 Mar
08 Mar
09 Mar
11 Mar
Coral Sea
QUEENSLAND
145
150
155


Tropical Cyclone ELLIE
31 Jan 2009 06:00 UTC to
01 Feb 2009 18:00 UTC
QUEENSLAND

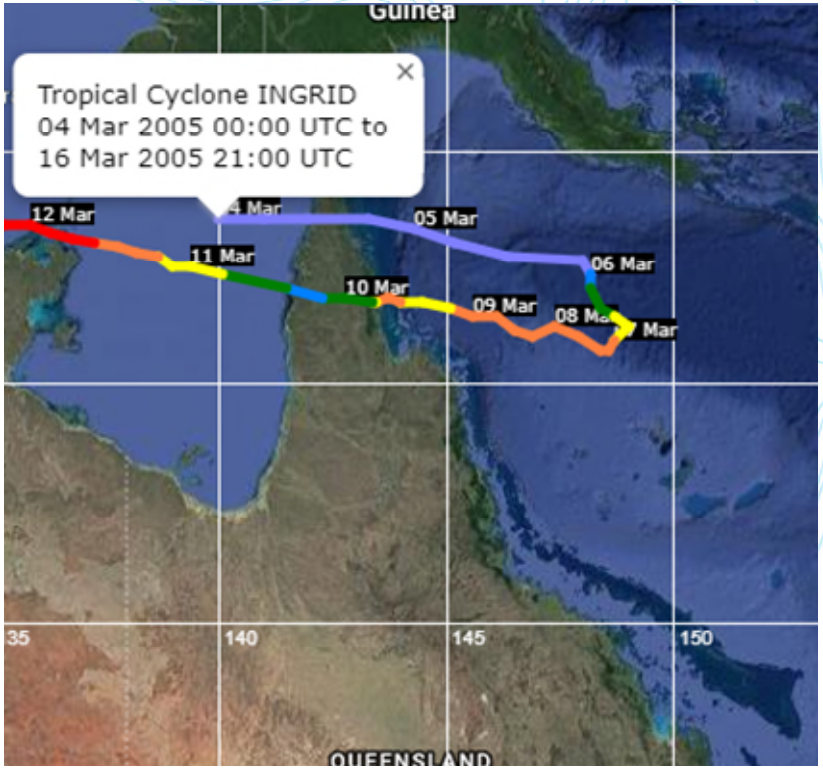

Bismarck Sea
Papua New Guinea
Tropical Cyclone PIERRE
15 May 2007 12:00 UTC to
23 May 2007 06:00 UTC
22 May
18 May
17 May
Solomon Islands
145
150
155
160
Coral Sea


Papua New Guinea
Tropical Cyclone MONICA
16 Apr 2006 00:00 UTC to
27 Apr 2006 18:00 UTC
7 Apr
Coral Sea
145
150
155
QUEENSLAND


Guinea
Tropical Cyclone LARRY
14 Mar 2006 12:00 UTC to
21 Mar 2006 11:00 UTC
16 Mar
Coral Sea
QUEENSLAND
145
150
155
160


Papua New
Guinea
Tropical Cyclone KATE
22 Feb 2006 00:00 UTC to
24 Feb 2006 00:00 UTC
23 Feb


Solomon Sea
Tropical Cyclone JIM
25 Jan 2006 00:00 UTC to
30 Jan 2006 00:00 UTC
26 Jan
Coral Sea
QUEENSLAND
145
150
155


Guinea
Tropical Cyclone INGRID
04 Mar 2005 00:00 UTC to
16 Mar 2005 21:00 UTC
12 Mar
11 Mar
10 Mar
09 Mar
05 Mar
06 Mar
35
140
145
150
QUEENSLAND