Key findings of the AMAP Arctic Ocean Acidification report - the need for ecosystem sensitivity research

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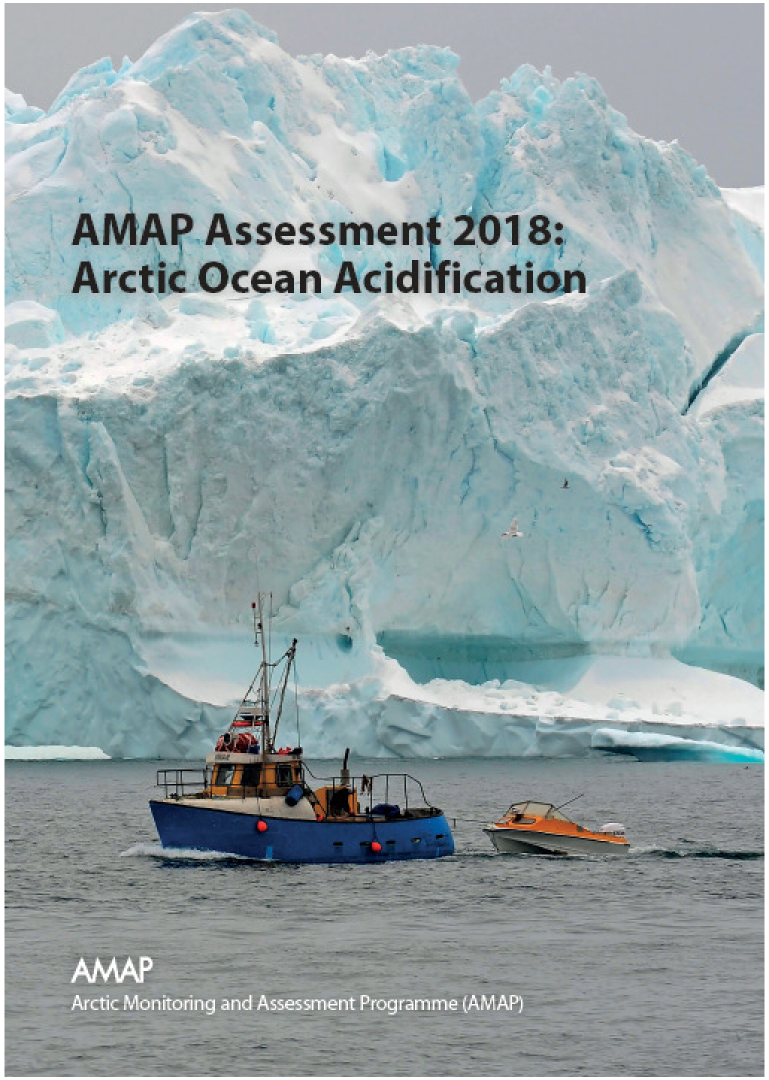
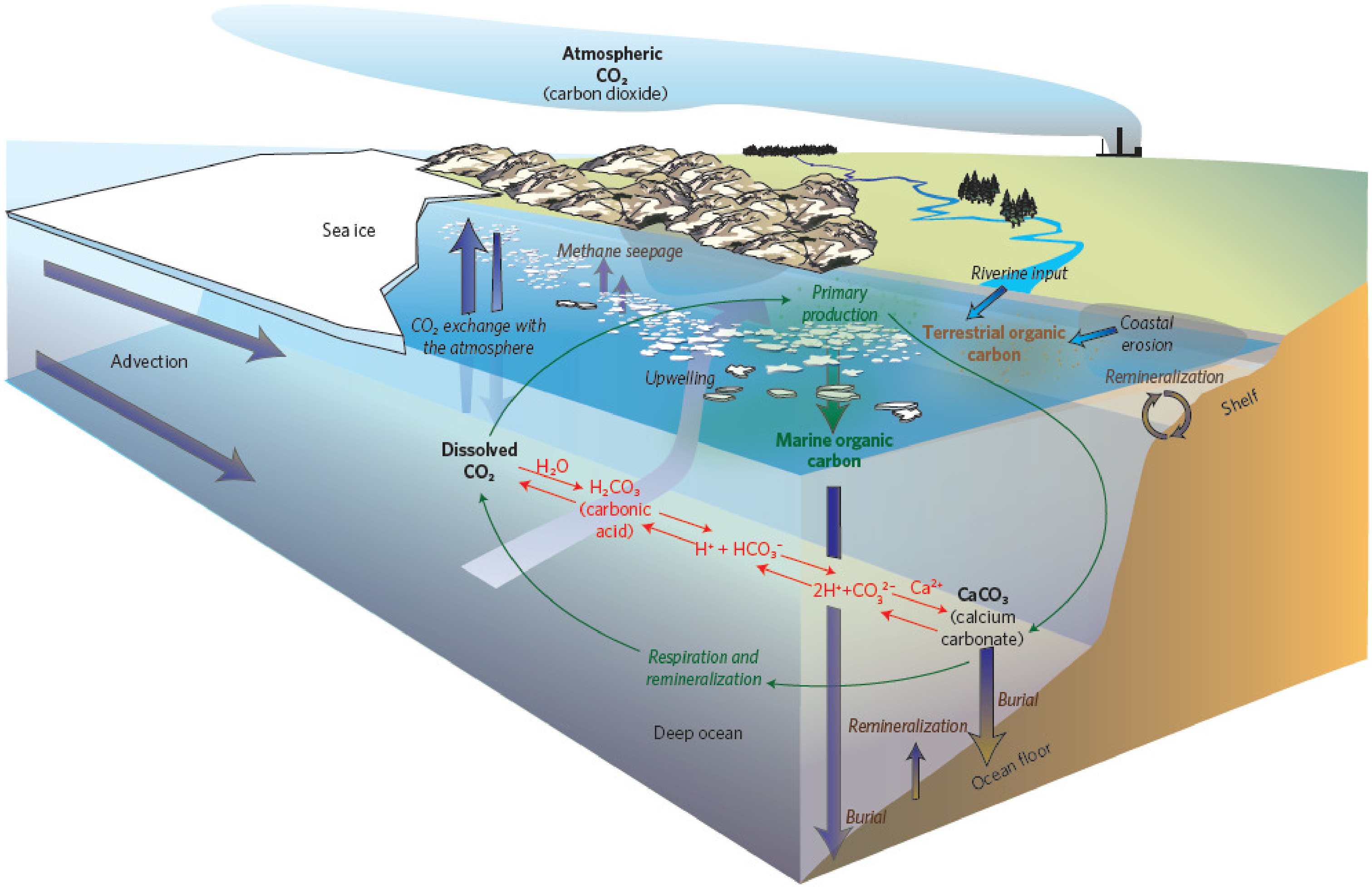
AOA 2018 report has just been published



3. Biological responses to ocean acidification

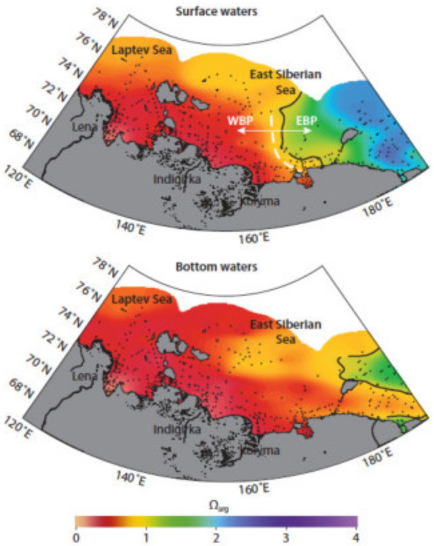
Processes controlling the carbonate system in the Arctic



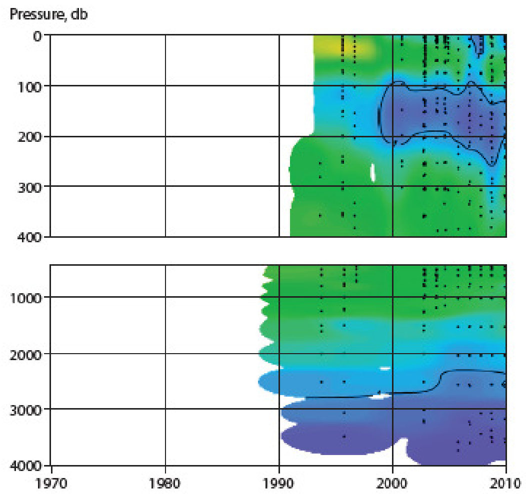
Bellerby 2017. *Nature Climate Change*

The Arctic is acidifying; with strong local to regional variability

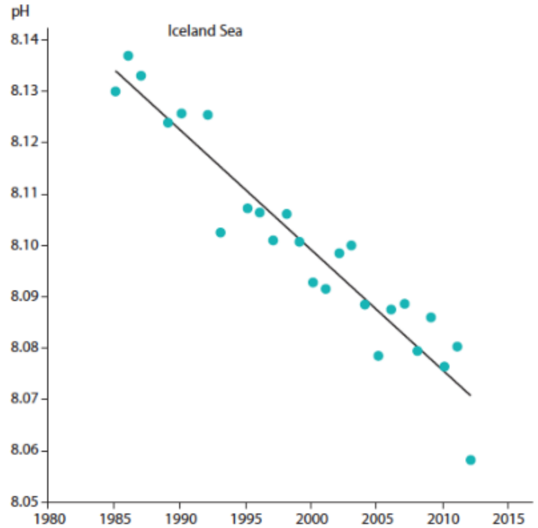
East Siberian Shelf



Canada Basin



Iceland Sea



Greenland Sea

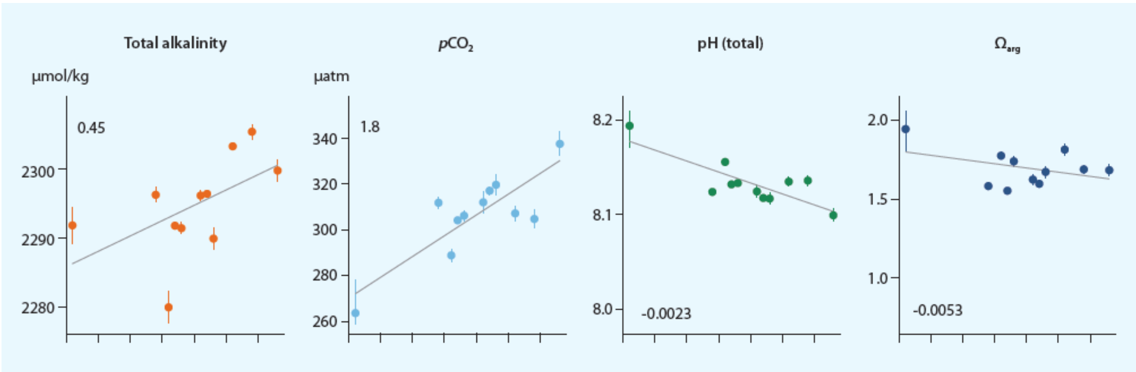
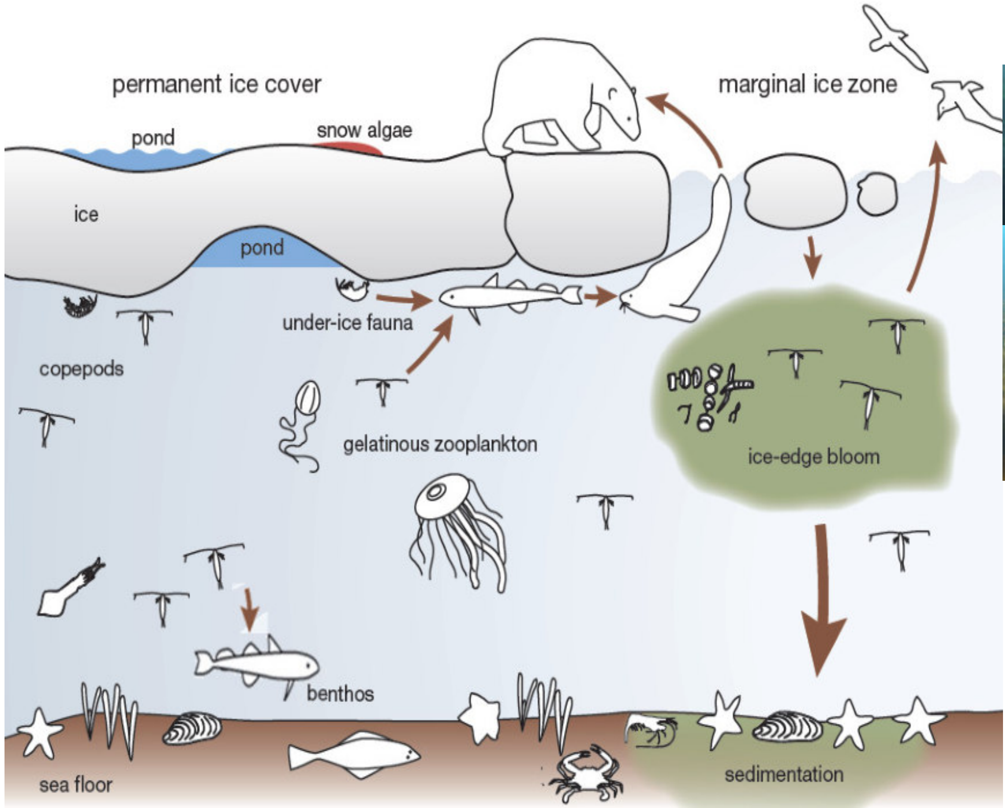
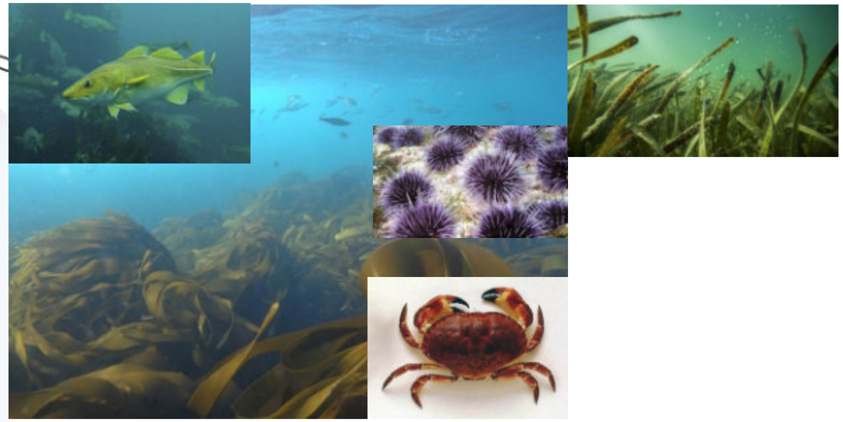


Table A3.1 cont.

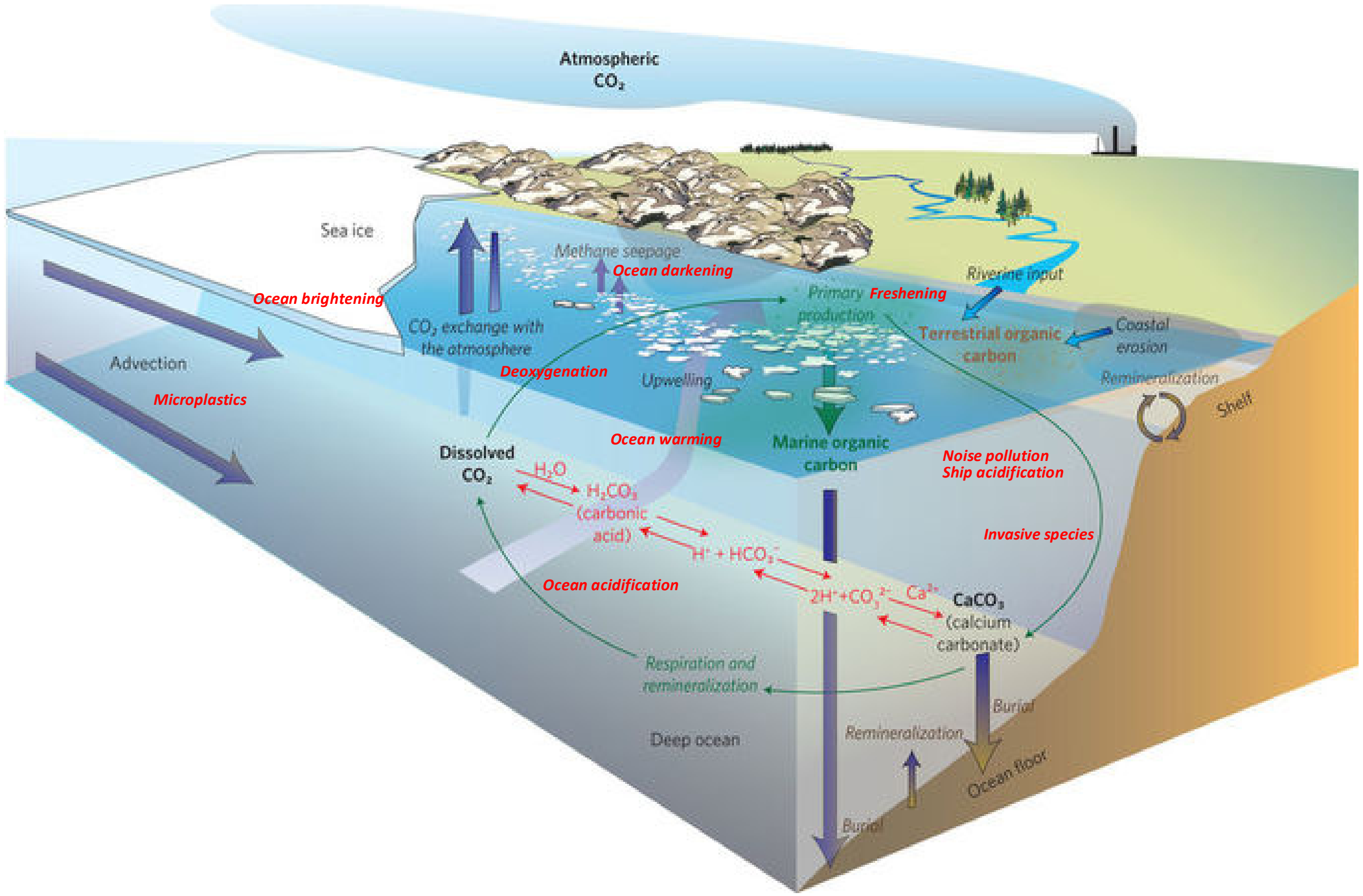
Section / Source	Study species / community / assemblage		Location	Ocean acidification treatment: CO_2, µatm		CO_2, ppm		pH	
				-	↓↑	-	↓↑	-	↓↑
Wood et al. 2008	Brittlestar	*Amphiura filiformis*	UK					8	7.7, 7.3, 6.8
Dupont et al. 2008	Brittlestar	*Ophiothrix fragilis*	Sweden					8.1	7.9, 7.7
Chan et al. 2015	Sea urchin / Brittlestar	*Strongylocentrotus purpuratus / Amphiurafiliformis*	USA / Sweden	458±32 / 425±13	1078±48, 2993±188 / 1126±83				
Hu et al. 2014a	Brittlestar	*Amphiura filiformis*	Sweden					8.1	7.6, 7.3, 7.0
Gonzalez-Bernat et al. 2013	Seastar	*Odontaster validus*	Antarctica	327	691, 1130, 4604				
Dupont and Thorndyke 2012	Sea urchin, Seastar	*Strongylocentrotus droebachiensis, Leptasterias polaris*	Arctic	350	1275				
Verkaik et al. 2016	Sea cucumber	*Cucumaria frondosa*	Newfoundland	446±22	1427±100				
Yuan et al. 2016	Sea cucumber	*Apostichopus japonicus*	China			~380	~750, 1900		
Morita et al. 2010	Coral, Sea cucumber	*Acropora digitifera, Holothuria spp.*	Japan			400-475	775-1005, 930-1260, 905-1660, 2115-3585, 12600-21100		
Yuan et al. 2015	Sea cucumber	*Apostichopus japonicus*	China	601±10	962±15, 1441±21, 2801±25				
3.2.9 / Crustaceans									
Bailey et al. 2016	Copepod	*Calanus glacialis*	Svalbard	530	320, 800, 1700				
Bailey et al. 2017	Copepod	*Calanus glacialis*	Svalbard	530	320, 800, 1700				
Thor et al. 2016	Copepod	*Calanus glacialis*	Svalbard	335-361	871-1060				
Thor et al. 2018a	Copepod	*Calanus glacialis*	Svalbard (Kongsfjord / Billefjord) / West Greenland	450±95 / 446±93 / 436±64	712±134 to 18567±2163 (8 treatments) / 638±49 to 4526±499 (6 treatments) / 721±91 to 19456±3521 (8 treatments)				
Hildebrandt et al. 2014	Copepod	*Calanus glacialis, Calanus hyperboreus*	Fram Strait	390	3000				
Hildebrandt et al. 2016	Copepod	*Calanus finmarchicus, Calanus glacialis*	Fram Strait	390	1120, 3000				
Weydmann et al. 2012	Copepod	*Calanus glacialis*	Svalbard					8.2	7.6, 6.9
Thor et al. 2018b	Copepod	*Calanus glacialis*	Svalbard					~8.0	~7.5
Niehoff et al. 2013	Mesozooplankton community		Svalbard	185	270, 375, 480, 685, 820, 1050, 1420				
Engel et al. 2013	Plankton community		Svalbard	178	180, 255, 345, 435, 611, 701, 892, 1136				
Walther et al. 2011	Spider crab	*Hyas araneus*	Germany, Svalbard			380	710, 3000		
Schiffer et al. 2014	Spider crab	*Hyas araneus*	Sweden	450	3300				
Zittier et al. 2013	Spider crab	*Hyas araneus*	Svalbard	380	750, 1120, 3000				
Long et al. 2013	Red king crab, Tanner crab	*Paralithodes camtschaticus, Chionoecetes bairdi*	Alaska	438±9	792±7, 1638±14				
Appelhans et al. 2012	Seastar, Green crab	*Asterias rubens, Carcinus maenas*	Baltic Sea	650	1250, 3500				
Fehsenfeld and Weihrauch 2013	Green crab	*Carcinus maenas*	Canada					7.7	7
Fehsenfeld et al. 2011	Green crab	*Carcinus maenas*	Baltic Sea					8.00-8.12	7.24-7.36
Hammer et al. 2012	Green crab	*Carcinus maenas*	Norway	~490	~ 2600, 7600, 16000, 30000				
Arnold et al. 2009	European lobster	*Homarus gammarus*	UK			380	1200		
Small et al. 2016	European lobster	*Homarus gammarus*	UK	450	1100, 9000				
Agnalt et al. 2013	European lobster	*Homarus gammarus*	Norway	~690	750, 1200				
Bechmann et al. 2011	Shrimp / Mussel	*Pandalus borealis / Mytilus edulis*	Norway	368-361 / 419-469	1291-1332 / 1388-1493				

Ecosystem effects





The Arctic Ocean ecosystem is coming under increasing pressure from multiple stressors



Adapted from Bellerby 2017. *Nature Climate Change*

Recommendations 1

- **The effects of acidification, in combination with other stressors, are highly uncertain.** That uncertainty is compounded when other environmental, social and economic responses and trends are also considered. **There is a need for multi-stressor research into how species are likely to respond.**

- **Ecosystem changes should be monitored in such a way that allows for the identification and differentiation of the impact of each stressor on the ecosystem, as well as the potential synergistic effects of multiple combined stressors.**

Recommendations 2

- Monitoring should also be extended to the North Atlantic, given the biological, commercial and subsistence importance of fisheries in these waters and the impact of outflow of increasingly acidified water from the Arctic basin.

- **There is a need for more Arctic-specific research into acidification and its effects, whether regarding impacts on species, habitats or economic consequences. Currently, the lack of such research means many findings are extrapolated from research undertaken in other geographic regions.**

Recommendations 3

- **Indigenous and traditional knowledge has been included to a very limited extent, and future work would benefit from actively involving local communities in monitoring and research projects.**

- **There is a need for research into longer-term responses of Arctic species and ecosystems to ongoing environmental change. Laboratory research into physiological responses and genetic adaptation will be key to improving predictions of these responses over time.**

Recommendations 4

- Enhancing research and monitoring of Arctic Ocean acidification must continue to be a high priority within the Arctic Council to promote cooperation between Arctic countries.

- **There is need for a unified monitoring program to harmonize and support adaptation actions in the Arctic and also to provide Arctic communities with the tools and training to conduct local, unified research and monitoring.**

A new international working group on ocean services in marginal seas

Co-Chairs: **Prof. Richard Bellerby (SKLEC-NIVA, Shanghai/Bergen)**
Prof. Su Mei Liu (Ocean University of China, Qingdao)

- Identify key system services, stakeholders, regulatory institutions and process
- Identify recent historical and present variability in marginal seas services
- Couple environmental and ecological change to services
- Develop scenarios of future marginal seas services
- Optimise boundary conditions towards informed co-adaption to coastal change

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