Climate change and the energy transition

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Marine and coastal environments are amongst the areas most threatened by climate change. Climate change is having and will, in the future, have even greater impacts, on fisheries, aquaculture, livelihoods and living space in the coastal zone. It will also have profound if uncertain impacts on coastal and marine ecosystems.

The complexity of coastal, marine or other water based socio-ecological systems makes responding effectively to these climate-induced changes challenging. However, there is scope for adaptive responses to climate change. In addition, such areas also have significant potential to mitigate climate change through on-shore and offshore renewable energy systems and through public sector, business and household initiatives to reduce emissions.

Physical and ecological changes

We cannot look at the sea in isolation from the land. It is connected to freshwater systems through rivers, snow and ice-melt. Increased flooding and water volumes affect salinity, with the capacity for introducing increased quantities of phosphates, nitrates and other pollutants from inland areas. Whether dealing with open oceanic coastal zones or largely enclosed seas like the Black Sea, the Baltic and the Mediterranean, these wider system connections must be acknowledged.

The basic physical and chemical relationships associated with climate change in coastal and marine areas are shown in Figure 1. Increased temperature caused by greenhouse gas (GHG) increases leads to the acidification of seawater. Increased air and water temperatures increase storm events, temperature gradients and cause more upwelling. The occurrence of oxygen shortages in shallow coastal and estuarine waters also appears to be increasing, almost certainly accelerated by human activities. Such changes tend to be seasonal and often lead to algal blooms, as seen in the Baltic Sea and the Black Sea, where overfishing compounds the problems of changing fisheries ecologies. These physical and chemical changes trigger a wide range of adverse responses in marine ecosystems, which are often compounded by other human factors.

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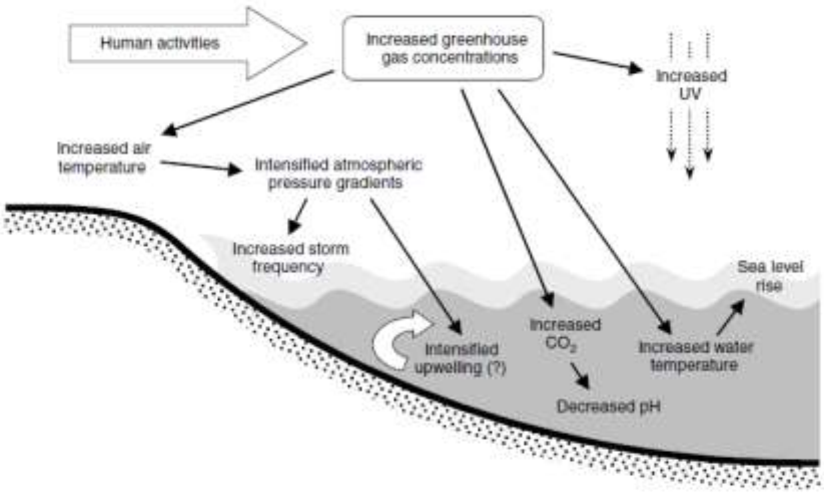

Figure 1 Physical and chemical changes in coastal and marine systems associated with climate change[2]

The ecological responses of marine and coastal ecosystems may be profound and potentially irreversible. Food webs are likely to change dramatically and food chains alter. Small changes can trigger bigger changes leading to amplified feedback loops. Fisheries, especially coastal fisheries and aquaculture, could be more affected by diseases, with devastating consequences for productivity. The changes will impact on fish breeding and larvae of quarry species and food chains.

The impact on fisheries communities will have a high geographical variability. Some local fisheries communities may be very severely impacted, while others will have much more room for manoeuvre. There will be enormous challenges in assessing just how these biological and physic-chemical forces might interact.

Impact assessment

We need to better understand impacts. Coastal and marine systems will be affected by climate change in different ways. Increased temperature and increased acidification will interact with other biophysical factors to produce very significant impacts on marine and coastal ecosystems. These impacts could directly affect human systems or on the bio-physical systems on which society depends.

Given the importance of anticipated temperature changes in Mediterranean regions, it is possible that extreme summer temperatures could drive coastal tourism northwards. As well as affecting tourism, temperature may also impact on retirement and lifestyle migration, reducing the 'livability' of certain regions and damaging the residential economy.

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[2] Harley C.D., Randall Hughes, A., Hultgren, K.M., Miner, B.G., Sorte, C.J., Thornber, C.S., Rodriguez, L.F., Tomanek, L. and Williams, S.L., (2006) The impacts of climate change in coastal marine systems. ***Ecol. Lett.*** 9(2):228-41

Different groups will be affected in different ways by extreme weather events. Increased flood and storm damage will disrupt communications systems and lead to power outages and damaged properties and harbours. Those living next to the sea will be particularly affected. Coastal erosion and inundation is likely to increase affecting coastal farmland. Prolonged periods of high temperatures are also a threat to tourism operators. Extreme droughts can impact the coastal hinterlands by reducing water supplies. Storm, heat and drought impacts will be profound.

It is widely expected that the major European marine areas are also likely to be affected in different ways by climate change. The warming in basins such as the Mediterranean and the Black Sea is likely to have profound negative effects, whereas warming of more northerly waters appears to be impacting positively on phyto- and zoo-plankton production and offers the prospect of increased fish catches.

The hotspots of change are likely to be those seas where climate change and other human-induced changes such as fishing, nutrient enrichment or runoff interact to produce great uncertainty in projections on the future state of marine ecosystems. Using the example of the Baltic Sea, we can see just how complicated it is to understand the effects of these interacting stressors on the marine and coastal system. Though intensively studied, the impact of multiple changes of climate and other factors on marine food webs in the Baltic remains inadequately understood.

Climate change can also adversely impact on aquaculture, although this is also likely to be very geographically varied, with modest warming of northern waters possibly enhancing productivity. However, increased algal blooms and increased disease risk will also occur.

What happens in the sea may have repercussions for what happens to migratory fish of both conservation and river fishery importance. Freshwater eel populations have been in steep decline. Atlantic salmon populations have been very volatile with downward trends in many rivers. The relationship between climate change and ecology is still not fully understood.

Energy developments also impact on marine ecologies. The bases of offshore wind turbines can form artificial reefs which benefit fish populations, but installations can impact adversely on birds through turbine inflicted mortality, and commercial fishing can be impeded by cables and structures. Coastal locations also have potential for renewable energy production from tidal barrages and lagoons and onshore wind to take advantage of higher average wind speeds. The construction and operation of tidal barrages do, however, raise numerous ecological concerns.

Adaptation

Adaptation seeks to reduce risks and adverse impacts and increase community resilience. Studies have noted how a lack of capacity to adapt can increase vulnerability.

Adaptation in marine and coastal situations takes place within a complex frame of multi-level governance. This requires the scale and agency of decision-making to be defined. Complex property rights and regulation of common resources makes the design, delivery, management and governance of adaptive responses very challenging. Adaptation that involves a strategic response to, say, the risk of inundation or floods can rarely be at the individual or household level, and the resourcing and powers of local government are likely to be crucial, as well as highly variable, across Europe.

Local communities often lobby for hard engineering solutions, even where evidence increasingly suggests that these can compound the problem from a physical geography perspective. There may be unforeseen effects when an approach that produces a solution to a problem in one area (e.g. coastal defences) actually exacerbates the problem of coastal erosion in another area. Hard engineering solutions can, at times, run counter to the biophysical realities.

In the marine environment, vested interests inevitably lobby for outcomes that best serve their specific needs, but there is often a zero sum game. Not everyone can be winners. The poor, the weak and those with the least well defined property rights are often the greatest losers in terms of adverse impacts.

Adaptation requires making decisions under uncertainty. Enhanced knowledge can reduce uncertainty. In seeking solutions, local knowledge may conflict with scientific knowledge. Different interests may draw on different types of knowledge. There is often scepticism from the public about whether strategies like 'managed retreat' of the coastline by breaching existing defences in a planned way can deliver positive outcomes. It seems too much like giving up.

Not all adaptation should be presumed to be a struggle against negative consequences. Especially in northern communities, the increase in primary production may increase feed availability for quarry species and impact positively on fish populations.

The scope for mitigation

Mitigation involves reducing emissions of greenhouse gasses (GHGs). The key principle of mitigation is to understand the sources of emissions and then seek to cost-effectively reduce them by undertaking appropriate actions.

First, it is necessary to identify the entities that generate emissions. Ideally, we should be thinking about supply chains and life cycle analysis but in practice the entities considered are often businesses or households or whole sectors such as energy or transport, with emissions estimated using defined IPCC[3] rules. Given that emissions can be highly variable between units of a similar type, there is a need for accurate estimates at an individual business or household level.

Arguably, the coastal economy demands a life cycle approach. It is not possible to look at the GHG emissions of tourism on, say, an Aegean island without considering the GHG footprint of the flights that carry tourists to and from the island. Neither can we ignore the GHG footprint of a Scottish maritime fishery that exports large volumes of fish and shellfish by chilled/frozen road freight to Spain or France.

Emissions reduction can arise through adoption of more energy-efficient technologies, which is also likely to be driven by rising fuel costs or by substituting biofuels. Many NGOs and government agencies now provide support to businesses to reduce emissions.

Households are a major source of emissions. Micro-generation of renewables (solar PV, solar thermal, small-scale turbines) and better insulation both have the capacity to reduce emissions, as do lifestyle changes which reduce energy consumption. The use of private cars and the nature of

[3] Intergovernmental panel on climate change (IPCC)

leisure activities also have the capacity to impact significantly on energy consumption. Fisheries and coastal communities can play their part in addressing the need to reduce emissions.

Marine and coastal areas are recognised as having considerable potential for renewable energy production, but the normalised costs still remain rather high, for example, if you compare off-shore and on-shore wind energy production. There has been a substantial investment in technology but, particularly with tidal and wave power, the promise of large amounts of energy has yet to be realised. Offshore wind is developing very fast, but not without controversy.

Investments in coastal and marine renewables have become a major part of development strategies, from greening development in Aegean and Baltic islands to high-quality inward investment (of high tech research firms and university out-stations) in Orkney (Scotland, UK), close to one of the highest potential tidal resources in Europe, in the Pentland Firth (Scotland, UK). Some islands have promoted green development strategies, often with initial reluctance from some citizens, but with some significant success stories, such as El Hierro (Canary Islands, Spain) or Samsø (Denmark).

Community or municipal ownership of coastal and marine renewables can offer an attractive development option, but regulatory environments range from very favourable in Germany and Denmark to neutral or even negative in other countries.

Creating transformative capacity to engineer the shift in smaller fishing communities, from a predominantly fishing basis for livelihoods to an energy-based system, has already happened in relation to the non-renewable oil and gas industry in the North Sea. Many firms that became prominent in North Sea offshore oil and gas exploitation grew out of fisheries businesses. The same needs to happen with marine renewables.

What role for FLAGs?

In line with the three broad strategic responses presented above (**impact assessment, adaptation and mitigation**), FLAGs present high potential to support community action in relation to climate change and energy transition.

Still, given the global interest in the impact of climate change on coastal communities, it is surprising that the literature about FLAGs contains so little reference to adaptive strategies in coastal areas to reduce the adverse impacts of storm events. There appears to be modest FLAG engagement to date to **mitigate** climate change and build **adaptive strategies** locally. Brokerage in creating capacities to engage in initiatives such as transition towns or national support schemes can create win-win opportunities - delivering on climate change agendas and supporting community development in fisheries and coastal communities. FLAGs can also play a key role in pushing for studies to better understand **climate change impacts** and renewable energy possibilities.

Not all marine and coastal communities will be equally adversely affected and some may indeed benefit. The greatest opportunity is undoubtedly marine and coastal renewables but the ownership structures will largely determine the extent of local benefit capture (please refer to the thematic document on "blue growth" for more information).

It is incumbent on FLAGs and coastal communities generally to position themselves within this geography of positive opportunity and negative effect, so that they can better understand their situation and build local development strategies that factor in climate change in a thorough and comprehensive manner. FLAGs have a very important role to play in reaching out to the climate change and renewable energy agenda and creating the building blocks for a deeper engagement. Multi-level engagement with climate change and renewables is possible, from individual households to family businesses to port authorities to whole coastal communities. FLAGs can and should provide a bridgehead to reviewing the opportunities and creating the framework conditions for change.

The final FARNET conference in March 2015 touched on these issues and came up with a number of **specific proposals** to start **linking climate change and local development:** .

- It was seen as crucial to **educate and inform local communities and businesses** about climate change and its potential impacts.
- It was seen as important to look to FLAGs to support the development of **green infrastructure** including **water quality** improvements. This is already being done in Sweden, where improving the quality of water in the Baltic is crucial to reviving fisheries. River basin FLAG areas act to feed cleaner water into the sea.
- If we look at the **inland FLAGs,** especially the carp farming areas, deepening ponds and using them for irrigation in dry months could bring aquaculture and agriculture closer together.
- Reinforcing **links between fishing activities and agriculture** would be a step forward towards integrative action. We already see positive linkages in the French Basque country, connecting FLAGs with LAGs, through bio fuel production by local farmers.
- These local actions may need supplementing by higher level actions to reduce fossil fuel use. Maybe **carbon taxes** are needed to drive the move to **renewable energy and fuels**; more so since oil prices have plummeted recently. It would really help local retention of benefits from renewables developments if governments in all Member States favoured **community and local municipal ownership** in planning and in grid link-up.
- Engagement with renewables is a great opportunity, but there may well be a need for a **toolkit for coastal communities on how to engage with the renewable energy sector**: a challenging and interesting task for the European network!

Overall, although fisheries and coastal communities are very much on the frontline in terms of dealing with the impacts of climate change, there is plenty of scope for positive responses to climate change and renewable energy developments, which generate wealth and help to create more resilient communities. A local transition, linking sustainable fishing, emissions reductions and renewable energy, offers a huge opportunity for community led local development along the European coastline and in inland fisheries areas.