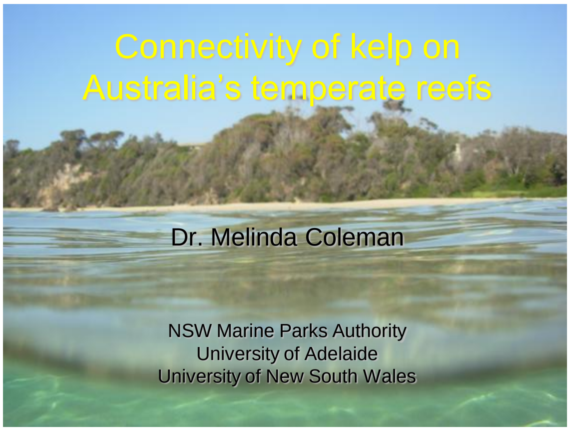

# Connectivity of kelp on Australia's temperate reefs

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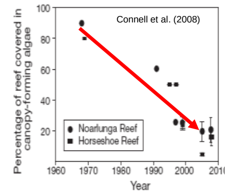
## Kelp in decline worldwide

- Europe, west coast USA
- Australia
  - Poleward shifts in distribution
  - Declines in TAS, SA, NSW
- Being replaced with turfing algae
- Urban coastlines

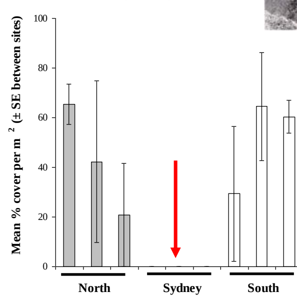



## Crayweed loss in Sydney

Coleman et al. (2008)

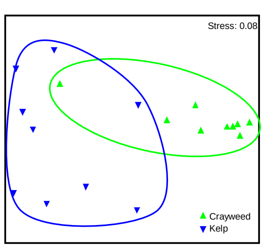
- Shallow subtidal - low intertidal
- Habitat-forming: canopies up to 3m high
- Biomass ~ 20 kgm$^2$
- Historically abundant throughout distribution (> 1000km)

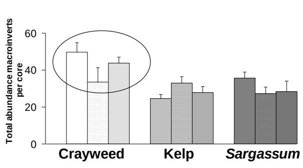
## Crayweed lost from urbanised reefs




- Common in 1940's
- Absent from Sydney
- 70km gap in dbn

## Implications of loss




Bishop et al (2008)

## Causes of kelp loss

- Poor water quality
- Warming temperature (climate change)
- Disease
- Indirect effects: harvesting of urchin predators
- Causes of loss multiple, synergistic

## What can we do?

- Management action to prevent loss/halt decline
  - MPAs to build resilience,
  - Legislation e.g. improve water quality
- Rehabilitate or re-forest areas

## What information do we need?

- Need basic biological information to achieve effective management
- Major limitation to effective management of kelp forests is lack of knowledge about connectivity
- Key component of conservation and management strategies

## Connectivity

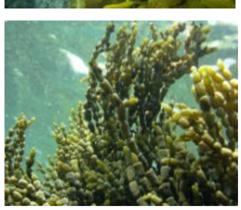
- Extent to which individuals, species and resources are shared among places or populations in space and time
- How much do populations exchange genetic material via movement of adults and reproductive propagules
- Family trees!
- How far do adults and young move?
- Who is breeding with who?
- Which areas should we protect?
- Where should we source plants?

## My research

- Understand connectivity of seaweeds
- Local, regional, continental scales
- Links to oceanography: major drivers on large scales
- Present and future connectivity
- Climate change
- Provide information for adaptive management
  - MPA design
  - Rehabilitation

## Habitat forming

*Ecklonia radiata* (common kelp)
*Phyllospora comosa* (Crayweed)
*Hormosira banksii* (Neptune's necklace)



## How do we estimate connectivity?

- Many different methods
  - Direct (tracking, mark-recapture etc)
  - Indirect (otoliths, genetics etc)
- Genetics
  - Microsatellite markers
  - Neutral portions of the genome, "junk DNA"
  - Look for differences in size/length of these areas
- ~ 2000 ind. Genotyped with 6-8 msat markers

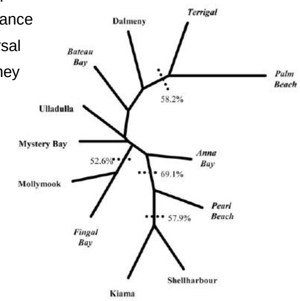
## Crayweed

Does the gap in distribution limit connectivity between N and S populations?

Implications for rehabilitation programmes?

## Crayweed is highly connected

- 70km gap is no barrier to dispersal
- No genetic patterns with distance
- Gas-filled vesicles aid dispersal
- Floating wrack found in Sydney

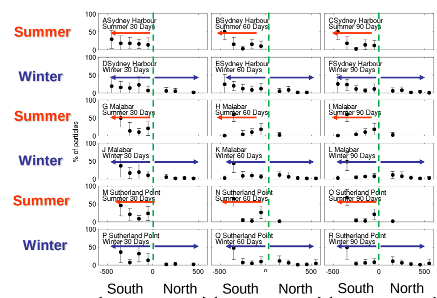



## Can currents explain patterns?

Moninya Roughan and Helen Macdonald (UNSW)

- High res. model of the EAC (~ 3km)
- Used particle tracking techniques to estimate surface dispersal along coast of SE Australia
- Particles released from 24 sites every 5 days during summer and winter (16,800 particles) for 15 year period and averaged
- Dispersal time scales of 30, 60 and 90 days (= wrack)

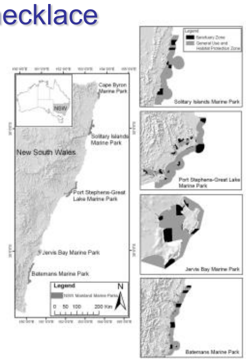
## Dispersal can occur in both directions in winter!




## Neptune's necklace

- NSW: 4/6 MPAs
- Each has multiple no-take zones
- Interidal and subtidal
- Seaweeds dominant habitat

Coleman et al. (2011), PLoS One

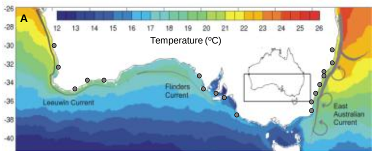



## Moderate connectivity in Neptune's necklace

- Moderate connectivity (but lowest of 3 spp)
- Intertidal species generally have lower connectivity than subtidal spp.
- NN reproduces at low tide!
- Consideration for intertidal spp in MPA design
- Intertidal SZ need different design criteria (spacing)?

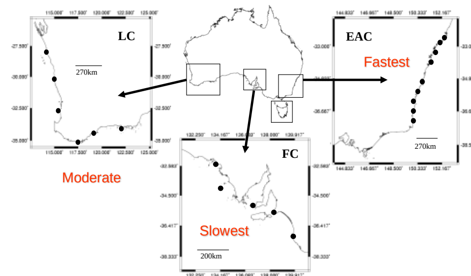
## Kelp: *Ecklonia radiata*

- Australia unique: 3 boundary currents
- Latitudinally compressed coastline, small temperature range
- Kelp a cosmopolitan species
- Is there generality among current systems?

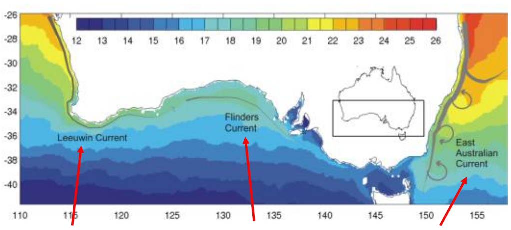



Coleman et al (2011). J Ecol.

## Is connectivity of kelp correlated to relative current strength?




## Kelp connectivity is correlated to current strength



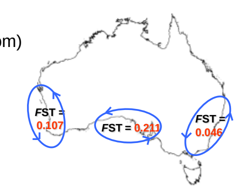

Moderate current = Low-med connectivity

Slowest current = very low Connectivity

Fastest current = High connectivity

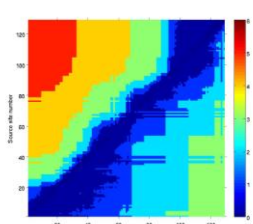
## Australia's coastlines all different

- EAC
  - Highest connectivity
  - No pattern with distance (random)
  - Widespread dispersal?
- LC and FC
  - Lowest connectivity
  - Strong relationship to distance
  - Dispersal restricted?
  - But currents important in directional dispersal?




## Can oceanography explain genetic patterns?

- First continental wide model of oceanographic connectivity
- Developed matrix of oceanographic connectivity (time) over 30d
- Mantel tests to correlate to genetic and oceanographic connectivity between all pairs of populations




## Currents & climate change

Coleman, Roughan and Kelaher

- Boundary current systems to change under climatic change
- EAC to strengthen, LC weaken in next 100 yrs
- Huge implications for connectivity of marine organisms
- Model of currents under IPCC scenarios
- Next step: implications for connectivity

## Implications for MPAs

- EAC promotes dispersal (esp. in subtidal spp)
- NSW MPA designs appropriate
- SA and WA: currents cause lower connectivity
- Lack of generality means MPAs may require different design criteria
- Lack of latitude/habitat generality: spatial designs need to consider this
- Park specific criteria?

## Take home messages!

- Understanding connectivity is imp. for conservation and management
- Different boundary currents - unique patterns of connectivity
- Oceanography can drive connectivity but relationships will change under future scenarios of climate change
- Implications for MPA design and management