



National Environmental Science Programme

# Human sensors – monitoring the Great Barrier Reef

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# Project update – expert workshop

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## **Townsville 7 December 2016**

### Aims:

- Provide an update on the research to date
- Outline next steps
- Obtain feedback on challenges and opportunities
- Discuss linkages to other projects

## Context and project aim

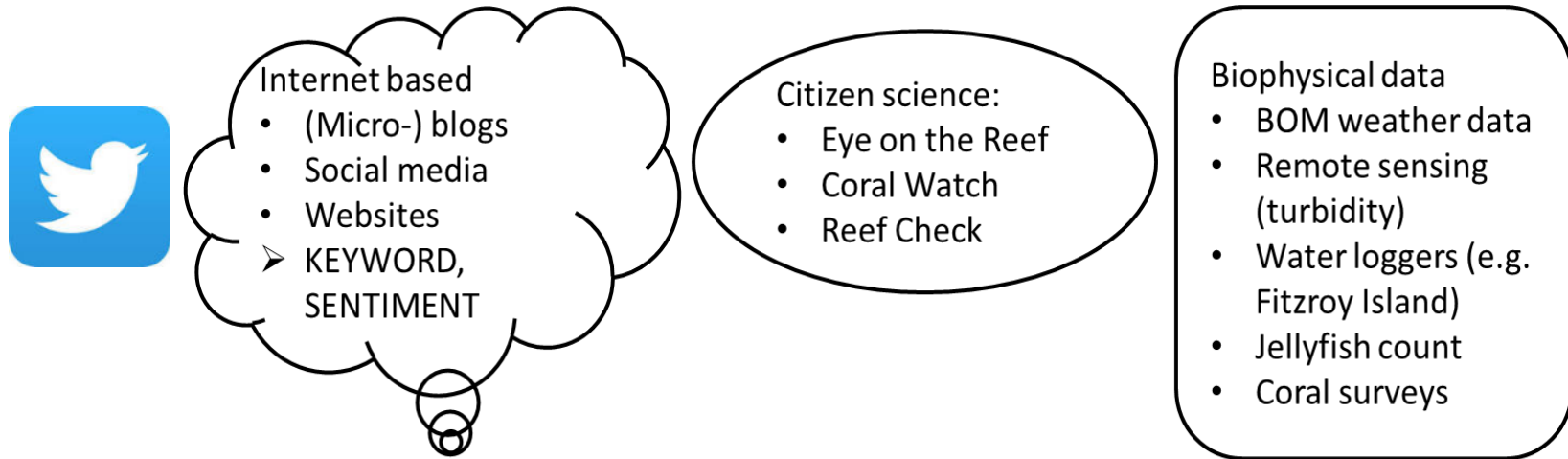
- Environmental changes at the GBR are significant, bio-physical monitoring is essential, but costly.
- Consolidation and integration of monitoring data.
- The GBR is an iconic tourism site that is much talked about in social media – locally and globally.
- About 2 million commercial visitors to the GBR plus many others (e.g. divers, indigenous users, etc.).
- **Project aim:** Improve monitoring of environmental and aesthetic conditions in real time by using information provided through *social media*.



# Human sensing and citizen science

	Collective sensing	Human sensors	Citizen science	Hybrid approaches	Professional monitoring
Cost and infrastructure	Low. Requirement for IT infrastructure (data collection, storage, analysis)	Low. Investment into data collection mechanism	High, as training and supervision are required	Very high	Very high
Data volumes and time-space resolution	Very large	Large	Low to medium	Potentially very large	Typically low
Data quality	Poor	Poor to medium	Medium	Mixed	High
Voluntary	Involuntary	Voluntary	Voluntary	Mixed	Professionally
Expertise/knowledge required	None	None to some	Some	Mixed	Considerable

## Different sources of data



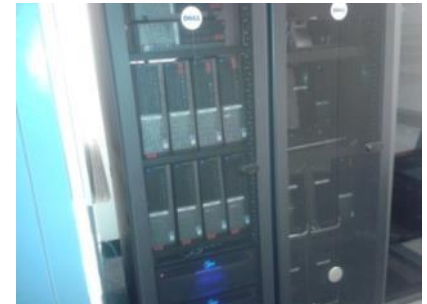
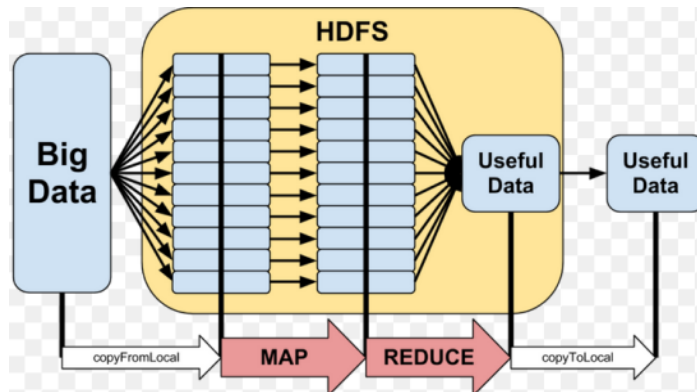
Step 1: Verification and validity

Step 2: Monitoring environmental quality through a portfolio approach

- We begin with Twitter (Geo located + keywords, sentiment, spatiotemporal).
- A portfolio approach could be desirable (see Connors et al., 2012 on the OakMapper.org).

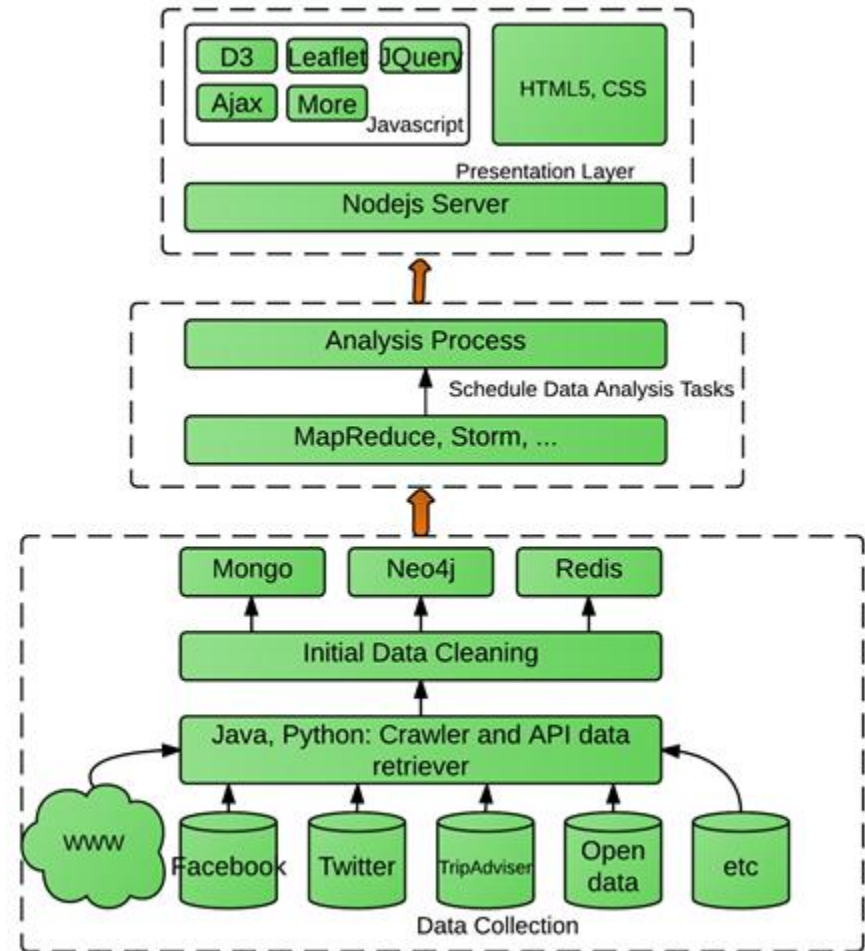
# Infrastructure

- Horizontally scaling of a ‘share nothing Hadoop style computing cluster’, where computers are connected but do not share disk and data.
- Computer space can add up to almost infinite capacity – allowing users to store and process large volumes of data in real time.

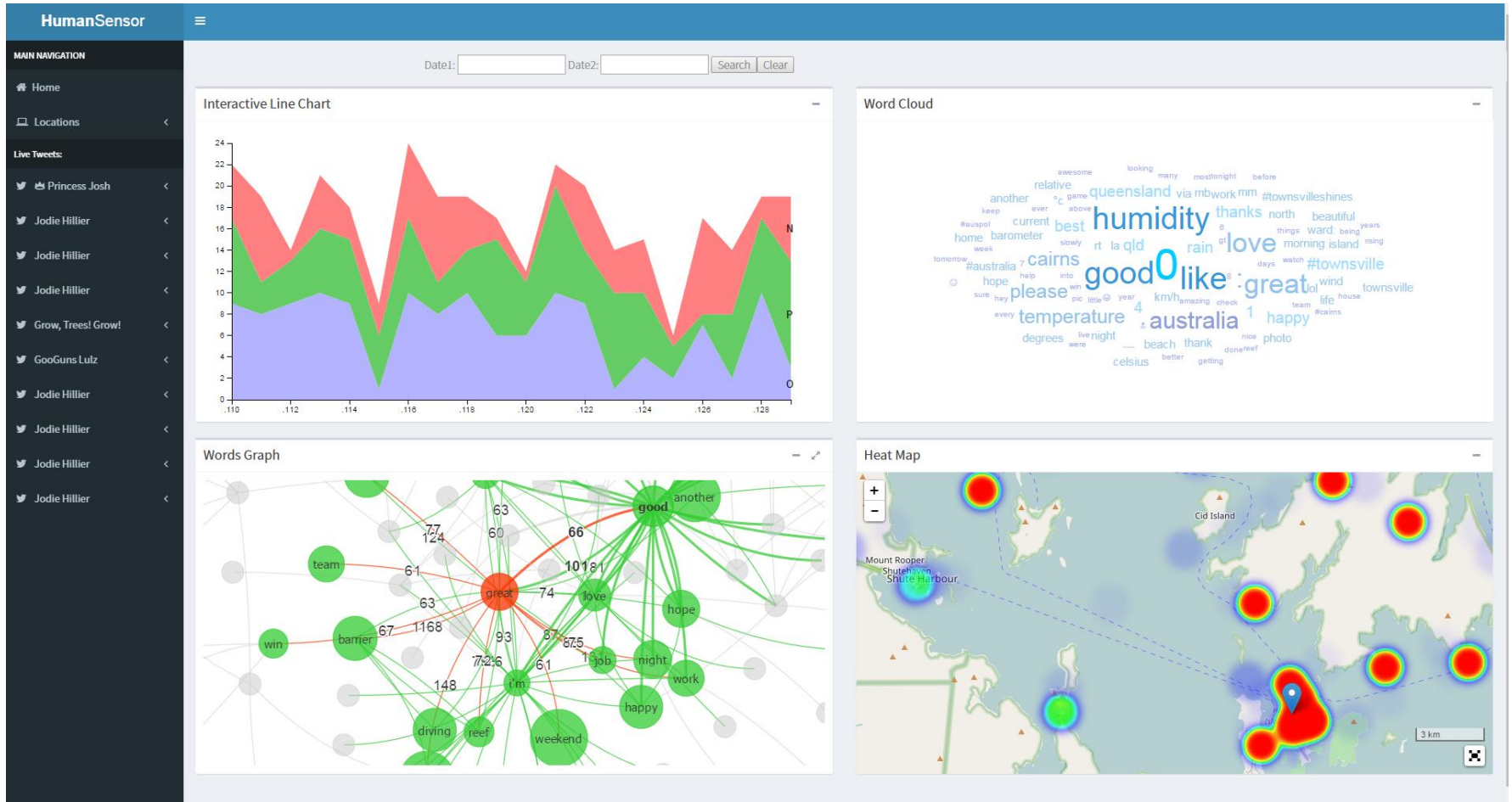


# System architecture

- Data obtained from different sources and in different formats are locally stored in a MongoDB NoSQL document database.
- Data are processed, aggregated and stored in Redis in-memory key value NoSQL database.
- In addition, we utilize Neo4j, which is a highly scalable native graph database.
- Analytics part consist of dedicated algorithms for sentiment analysis, machine learning and deep learning.
- Sample presentation layer is built on Nodejs server enhanced by Ajax, D3 to ensure dynamic visualization.

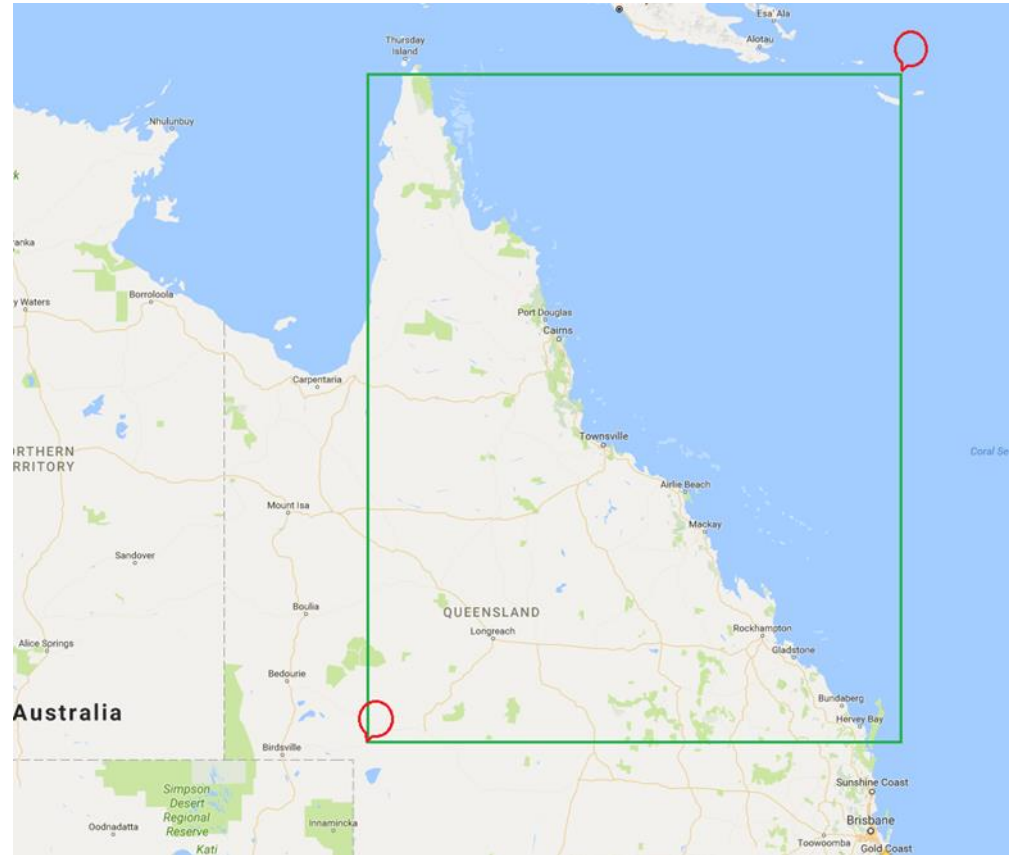


# Visualization of Human Sensors



# Method – Overview

- Use Twitter API's and obtain publically available tweets within the GBR bounding box, livestream, stored in the JSON format
- Additionally search for words of GBR interest posted from world wide
- Identify targets, aspects and perform sentiment analysis
- Developed algorithm for downloading public Facebook page content.
- Use API's to access and store BOM weather data and other.



# Twitter statistics

- 208,525 tweets posted from the GBR region between 18 March to 3 October 2016
- 16.7% of the tweets represent exact locations (longitude and latitude)
- Over 1000 tweets per day

Variable Name	Variable Label
username	User name
Id	Respondent ID
userstatuses_count	Count of User Statuses
text	Tweet text
Lang	Language of Tweet
timestamp_ms	Time stamp of tweet
created_at	Time tweet created
Placename	Place tweet created (short)
placefull_name	Place tweet created (full name, location hierarchy)
usertime_zone	Users time zone setting (Account details)
Userlocation	Users specified location (Account details)
usercreated_at	When user created Twitter account
userfollowers_count	Count of Users Followers (Account details)
Userlang	Users specified language (Account details)

# Keyword framework

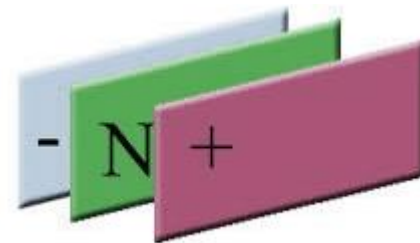
Location	Activity	Marine life	Water	Coral
Cairns	Swim	Fish	Clarity/ clear	Bleach/bleaching
Townsville	Snorkel	Turtle	Visibility	White
Cooktown	Dive	Shark	Turbid/ turbidity	Colourful
Daintree	Scuba	Whale	Pristine	Algae
Mission Beach	Marine	Dugong	Dull	Broken
Rockhampton	Boat	Dolphin	Algae	Damaged
Whitsunday Islands	Sail	Nemo	Dirty	Dead
Hamilton Island	Paddle	Clownfish	Blue	Destroyed
Lady Musgrave Island		Anemone	Grey	Pristine
Whitehaven Beach		Starfish	Turquoise	Dirty
Airlie Beach		Coral		Green
Magnetic Island		Ray (stingray)		Brown
Daydream Island		Jellyfish		Spagetti coral
Lady Elliot Island		Grouper		Brain coral
Heron Island		Trout		
Green Island		Wrasse		
Fitzroy Island				

# Sentiment analysis

- Sentiment analysis is a polarity classification problem: positive, negative or neutral

## Four main approaches:

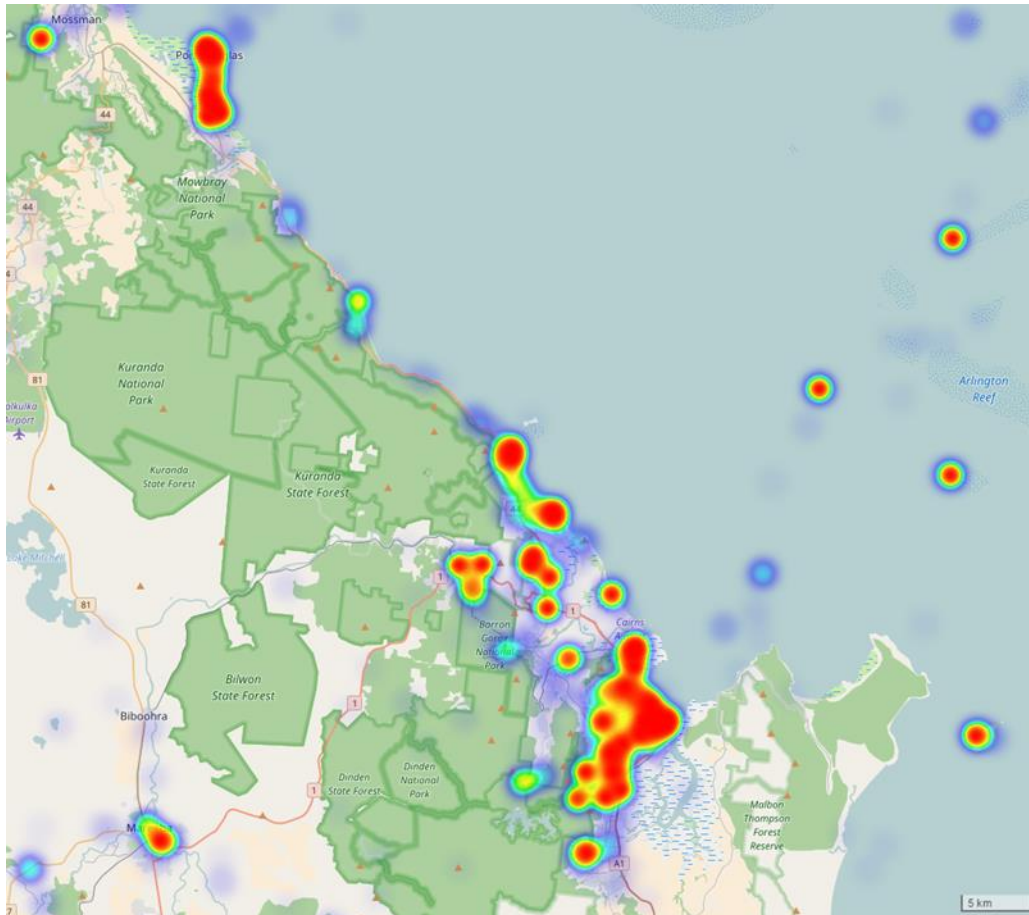
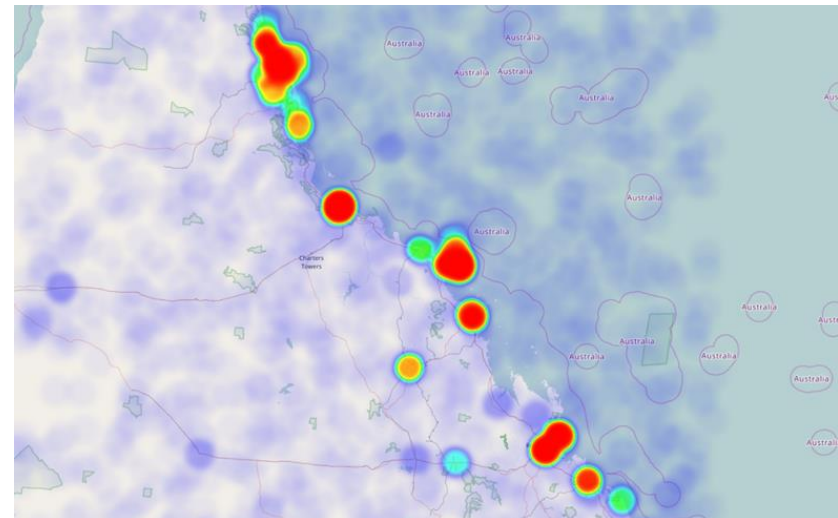
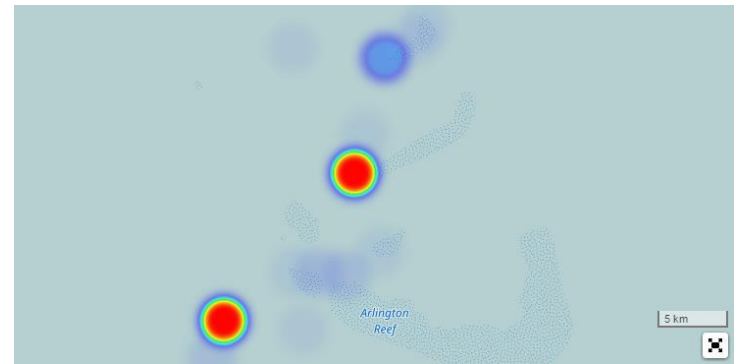
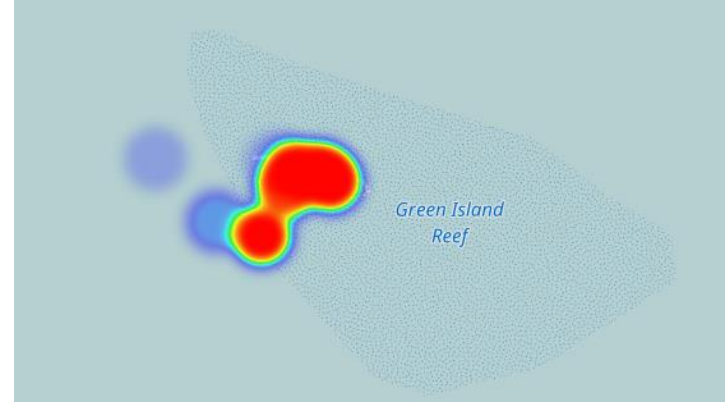
- » Rule/lexicon-based (i.e. a combination of lex resources and Natural Language Processing techniques);
- » Supervised machine learning approaches (SVM, Deep Neural Networks).
- » Unsupervised – based on clustering
- » Hybrid approaches - introduced in this project.



# Geographic location

- The concept of location is essential to human sensing and ‘Volunteered Geographic Information’
- Challenging with Twitter data
  - » Tweet posted from location
  - » Account registered at the location
  - » Location mentioned in tweet

# Heat map: geo-referenced tweets



# Account holder

- 35% of tweets come from accounts that are registered in the GBR region
- 51% of tweets are from Australian context outside the GBR region
- 14% are from overseas accounts
- 79% in English language
- 5% in Japanese
- 1.4 in Spanish...

Why does it matter?

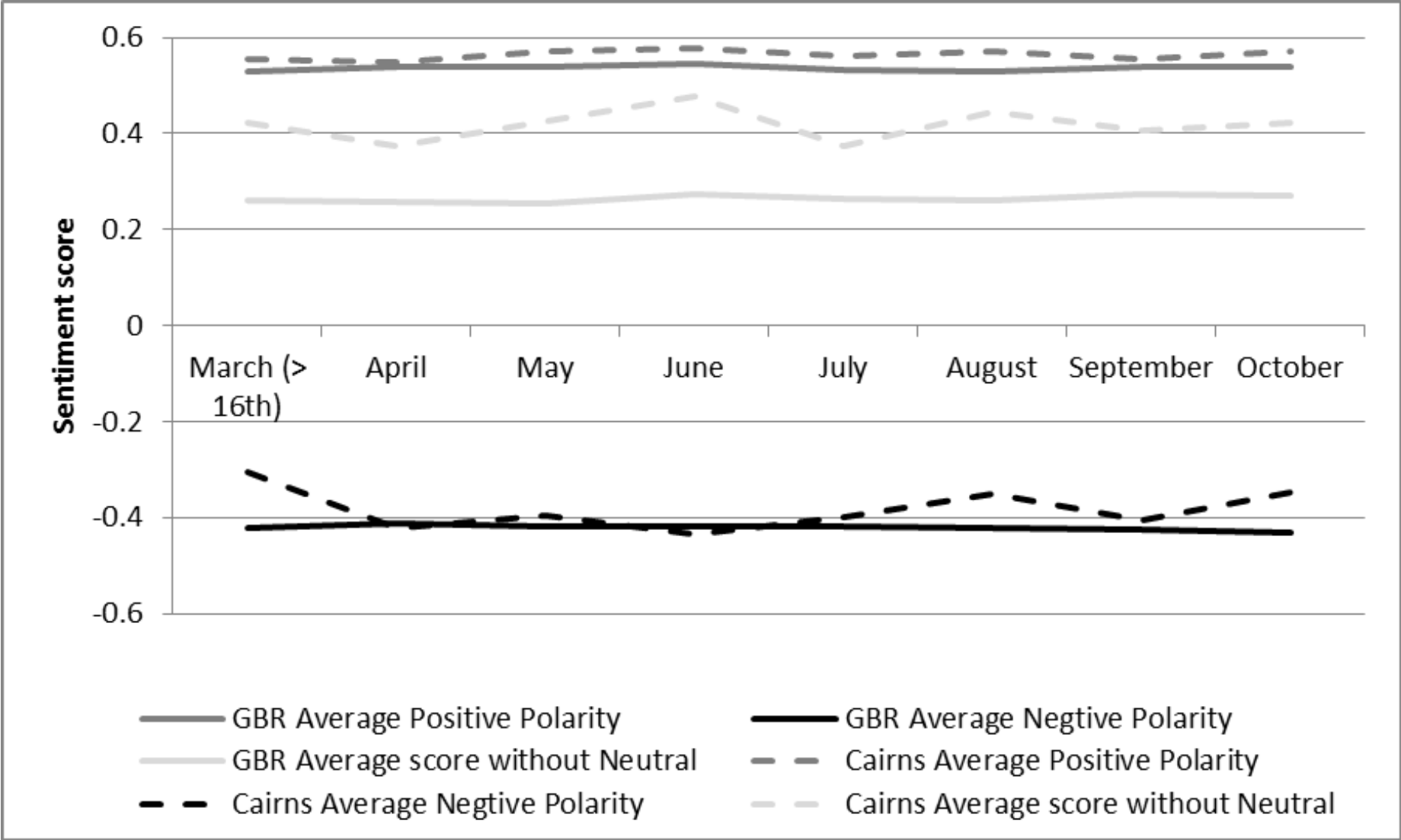
Location	Number of Tweets	%
Townsville	20992	13.94
Australia (only registered as Australia)	20936	13.90
Cairns	18316	12.16
Queensland (registered as Queensland)	15749	10.46
Sydney	7931	5.27
Melbourne	7312	4.85
Mackay	6396	4.25
Brisbane	6155	4.09
England	2260	1.50
Papua New Guinea	2256	1.50
Sunshine Coast	1853	1.23
Bundaberg	1801	1.20
Melbourne, Cairns	1566	1.04
Port Moresby	1476	0.98
London	1454	0.97

# Places mentioned

- Just 2 more hours at cairns, fly to Gold Coast , then 2 hours home on the train.. Kill me -0.6908
- Soaking up the Fitzroy Island magic @CairnsGBR Full #ootd post on #wanderlust #travel
- Back in cairns and can't wait for our diving trip!! 0.2225
- Brilliant day #snorkelling @reefexperience Whales, a reef shark, dolphins & fish. @Queensland @CairnsZoom 0.5859

Reef locations	N
Cairns	5052
Townsville	4421
Rockhampton	747
Hamilton Island	387
Airlie Beach	321
Daintree	275
Magnetic Island	275
Whitehaven Beach	225
Whitsunday Islands	189
Mission Beach	85
Green Island	84
Cooktown	70
Fitzroy Island	57
Daydream island	49
Lady Elliot, Heron, Lady Musgrave Island	29

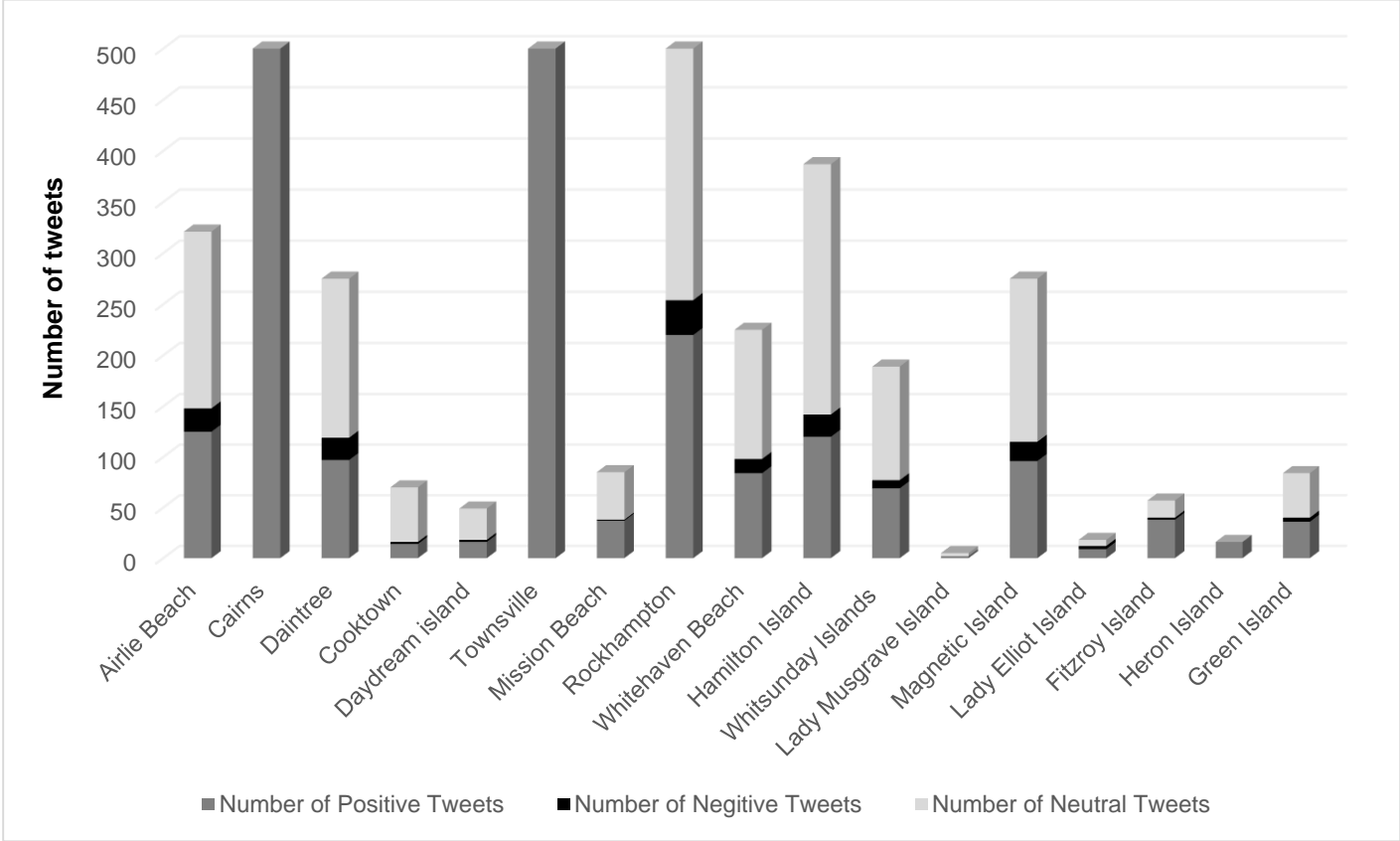
# Sentiment scores



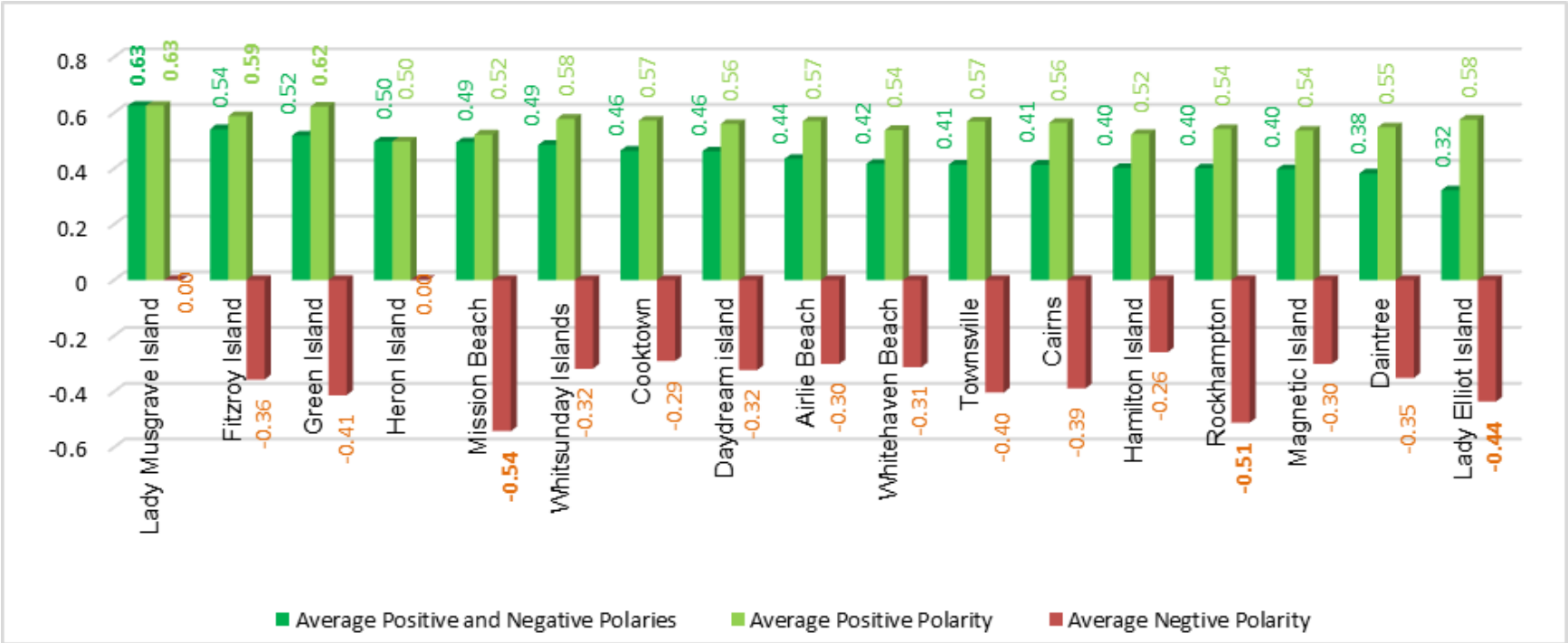
# Important to check sample size

Cairns: 1,892 positive;  
 357 negative; 2,803  
 neutral

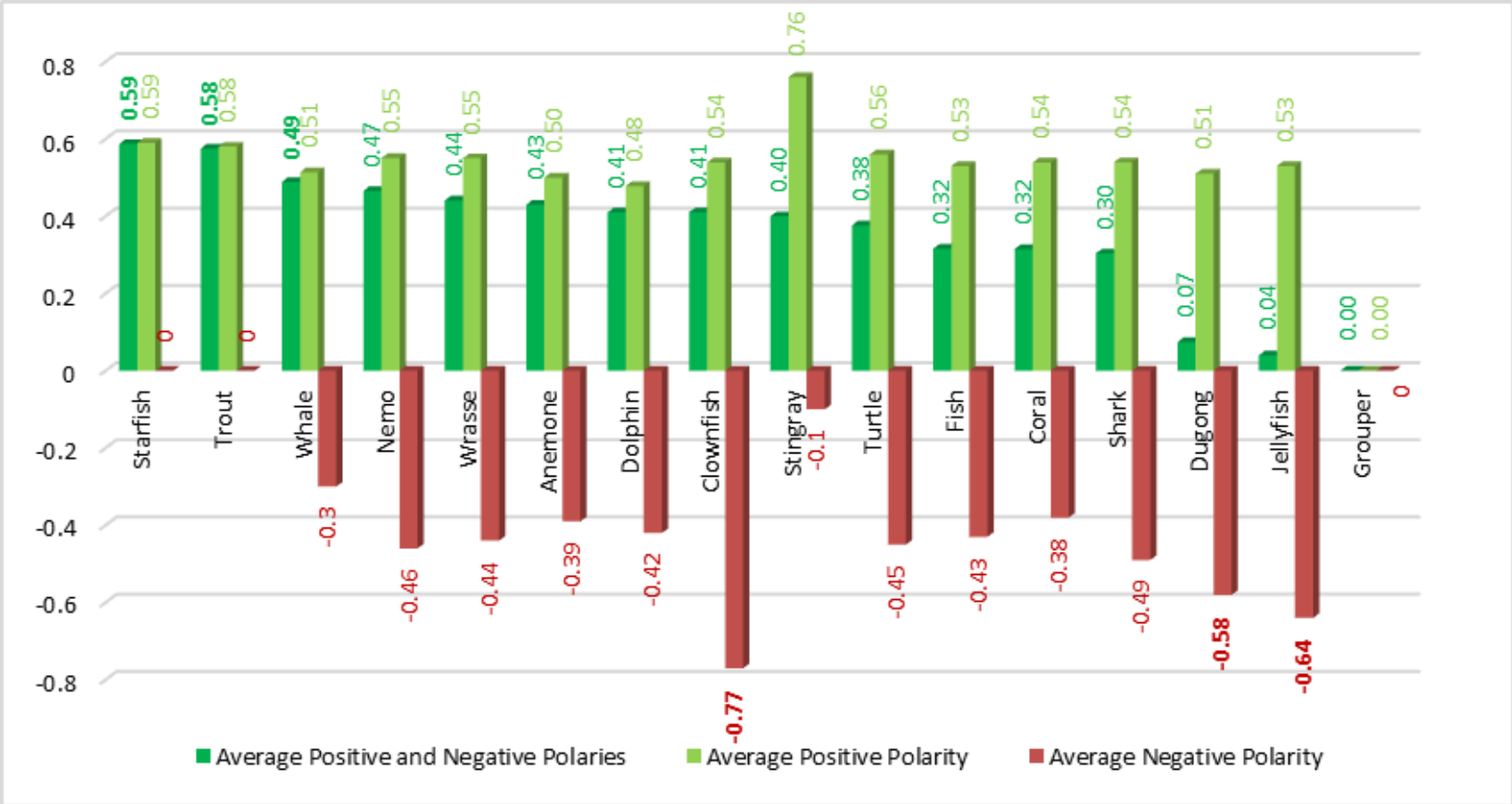
Townsville: 1,140  
 positive; 216 negative;  
 3,065 neutral



# Sentiment by location



# By marine species



•Note: only 3% of clownfish tweets negative, but 39% of jellyfish tweets

# By activity

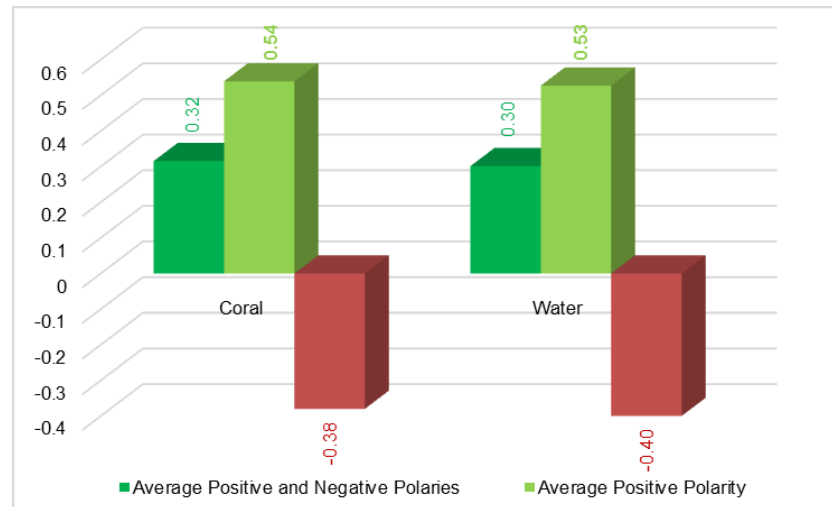


•Note: Snorkel, Sail, Scuba only 5-6% of tweets negative

# Keywords Water and Coral

Note: small sample sizes

- Water: N= 1354
- Coral: N= 307
- 12 and 13 % of tweets negative



## In summary – Twitter as a data source

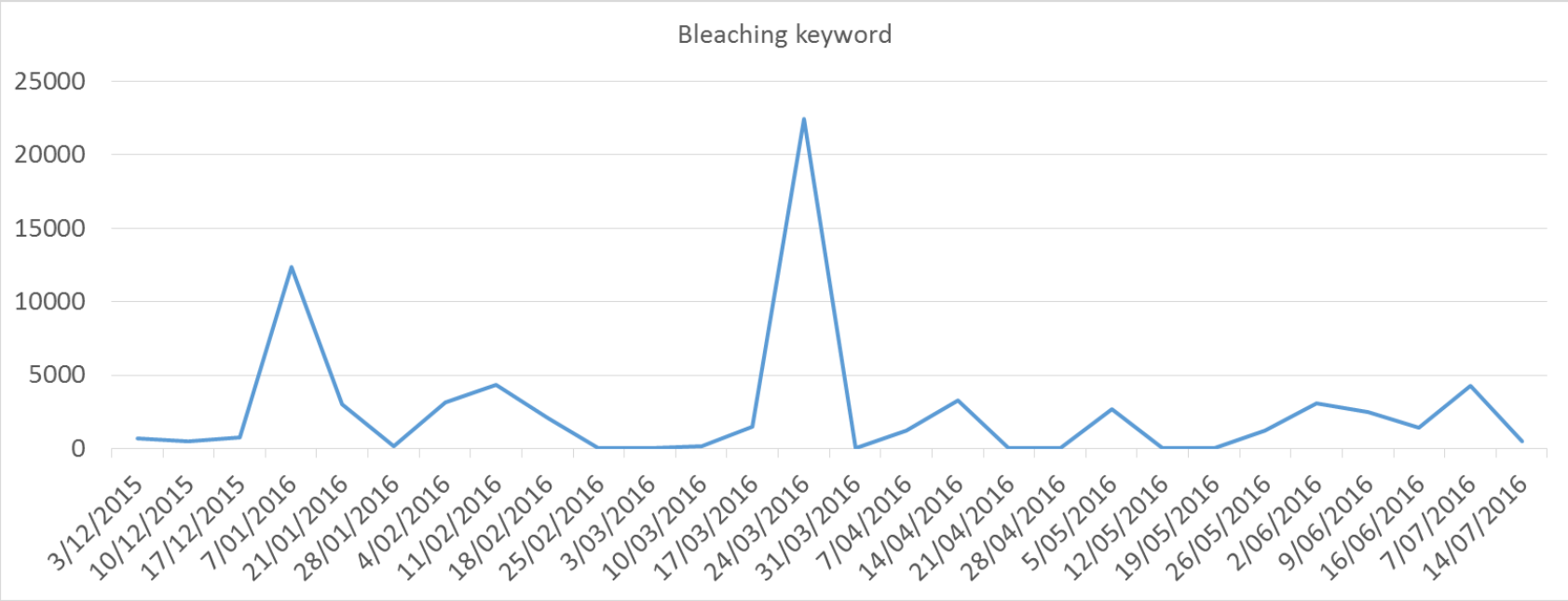
- Real time and ‘honest’ information (election prediction is a proof)
- Unspecific content
- Data less abundant than thought (only 1-5% are relevant tweets), however indirectly a lot of valuable information can be obtained (spatio-temporal migration, population, areas of interest, etc)
- Issues with exact geographic locations

BUT:

- Useful insights on certain topics, especially sentiment related to defined targets
- Maybe more suited for socio-economic monitoring (both visitors and residents)
- Could increase over time (encourage the use of Twitter) and other social media can be used, other public social media could be considered
- Long-term patterns likely, esp. in relation to other data sources
- Likely to be useful for ‘red flag’ situations or crises

**We can address some of the shortcomings....**

# A parallel investigation – global tweets on the GBR



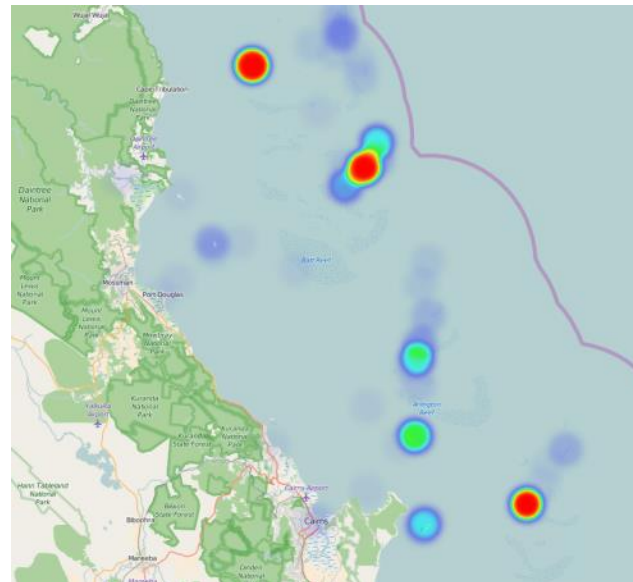
# Examples of global tweets

246	Mon Apr 04 15:45:16 +0000 2016	Green Evolution	Great Barrier Reef coral bleaching is now more widespread than ever <a href="https://t.co/0btr9UGzLM">https://t.co/0btr9UGzLM</a> #Green #Eco... <a href="https://t.co/6xPIRKV5dv">https://t.co/6xPIRKV5dv</a>
247	Mon Apr 04 15:49:12 +0000 2016	Bantalpad	climate change implications bring about, coral reef bleaching. Ocean acidification, you winner! <a href="https://t.co/rs8U1oAuwO">https://t.co/rs8U1oAuwO</a>
248	Mon Apr 04 15:49:46 +0000 2016	Malena Copeland	"Great Barrier Reef coral bleaching is now more widespread than ever" <a href="https://t.co/XFWf8DWMK0">https://t.co/XFWf8DWMK0</a> #environment #ocean #green
249	Mon Apr 04 15:51:08 +0000 2016	Janine Friedland	RT @MonaRailey: Evidence that Australia's Great Barrier Reef is experiencing its worst coral bleaching on record has renewed calls for the
250	Mon Apr 04 15:52:34 +0000 2016	Green Evolution	Great Barrier Reef coral bleaching is now more widespread than ever <a href="https://t.co/0btr9UGzLM">https://t.co/0btr9UGzLM</a> #Green #Eco... <a href="https://t.co/S7TrW4sD7B">https://t.co/S7TrW4sD7B</a>
251	Mon Apr 04 15:52:35 +0000 2016	UFH Expert	Great Barrier Reef coral bleaching is now more widespread than ever: <a href="https://t.co/hVLHOUtvpR">https://t.co/hVLHOUtvpR</a>
252	Mon Apr 04 15:53:03 +0000 2016	Asia Permaculture	Great Barrier Reef coral bleaching is now more widespread than ever <a href="https://t.co/opvsTNRNY0">https://t.co/opvsTNRNY0</a> #Hijau #Berkebun #Asia #Indonesia #Brunei #Mal
253	Mon Apr 04 15:56:52 +0000 2016	CHIRON INC	Great Barrier Reef coral bleaching is now more widespread than ever <a href="https://t.co/k5EdfAGLvi">https://t.co/k5EdfAGLvi</a>
254	Mon Apr 04 15:57:24 +0000 2016	Dr. Mark Eakin	RT @therightblue: Dive teams head underwater to survey true extent of coral bleaching on Great Barrier Reef <a href="https://t.co/OlqFzZ0LQh">https://t.co/OlqFzZ0LQh</a> #scuba
255	Mon Apr 04 15:58:10 +0000 2016	Sue Hayes	Great Barrier Reef coral bleaching is now more widespread than ever <a href="https://t.co/O9w6Tuw5V0">https://t.co/O9w6Tuw5V0</a>
256	Mon Apr 04 15:58:37 +0000 2016	Acen Suarez	RT @HuffingtonPost: Widespread coral bleaching devastates the once-pristine Great Barrier Reef <a href="https://t.co/ngiEzvGK46">https://t.co/ngiEzvGK46</a>
257	Mon Apr 04 15:59:32 +0000 2016	Zoe Norton	Great Barrier Reef coral bleaching is now more widespread than ever <a href="https://t.co/D9E9YKz2EB">https://t.co/D9E9YKz2EB</a>
258	Mon Apr 04 16:00:25 +0000 2016	cragelmeyer	Great Barrier Reef coral bleaching is now more widespread than ever via INHABITAT - New research, ... <a href="https://t.co/ASmLIEYTai">https://t.co/ASmLIEYTai</a>
259	Mon Apr 04 16:02:58 +0000 2016	The Pita Group	Northern Great Barrier Reef in midst of its worst bleaching event on record: <a href="https://t.co/xJ4rmljtU9">https://t.co/xJ4rmljtU9</a> via .@mashable
260	Mon Apr 04 16:03:12 +0000 2016	Angelo Villagomez	Great Barrier Reef coral bleach threat upgraded to level 3 <a href="https://t.co/ajLXmWhrrp">https://t.co/ajLXmWhrrp</a>
261	Mon Apr 04 16:03:31 +0000 2016	Aeyoung	RT @SeaLifeProject: Our incredible Great Barrier Reef is experiencing severe bleaching. A recent aerial survey <a href="https://t.co/wonArUh51w">https://t.co/wonArUh51w</a> htt
262	Mon Apr 04 16:03:43 +0000 2016	SpaceAim	Great Barrier Reef experiencing the worst bleaching in 15 years <a href="https://t.co/JPIO7XtmVw">https://t.co/JPIO7XtmVw</a> #space
263	Mon Apr 04 16:05:39 +0000 2016	Angfro Saxon	Great Barrier Reef coral bleaching is now more widespread than ever <a href="https://t.co/7v6wMVYgFX">https://t.co/7v6wMVYgFX</a> <a href="https://t.co/OWVlyu347Y">https://t.co/OWVlyu347Y</a>
264	Mon Apr 04 16:13:28 +0000 2016	Evelina C. Urgolo	RT @JamieSmythF: Australia approves one of world's biggest coal mines as Great Barrier Reef bleaches white <a href="https://t.co/3mjQHDLCI">https://t.co/3mjQHDLCI</a> <a href="https://t.co/IsfS29j9Gr">https://t.co/IsfS29j9Gr</a>
265	Mon Apr 04 16:17:36 +0000 2016	Magdalena Agestam	The Great Barrier Reef still is a stunning natural wonder. Acute threats include bleaching and a coal mine. <a href="https://t.co/IsfS29j9Gr">https://t.co/IsfS29j9Gr</a>
266	Mon Apr 04 16:23:17 +0000 2016	WilmingtonNC4Bernie	RT @billmckibben: Australia is nuts. As Great Barrier Reef bleaches, govt approves world's biggest coal mine <a href="https://t.co/cdLFXd9YMo">https://t.co/cdLFXd9YMo</a>
267	Mon Apr 04 16:25:05 +0000 2016	Jyoti Mathur-Filipp	RT @SolheimDAC: Environment warning of the week:Great Barrier Reef hit by worst coral bleaching on record. <a href="https://t.co/zAgTqyRs0f">https://t.co/zAgTqyRs0f</a> <a href="https://t.co/oypB34qBsL">https://t.co/oypB34qBsL</a>
268	Mon Apr 04 16:25:53 +0000 2016	Gustavo Sosa	RT @grist: The Great Barrier Reef is nearly 95 percent bleached -- can it make a comeback? <a href="https://t.co/qplLqEaDU">https://t.co/qplLqEaDU</a> <a href="https://t.co/oypB34qBsL">https://t.co/oypB34qBsL</a>
269	Mon Apr 04 16:27:19 +0000 2016	Bianca Gibb	RT @billmckibben: Australia is nuts. As Great Barrier Reef bleaches, govt approves world's biggest coal mine <a href="https://t.co/cdLFXd9YMo">https://t.co/cdLFXd9YMo</a>
270	Mon Apr 04 16:31:30 +0000 2016	Martin Bryan	RT @NRDC: An aerial survey of northern Great Barrier Reef showed that 95% of reefs are now severely bleached: <a href="https://t.co/E8zmb94FaX">https://t.co/E8zmb94FaX</a> via @
271	Mon Apr 04 16:34:27 +0000 2016	Dawn buckner	RT @HuffingtonPost: Widespread coral bleaching devastates the once-pristine Great Barrier Reef <a href="https://t.co/ngiEzvGK46">https://t.co/ngiEzvGK46</a>
272	Mon Apr 04 16:40:24 +0000 2016	new news	Great Barrier Reef Bleaching 'Worst in Its History': Severe bleaching in Australia's Great Barrier Reef, descr... <a href="https://t.co/Va9oGjzaZR">https://t.co/Va9oGjzaZR</a>
273	Mon Apr 04 16:41:58 +0000 2016	TOP in Geography	" Great Barrier Reef Bleaching 'Worst in Its History': Severe bleaching in Australia's Great Barrier Re... <a href="https://t.co/afCl7ptunB">https://t.co/afCl7ptunB</a> #earth
274	Mon Apr 04 16:41:59 +0000 2016	viav7	Great Barrier Reef Bleaching 'Worst in Its History': Severe bleaching in Australia's Great Barrier Reef... <a href="https://t.co/MRwhxsQ21Z">https://t.co/MRwhxsQ21Z</a> #Earth
275	Mon Apr 04 16:41:59 +0000 2016	viav7	Great Barrier Reef Bleaching 'Worst in Its History': Severe bleaching in Australia's Great Barrier Reef... <a href="https://t.co/0CkWWvdNaN">https://t.co/0CkWWvdNaN</a> #Earth
276	Mon Apr 04 16:42:00 +0000 2016	SAVE Our TIGERS	Great Barrier Reef Bleaching 'Worst in Its History': Severe bleaching in Australia's Great Barrie... <a href="https://t.co/bAwE6cGapl">https://t.co/bAwE6cGapl</a> #SaveAnimals
277	Mon Apr 04 16:42:10 +0000 2016	Clifton Lemon	RT @grist: The Great Barrier Reef is nearly 95 percent bleached -- can it make a comeback? <a href="https://t.co/UiyoiZDt6oU">https://t.co/UiyoiZDt6oU</a> <a href="https://t.co/Ajgi6ZJFGv">https://t.co/Ajgi6ZJFGv</a>

# Additional data: Eye on the Reef

**Eye on the Reef** (GBRMPA) citizen science and tourism operator data:

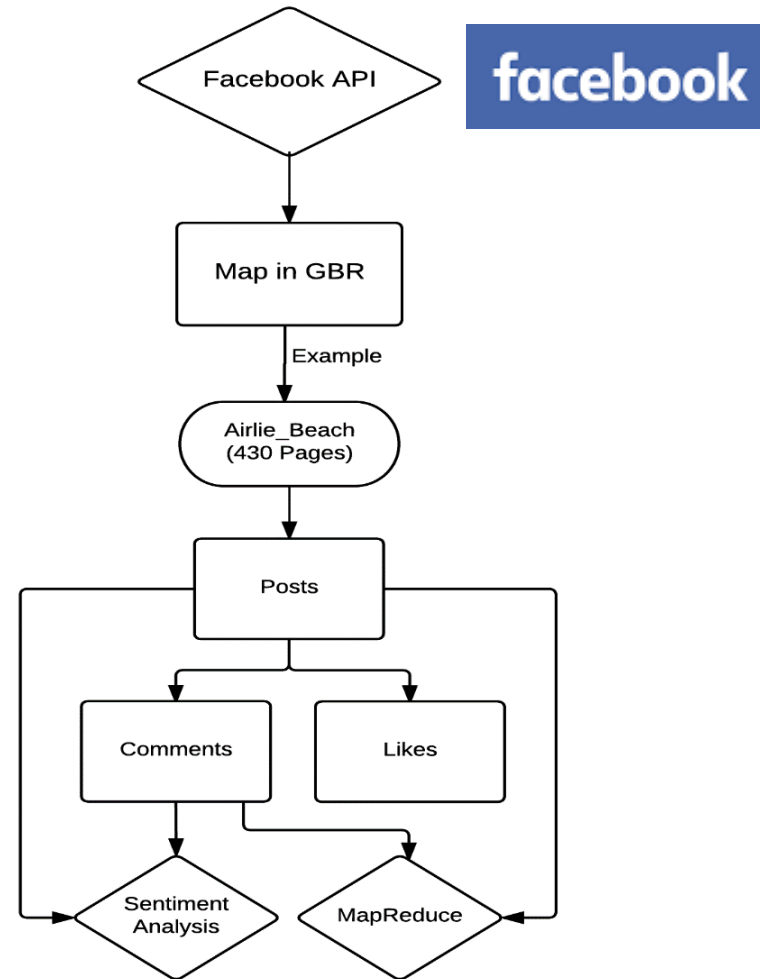
- Rapid monitoring,
- Tourism weekly,
- Reef Health and Impact Surveys
- Sightings network



Additional data: Facebook

## Publicly available Facebook pages

- Identify relevant public Facebook pages.
- Use Facebook API to get the posts, comments, followers and likes.
- Store all the real time Facebook Data in NoSQL MongoDB.
- Perform MapReduce, process of aggregating data and also Sentiment Analysis calculation.
- Store all aggregated data in Redis, in-memory NoSQL database.



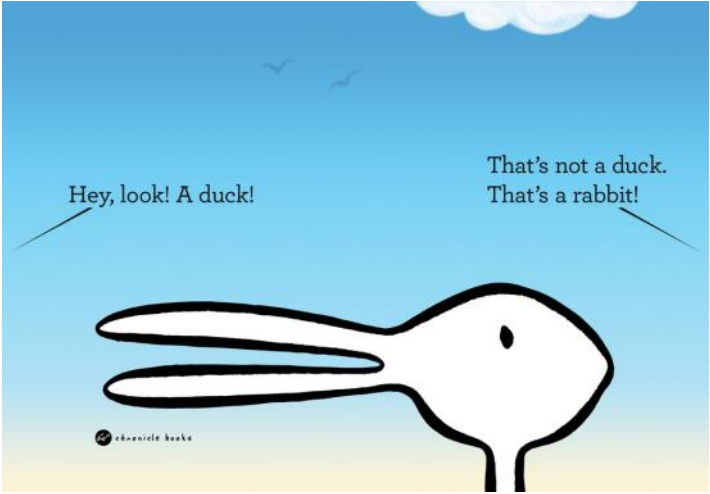
# Next steps and projects

- Aesthetic value



# Image recognition

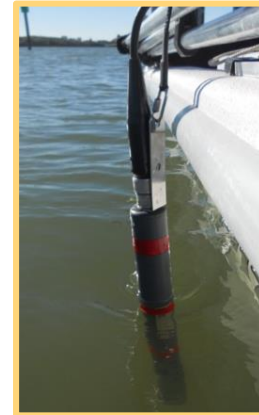
- Which species and habitats?
- Machine learning, automated recognition
- Utilization of deep learning methods



# History of measuring dissolved oxygen



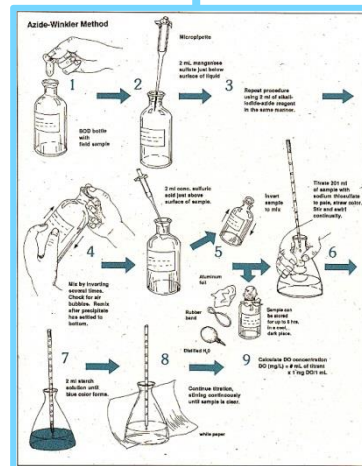
The Winkler method



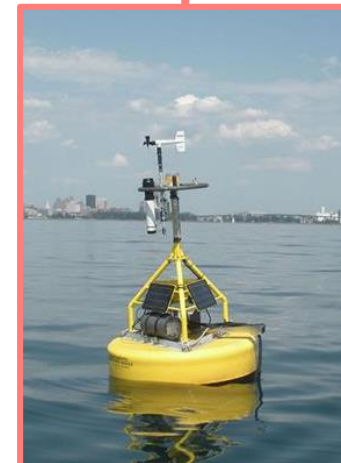
Continuous in-situ monitoring



The original method



DO sonde





yellowfintripodfish



yellowfintripodfish



weepingtoadfish



yellowfintripodfish



# Part of NESP Big Data project group

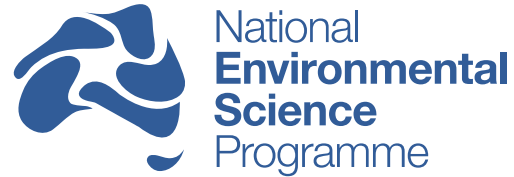


Big Data and Smart Analytics lab several RA's and PhD students





**Australian Government**



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