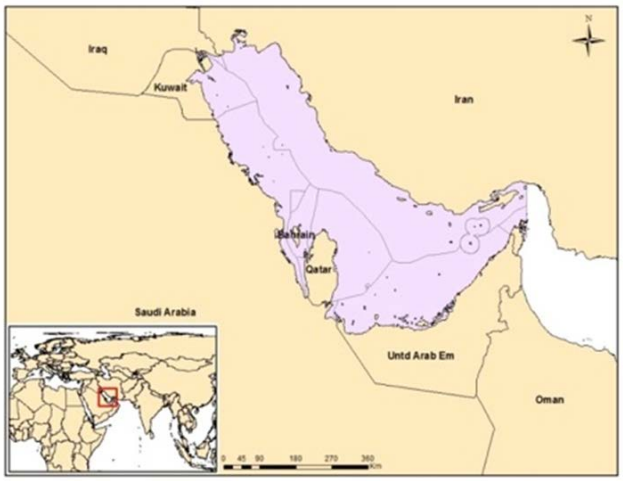
CONCEPTUAL OVERVIEW
Marine Biodiversity & Climate Change

William W. L. Cheung (Principal Investigator)
University of British Columbia.
Co-Authors
Vicky Lam, Gabriel Reygondeau, Lydia Teh, Colette Wabnitz,
Dalal Al-Abdulrazzak, Myriam Khalfallah, Deng Palomares, Dirk Zeller, and Daniel Pauly

Marine biodiversity, ecosystem health and fisheries are currently threatened by overfishing, but also by pollution and other anthropogenic impacts. Climate change further challenges our ability to devise sustainable management and conservation plans to maintain ecosystem services, as it has begun to alter ocean conditions, particularly water temperature and various aspects of ocean biogeochemistry. Marine biodiversity responds to shifting temperatures and other ocean conditions through changes in organismal physiology and phenology, as well as population dynamics and distributions. These responses to ocean–atmospheric changes have been projected to lead to altered patterns of species richness; changes in community structure ecosystem functions; and consequential changes in marine goods and services.

Given the unique characteristics of the Arabian Gulf - particularly its extreme environmental conditions, the array of human disturbances it is exposed to, and the high sensitivity of its biota to environmental fluctuations as species are close to their environmental limits - climate change should have substantial implications for its marine ecosystems and fisheries. Extreme seasonal temperatures and salinity fluctuations select for species with high tolerance or adaptability to such short-term changes creating a 'provincial barrier' for short-range endemics. Consequently, the Gulf is a region that is relatively species poor, at least in comparison with the open Indian Ocean. However, as part of the Western Indian Ocean province of the Indo-West Pacific ecoregion, which hosts a very distinct assemblage of species, the Gulf is considered a biologically valuable region.

Figure 1: The Arabian Gulf study region



The overall aim of the study was to provide a comprehensive assessment of the potential vulnerability of marine biodiversity and fisheries in the Arabian Gulf to climatic change. This involved three major activities, (1) assessment of the status and trends for biodiversity and fisheries in the Arabian Gulf using local and internationally available data; (2) application of simulation modelling approaches to assess the climate change impacts to, and vulnerability of, selected marine biodiversity and fisheries that are considered priority species in the region; and (3) exploring the implications of these impacts for conservation and fisheries management policies for the region. The focus of the study was on 55 priority species encompassing the most important commercial fish species (47), charismatic species (5), and seagrass species (3) in the Arabian Gulf (see Figure 1).

Marine biodiversity, distribution, and biology data for the Gulf was extracted from FishBase (www.fishbase.org) and SeaLifeBase (www.sealifebase.org) after enriching these databases with local data from stakeholders. Fishery catch reconstructions was undertaken for each country in the Gulf region from 1950 to 2010. The vulnerability assessment incorporated information of current and future conditions in Gulf waters. For current conditions, environmental parameters known to influence marine species distribution were gathered at a global gridded scale, including sea surface/bottom temperature, salinity, nutrient concentrations from the World Ocean Atlas. For conditions in the Gulf under climate change, outputs from the LNRCCP's regional ocean modelling sub-project were used for the current (2000-2020) and future (2080-2100) periods (Edson et al. 2015) based on Representative Concentration Pathway (RCP) 8.5. The rate of species invasion, rate of species local extinction, and sum of habitat suitability under climate change were modelled using the NPPEN, ENFA, and BIOCLIM models. A large number maps were developed, detailed results of which are available online at the Marine Biodiversity & climate change Inspector (www.ccr-group.org/marinebiodiversity).

Climate change is projected to have significant adverse impacts on commercial fisheries in the Gulf. The models project a high rate of local extinction in the Arabian Gulf by 2090 relative to 2010 under the RCP 8.5 scenario. Spatially, local extinction is highest in the southwestern part of the Arabian Gulf, off the coast of Saudi Arabia, Qatar and the UAE. In contrast, species invasion is limited to small areas in the northern part of the Arabian Gulf, off the coast of Kuwait and northern Iran. There is general agreement for these conclusions across all three models' results.

For the charismatic species, results showed varying ranges of loss in habitat suitability. For dugongs, the Arabian Gulf is currently the major remaining habitat, after Northern Australia. Projections from the BIOCLIM and NPPEN models showed that the Gulf would become less hospitable to dugong, particularly around the southwestern region such as the waters around Bahrain. For green and hawksbill turtles, projections from BIOCLIM and NPPEN showed a loss of habitat suitability around the southwestern parts of the Gulf and near the Strait of Hormuz. Overall, the highly migratory nature of marine turtles, and their ability to move considerable distances in short periods of time, should increase their resilience to climate change. In the context of the Arabian Gulf, this may mean that turtles may come to spend less time in the

region. For Indo Pacific dolphins, habitat suitability, the model projections showed loss of habitat suitability particularly around the southwestern parts of the Gulf, and extending to Bahrain and Qatar.

Impacts of climate change on marine biodiversity can be moderated by reducing stresses from overfishing and destructive fishing practices; habitat degradation; pollution and runoff; oil and gas exploration; land-use transformation, land reclamation and sedimentation; as well as invasive species. Therefore, effective implementation of ecosystem-based management that considers a much wider range of environmental and human stressors is fundamental to increasing the adaptive capacity of marine social-ecological systems to climate change. This includes strengthening the implementation and enforcement of current regulations and agreements to protect marine resources in the Arabian Gulf. Adaptive marine conservation and management is also important in uncertain future ocean ecosystems.