Overview of talk

- Climate variability drivers in the marine environment
- WAMSI Shark Bay Project - CfoC
- Ongoing/ planned consultation
- Ongoing marine & climate-related challenges for the region - discussion

Acknowledgement: WAMSI Partner Researchers [esp. Prof. Di Walker] for some of the slides
Sea surface temperatures off the WA west coast have warmed by 0.8°C
Western Australia’s Maritime Estate
Physical Environment

- Important factors:
  - Currents
  - Temperatures
  - Winds
  - Surface Waves
  - Storm activity

- Relation to forcing from large-scale modes of climate variability:
  - ENSO, IOD
  - Remote forcing of winds over the Pacific & Indian Oceans
  - Planetary waves that propagate into the region

Slide: Evan Weller, CSIRO
Climate variability over a range of spatial & temporal scales – the natural rhythms!

- Inter-annual variability
- Decadal scale variability
- Seasonal variability
- Seasonal variability
- Astronomical Tidal Cycles: 4.4 yr cycle
  - 8.8 yr perigee cycle
  - 18.6 yr nodal cycle
Oceans Systems Forecasting

- Downscaled Nested Hydrodynamic Models for Western Australia
  - Oceanic -> shelf (Leeuwin Current) -> lagoon (Ningaloo and Marmion)
- Downscaled climate change projections and predicted year-to-year variations in the marine environment of WA

Outcomes – increased understanding of
- transport mechanisms; and
- key drivers of variations in WA marine environment (ENSO/IOD)
*El Nino* Southern Oscillation (ENSO) signals are observed to propagate along WA coast

Feng, Meyers, Pearce, Wijffels 2003
2010/11 *La Nina* “Heatwave”

- February 2011 large rise in SST
  - caused by the combined effects of long term warming trends, a decadal strengthening of the Leeuwin Current & one of the strongest *La Nina* events in history
  - immediate effect - fish kills, coral bleaching

**Learnings:**
- Baseline datasets
- Bring together WA science community at short notice
- Improved capacity for fisheries & marine parks management
Decadal prediction
– a new frontier of climate research

Our understanding of climate variability and our ability to predict it is not constant across timescales.

Predicting the Climate of the Coming Decades
RSMAS -- January 11, 2010
Case Study – Western Rock Lobster Recruitment

Influence on the oceanic larval stages

Coastal **sea level** and the **Leeuwin Current** are highly correlated with ENSO and puerulus sett.

ENSO used as a good prediction tool in the past for WA several fisheries but not 100% accurate i.e. 2008

*(Pearce and Phillips, 1988; Caputi et al., 2001; 2003)*
Sea Level Change (MSL)

- +100 cm
- 80 cm
- 20 cm

Church and White (2006)

IPCC (2007)

Rahmstorf (2007); Rahmstorf et al. (2007); Grinsted et al. (2009)
Annual Mean Fremantle Sea Level

Linear Trend: 1.54 mm yr$^{-1}$
Changes in Extreme Sea Level

1. Direct
2. Indirect &
3. Storminess

Source: Hunter (2009)
The broader “human” dimension

- Vulnerability to climate change depends on a balance between environmental impacts and the community's capacity to adapt
  
  Source: CSIRO

- Australia is likely to become warmer, with less rainfall and more droughts in the south, uncertain rainfall changes in the north, more heatwaves, less snow, more fires, more heavy rainfall events and more intense cyclones

  Source: CSIRO
Drivers: Societal Issues

- Agriculture (land, rainfall)
- Storm surges
- Fisheries
- Maritime forecasts
- Safety & Rescue
- Environ. Mgmt
- Transport
- Industrial operations
- New technology/industry
- Defence
- Research and knowledge
- Financial sector
- Land use change
- Floods
- Drought/mitigation
- Haze
- ... Tourism
- ... Retail
- 10-20 d
- 1, 2, 4 yr
- diurnal

SOCIO Nov 2000
Caring for Our Country Project - Shark Bay
Effects of Rising Water levels on the Faure Sill and Stromatolites:

- 700K/ 3 years – Predicting the likely impacts of climate variability/ SL rise on the Hamelin Pool stromatolites
- WAMSI-led project: UWA, CSIRO, Curtin
- Oceanography, modeling, riverine inputs, ecological responses, future predictions, community engagement

Source: UWA
Reports saying “Climate Change Threats to WH Values” needs addressed – both State & Federal governments
Shark Bay at Present

- Semi-arid to arid climate - hot dry summers & mild winters
- Evaporation exceeds rainfall by a factor of 10
  - Mean annual precipitation ranges from 200 mm in the east to 400 mm in the far southwest
  - Mean annual evaporation ranges from 2000 mm in the west to 3000 mm in the east
- As a result, Shark Bay has a strong salinity gradient from marine (35 ppt) to hypersaline (70 ppt) in Hamelin Pool
Outstanding examples representing the major stages of the earth's evolutionary history

- Shark Bay contains the most diverse and abundant examples of stromatolitic microbialities in the world. The living cyanobacteria (*Scytonema*) still building stromatolites at Hamelin Pool are similar to the earliest Cyanobacterial life forms which dominated the earth for 3 billion years.
Outstanding examples representing significant ongoing geological processes, biological evolution and human interaction with the natural environment

- Shark Bay's enormous seagrass beds (>4000 km²)
- an impressive example of the role seagrasses play in modifying a whole marine ecosystem
- directly influence the physics, chemistry, biology and geology of the Bay.
Faure Sill = critical to WH values

Vulnerable to sea level rise and catchment runoff
The edge of the Faure Sill
WAMSI project addresses climate change impacts on SB World Heritage Values

- Potential climate variability change effects on WH values;
- Need for baseline information on the condition & extent of WH values & potential threats to the integrity of the values:
  - Catchment inputs from degraded agricultural land to the Shark Bay ecosystem;
  - Weather, water circulation and nutrient availability;
  - Coupling of inter-annual variability in weather, water level and wave regime data with monitored biological information;
  - Understanding the growth rates of the Faure Sill
Imagery from Modis
January floods
Project Components

1. Detailed habitat mapping & bathymetry of Faure Sill & Hamelin Pool
2. Effects of SL rise on circulation patterns & flushing
3. Historic river flow patterns for Wooramel River & climate variability over catchment
4. Likely response of Faure Sill & stromatolites to a range of physical drivers
5. Formal scenario development – communicating science predictions to stakeholders & mgmt agencies
6. Communication & Extension
Where we worked
Healthy *Amphibolis*
How?

- Detailed habitat mapping of the Faure Sill, Hamelin Pool and lower reaches of Wooramel River
- Prediction of sea level rise on circulation patterns and flushing rates of Hamelin Pool
- Historical analysis of rainfall changes
- Prediction of river discharge inputs into Shark Bay
- Likely seagrass and stromatolite responses to decreases in salinity and predicted increase in terrigenous sediment inputs into Hamelin Pool
- Microbial mats, stromatolites: likely risk zones and changes to tidal flat communities
Measuring likely responses?

- Field deployments of instruments to measure depth, light, salinity and sedimentation

- Detailed experimental investigations of potential effects of changed depth, light, temperature, salinity and sedimentation, and their interactions, on biota associated with the Faure Sill & its maintenance
Jim Fourquarean coring underwater
Collaboration

- Professor Jim Fourquarean, Florida, USA, (biogeochemistry and P availability)-
  - Workshop on the biogeochemistry of Shark Bay
    - Publication of management related results planned for later in the year
- Professor David Patterson, St Andrews, Scotland, (cyanobacterial mats, structure and coherence): short-term responses of stromatolites
Risk from Climate Change - summary

- Values depend on geomorphology & climate

- Any change to water circulation will affect all the values for which Shark Bay is listed!
Downscaling of future climate scenarios

Slide: R. Brinkman
‘MSL offset Method’

Source: I. Haigh (2010)
Sustainable Livelihood Assessment

Natural capital
- Fish resources
- Water quality
- Biodiversity

Physical capital
- Fishing gear and boats
- Processing equipment
- Markets
- Transport
- Housing
- Roads
- Jetties

Human capital
- Skills, knowledge, Education
- Health
- Access to information

Social capital
- Community groups
- Linkages between communities
- Exchange relationships
- Kinships

Financial capital
- Assets (convertibility into cash)
- Saving
- Credit availability
- Insurance

Slide: S. Metcalf, A climate change adaptation blueprint for coastal regional communities
Aim: Building industry & community knowledge ........ Early Warning!
Stakeholder consultation - 2011

- Public presentation 17\textsuperscript{th} May 2011 - Rose Freycinet Gallery, Discovery Centre, Denham

- Cheryl Cowell, Shire President, introduced the event

- Approximately 50 people attended with good feedback

- Attended for WAMSI: Dr Steve Blake, Professor Di Walker, Professor Lindsay Collins, Ms Linda McGowan, Professor Peter Fears, Dr Wojciech Klonowski, Dr Geir Johnsen, Dr Mat Vanderklift
Stakeholder consultation – 2012

- 8th August – Suggested public presentation evening [venue: Rose Freycinet Gallery, Discovery Centre, Denham?]

- 9th August – WAMSI Board Meeting

- 10th August – Scenario Planning Workshop for stakeholders [venue – TBA]

- Circulation of finalised scenario documents – soon after
Ongoing marine & climate-related challenges for the region