SROCC  Chapter 5

Changing Ocean, Marine Ecosystems & Dependent Communities

Phil Williamson
NERC/UKRI & University of East Anglia
Extra heat in the Earth system
(93% in the ocean, 3% to cryosphere, 3% to land surface and only ~1% in the atmosphere)

From poles to equator
From beach to abyss

Ocean impacts
Observed and projected

Globe: pixy.org
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- Mixing & circulation
- Sea-level rise
- De-oxygenation

Extra CO₂: Ocean acidification

- Sea-ice cover
- Storms & heat waves
- Nutrient supply
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With knock-on impacts on ecosystem services and human society
But are we sure that these changes are really happening?

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ALL AFFECTING ORGANISMS & ECOSYSTEMS

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**Observed regional impacts on ocean physics, ecosystems and ecosystem services**

<table>
<thead>
<tr>
<th>Attribution</th>
<th>Arctic</th>
<th>EBUS 1</th>
<th>North Atlantic</th>
<th>North Pacific</th>
<th>South Atlantic</th>
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| Climate Change | Upper water column | ![icon](image51) | ![icon](image52) | ![icon](image53) | ![icon](image54) | ![icon](image55) | ![icon](image56) | ![icon](image57) | ![icon](image58) | ![icon](image59) | ![icon](image60) |
| | Coral | ![icon](image61) | ![icon](image62) | ![icon](image63) | ![icon](image64) | ![icon](image65) | ![icon](image66) | ![icon](image67) | ![icon](image68) | ![icon](image69) | ![icon](image70) |
| | Coastal wetlands | ![icon](image71) | ![icon](image72) | ![icon](image73) | ![icon](image74) | ![icon](image75) | ![icon](image76) | ![icon](image77) | ![icon](image78) | ![icon](image79) | ![icon](image80) |
| | Kelp forest | ![icon](image81) | ![icon](image82) | ![icon](image83) | ![icon](image84) | ![icon](image85) | ![icon](image86) | ![icon](image87) | ![icon](image88) | ![icon](image89) | ![icon](image90) |
| | Rocky shores | ![icon](image91) | ![icon](image92) | ![icon](image93) | ![icon](image94) | ![icon](image95) | ![icon](image96) | ![icon](image97) | ![icon](image98) | ![icon](image99) | ![icon](image100) |
| | Deep sea | ![icon](image101) | ![icon](image102) | ![icon](image103) | ![icon](image104) | ![icon](image105) | ![icon](image106) | ![icon](image107) | ![icon](image108) | ![icon](image109) | ![icon](image110) |
| | Polar benthos | ![icon](image111) | ![icon](image112) | ![icon](image113) | ![icon](image114) | ![icon](image115) | ![icon](image116) | ![icon](image117) | ![icon](image118) | ![icon](image119) | ![icon](image120) |
| | Sea-ice-associated | ![icon](image121) | ![icon](image122) | ![icon](image123) | ![icon](image124) | ![icon](image125) | ![icon](image126) | ![icon](image127) | ![icon](image128) | ![icon](image129) | ![icon](image130) |

| Human systems and ecosystem services | Fisheries | ![icon](image131) | ![icon](image132) | ![icon](image133) | ![icon](image134) | ![icon](image135) | ![icon](image136) | ![icon](image137) | ![icon](image138) | ![icon](image139) | ![icon](image140) |
| | Tourism | ![icon](image141) | ![icon](image142) | ![icon](image143) | ![icon](image144) | ![icon](image145) | ![icon](image146) | ![icon](image147) | ![icon](image148) | ![icon](image149) | ![icon](image150) |
| | Habitat services | ![icon](image151) | ![icon](image152) | ![icon](image153) | ![icon](image154) | ![icon](image155) | ![icon](image156) | ![icon](image157) | ![icon](image158) | ![icon](image159) | ![icon](image160) |
| | Transportation/shipping | ![icon](image161) | ![icon](image162) | ![icon](image163) | ![icon](image164) | ![icon](image165) | ![icon](image166) | ![icon](image167) | ![icon](image168) | ![icon](image169) | ![icon](image170) |
| | Cultural services | ![icon](image171) | ![icon](image172) | ![icon](image173) | ![icon](image174) | ![icon](image175) | ![icon](image176) | ![icon](image177) | ![icon](image178) | ![icon](image179) | ![icon](image180) |
| | Coastal carbon sequestration | ![icon](image181) | ![icon](image182) | ![icon](image183) | ![icon](image184) | ![icon](image185) | ![icon](image186) | ![icon](image187) | ![icon](image188) | ![icon](image189) | ![icon](image190) |

1 Eastern Boundary Upwelling Systems (Benguela Current, Canary Current, California Current, and Humboldt Current); [Box 5.3]
Observed regional impacts on ocean physics – also covered in other talks

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Arctic</th>
<th>North Atlantic</th>
<th>North Pacific</th>
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<td>⬆️</td>
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<td>Sea-ice extent</td>
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Summary of changes: 20↑ 20↓ 5↕ and confidence: 12 ●●● 19 ●● 14 ●
Observed regional impacts on ocean ecosystems

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<th>Arctic</th>
<th>EBUS 1</th>
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<td>Kelp forest</td>
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<td>Rocky shores</td>
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<td>Sea-ice-associated</td>
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</table>

Summary of changes: 2 + 30 - 5 +/- and confidence: 6 ●●● 24 ●● 10 ●
**Observed** regional impacts on ocean ecosystem services & human society

<table>
<thead>
<tr>
<th>Human systems and ecosystem services</th>
<th>Fisheries</th>
<th>Tourism</th>
<th>Habitat services</th>
<th>Transportation/shipping</th>
<th>Cultural services</th>
<th>Coastal carbon sequestration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>![Fishing boat](Jon Anderson/Flickr)</td>
<td>![Tourism](Jon Anderson/Flickr)</td>
<td>![Habitat](Jon Anderson/Flickr)</td>
<td>![Transportation](Jon Anderson/Flickr)</td>
<td>![Cultural](Jon Anderson/Flickr)</td>
<td>![Sequestration](Jon Anderson/Flickr)</td>
</tr>
</tbody>
</table>

Summary of changes: 2 + 35 - 4/+ - and confidence: 1 ●●● 14 ● 23 ●

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1 Eastern Boundary Upwelling Systems (Benguela Current, Canary Current, California Current, and Humboldt Current); (Box 5

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Changes
- positive
- negative
+/- positive and negative

Attribution confidence
- ●●● high
- ● medium
- ● no assessment

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Glen R Specht

Jesus M Castillo
Current status and projected impacts on ocean ecosystems for two emission scenarios

(a) Simulated net primary production

RCP 2.6 (low emissions)

RCP 8.5 (high emissions)

SPM Fig 3a
Current status and projected impacts on ocean ecosystems for two emission scenarios

RCP 2.6 (low emissions)

RCP 8.5 (high emissions)

Percent change
Average by 2081-2100, relative to 1986-2005

SPM Fig 3b
Current status and projected impacts on ocean ecosystems for two emission scenarios

(c) Maximum fisheries catch potential

RCP 2.6 (low emissions)

RCP 8.5 (high emissions)

IPCC
Projected impacts & risks on ocean ecosystems

Global mean sea surface temperature (SST) change relative to pre-industrial levels (°C)

Confidence level for transition:
- •••• = Very high
- ••• = High
- •• = Medium
- • = Low
- | = Transition range

SPM Fig 3d
Projected impacts & risks on ocean ecosystems

Global mean sea surface temperature (SST) change relative to pre-industrial levels (°C)

- Present day
- Warm water corals
- Kelp forests
- Seagrass meadows
- Epipelagic**
- Rocky shores
- Salt marshes
- Cold water corals
- Estuaries
- Sandy beaches
- Mangrove forests
- Abyssal plains

Confidence level for transition:
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- • = Low
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Projected impacts & risks on ocean ecosystems

- RCP 8.5 (high emissions)
- RCP 2.6 (low emissions)

Temperature by 2100:
- 4°C
- 3°C
- 2°C
- 1°C
- Present day (2006-2015)

Warm water corals

Confidence level for transition:
- = Very High
- = High
- = Medium
- = Low
- = Transition range

Level of added impacts/risks from climate change:
- Very high
- High
- Moderate
- Undetectable
Warm water corals are already being seriously affected by warming (heat waves causing coral bleaching), ocean acidification and storm damage – as well as pollution and other stressors.
Projected impacts & risks on ocean ecosystems

- Seagrass meadows
- Salt marshes
- Mangrove forests

Global mean sea surface temperature (SST) change relative to pre-industrial levels (°C)

- Warm water corals
- Kelp forests
- Rocky shores
- Estuaries
- Sandy beaches
- Abyssal plains

Present day
Projected impacts & risks on ocean ecosystems

| Global mean surface temperature (GMST) change relative to pre-industrial levels (°C) |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 5                               | 4                               | 3                               | 2.5                             | 2                               | 1                               | 0                               |
| present day                     |                                 |                                 |                                 |                                 |                                 |                                 |
| Warm water corals               | Kelp forests                     | Seagrass meadows                | Epipelagic**                    | Rocky shores                    | Salt marshes                    | Old water corals                |
|                                 |                                 |                                 |                                 |                                 |                                 | Estuaries                       |
| Sandy beaches                   | Mangrove forests                 | Abyssal plains                  |                                 |                                 |                                 |                                 |

‘blue carbon’ ecosystems provide coastal protection, carbon storage & biodiversity support
The rate of future climate change is a critical factor for the integrity of many coastal ecosystems e.g. response to sea level rise.
"This assessment reveals the benefits of ambitious mitigation and effective adaptation for sustainable development ... [and] highlights the urgency of prioritising timely, coordinated and enduring action (very high confidence)"

SROCC SPM C4.7
Thanks for your attention!

p.williamson@uea.ac.uk