The relevance of environmental monitoring systems to increase resiliency in fisheries and aquaculture:

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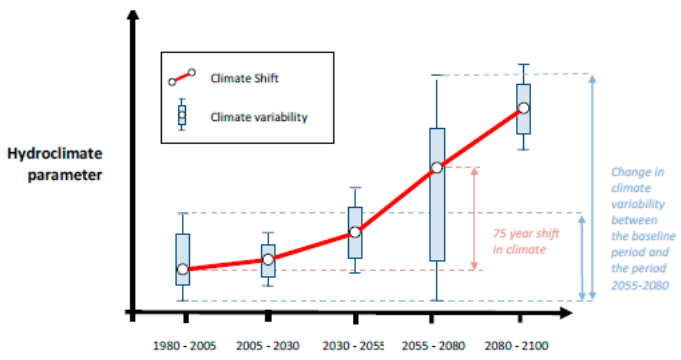
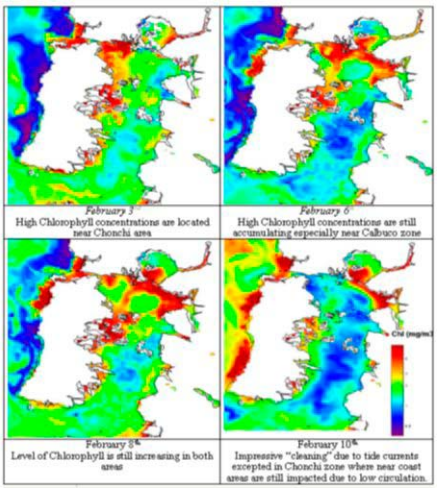
Climate variability vs Climate change

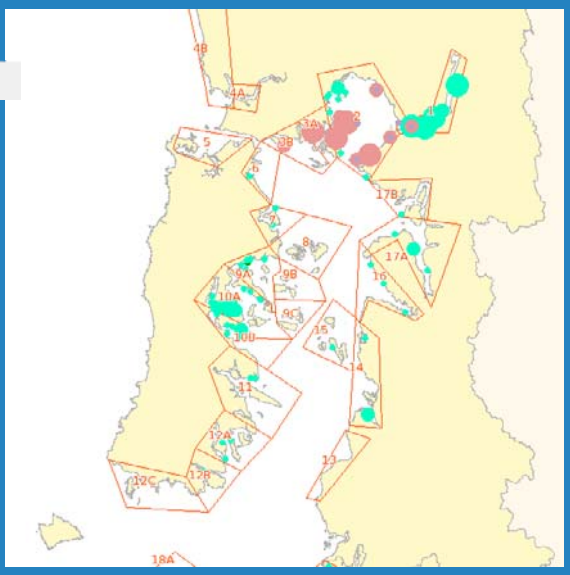
Figure 3-12: Quantifying changes in hydroclimate variables: *The study assesses long-term signals of shift over multiple decades, as well as the variability between years and seasons within 25 year periods (Diagram is illustrative only)*



Can we help fishermen and fish farmers with relevant local and regional information?

- Do fishermen access any information to guide them on when to fish what to fish and how to fish?, should we provide more information to ensure and protect their livelihoods??
- Do fish farmers (including shrimp farmers and bivalve farmers) permanently monitor or access information to help them to decide how to better manage/protect their crop?





Leptocylindrus danicus

Chatonella globosa and *Chatonella* sp

Information provided by Plancton Andino SA
http://www.plancton.cl/
http://sig.plancton.cl/centros/

A participatory process to create local monitoring systems and EW using best available information in line with the ecosystem approach to fisheries (EAF) and aquaculture (EAA)

Threat	Action	Increased resiliency
Identify main threats and risk factors -appropriate baselines (or best local knowledge) needed -risk analysis can be useful -careful with surprises STEP 1	**Design and implement the monitoring system** -Identify simple indicators and or proxies -Plan and implement the monitoring (where, when, who etc.) -Establish the data management and interpretation platform/system STEP 2	**Elaborate and implement the response** -EWS -Specific management recommendations -Monitor/evaluate the management response STEP 3

Step 4 -Review and adjust/improve

Principles to consider when developing a monitoring system

- Must be useful to farmers/fishers
- Must involve farmers/fishers
- Must be effective (prove to be useful to fishermen and fish-farmers)
- Must be timely
- Must lead to/promote sustainable use of resources
- Must be long term planned/ reviewed and maintained

Establish the baseline situation of fisheries and aquaculture

Capture Fisheries (example)

- More than xxx species in the watershed/lake
- xxx tonnes per year catches (lots of under-reporting)
- Water hydrodynamics, limnology and the annual flood pulse as relevant drivers of the fisheries productivity and cycle
- For many households fisheries is the only income!
- Etc. etc.

Aquaculture (example)

- Much newer than fisheries but increasing exponentially
- It is estimated that more than xxx tonnes are being produced in xxxxx
- Aquaculture intensification condition (this may be a risk factor)
- Aquaculture is located in a high risk area (flooding and increase salinity)
- Exotic species relevance (can this add additional threat?)
- Etc.

IDENTIFY MAIN CLIMATE CHANGE THREATS

Forcing factors (examples)

- Increase in T°C
- Changes in rainfall patterns and water drawdown
- Salinity rise
- Increase in storminess
- Adaptation to CC in other sectors water extraction from the lake
- Dams above

Some impacts (biophysical)

- Changes in species diversity, distribution, abundance
  - Exotic species can spread more rapidly?
- Reproduction and migration patterns change, some species can slowly disappear
  - Sudden changes of fish behaviour, reproduction, migration patterns
  - Increase in sedimentation
  - Habitat losses
- Increase of aquaculture diseases
- Decrease productivity
- Losses of infrastructure and production

How to design the monitoring and EWS and response mechanism

- What to monitor
- Spatial and temporal scales
  - Where
  - When,
  - how often
- By whom
- Who will collect and analyse the information
- How will this analysis be translated in a response

What to monitor for fisheries according to main threats (examples)

- Increase storminess and flooding; proxies/indicators
  - Water level Measures and variation rate; it is being measured in numerous national and regional stations (limnimeters) but are they connected , anyone watching for the larger and smaller scale?. Need more limnimeters?
  - Key/adapted meteorological information and forecast, risk maps (GIS ie satellite radar etc.)
- Changes in the water cycle flooding pattern
  - Water level Measures/indicators
  - Species as proxies (new species in the catches or common species disappearing). Fishermen and traders could be the main collectors and suppliers of information
- Temperature and salinity changes
- Turbidity (e.g. secchi readings)

What to monitor for aquaculture

We need to agree on the main threats to select the better proxies

- TºC, Salinity, Oxygen, suspended solids etc. any condition that may affect fish physiology and behaviour
  - Stressing environmental conditions are known to trigger diseases and facilitate their expansion.
- Disease presence, prevalence etc.
- Abnormal fish conditions
- Water levels

Where to monitor?? : set of criteria should be decided

- Choosing the hotspots and more vulnerable areas
  - Vulnerability
    - Hotspots regarding **exposure** (e.g. areas that are always flooded, areas that will get the highest temperature or salinity increases, areas under certain threats such as dams construction)
    - E.g. where there is a larger concentration of farms/ fishermen families i.e. **more sen**sitive areas
    - Areas with **some adaptation capacity**
- Some logical impact-response units; e.g. Watersheds, lakes, considering the water connection and fish migrations
- Key spatial points representative of other areas (for scaling up)
- Last but no least: human and economic resources!!!!, often there is a need to minimize number of monitoring spots

When and how often to monitor

- We need to keep track of the long term changes and of surprises, sudden changes that take place when thresholds are crossed
  - We have to be aware of those impacts we do not know of and therefore there is a need for a combination of temporal scale recordings
- Sampling time should address the highest risk periods of the year, with higher frequency if possible
- Sampling intensity should match the risks and most vulnerable areas
- Frequency will always be subject to budget and human resources

Collecting/providing the information: who should do this?

- Fishers (e.g. community leaders) should permanently provide information on the species composition and abundance of catch and unusual fish behaviour (e.g. using cell phone?)
- Fishers/fish farmers could also collect basic information such as temperature, water level, transparency (secchi disks)
- Fishfarmers (leading farmer?)could report on all indicators/proxies relevant to the farm including the above
  - In all cases appropriate training should be provided and value of the information could be the main incentive (but no always).
- Traders or designed information collection monitors in the local fish market
- Specialized technicians and professionals

Analysing the information and providing feedback

- A multidisciplinary technical team is needed;
  - multi-institutional?
  - A network of institutions?
- Long term funding must be granted
- Team must have the technical capacity and tools (e.g. some modelling? GIS tools) to make appropriate “interpretation” of the information and provide feedback
- Feedback information provided **must be timely and useful** to fishermen, fish farmers and managers also to planners and policy makers in short and longer term
- Information must be connected to some EWS and or DRM system

Early warning can be on

- Major life/property threatening events (short term warning normally)
- Events that may affect production and catches and therefore affect earnings livelihoods (short term and longer term warning)
  - E.g. raising water temperatures, increasing salinity, decreasing precipitation(short term events)
  - Algal blooms, fish mortality and other short term or sudden events that may cause fish to move elsewhere or cause population declines or that may trigger diseases/facilitate the expansion in aquaculture
  - Etc.

Responses

- Short term responses
  - Early warning at different geographical scales
  - fisheries management and decision making recommendations
  - Aquaculture management recommendations
- Longer term responses
  - Appropriate policies considering adaptation and preparedness in the sector
  - Longer term planning including spatial planning of activities

Making fishermen and fish farmers more aware is a key