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Ecological Risk Assessment of Impacts of Climate Change on Fisheries and Aquaculture Resources

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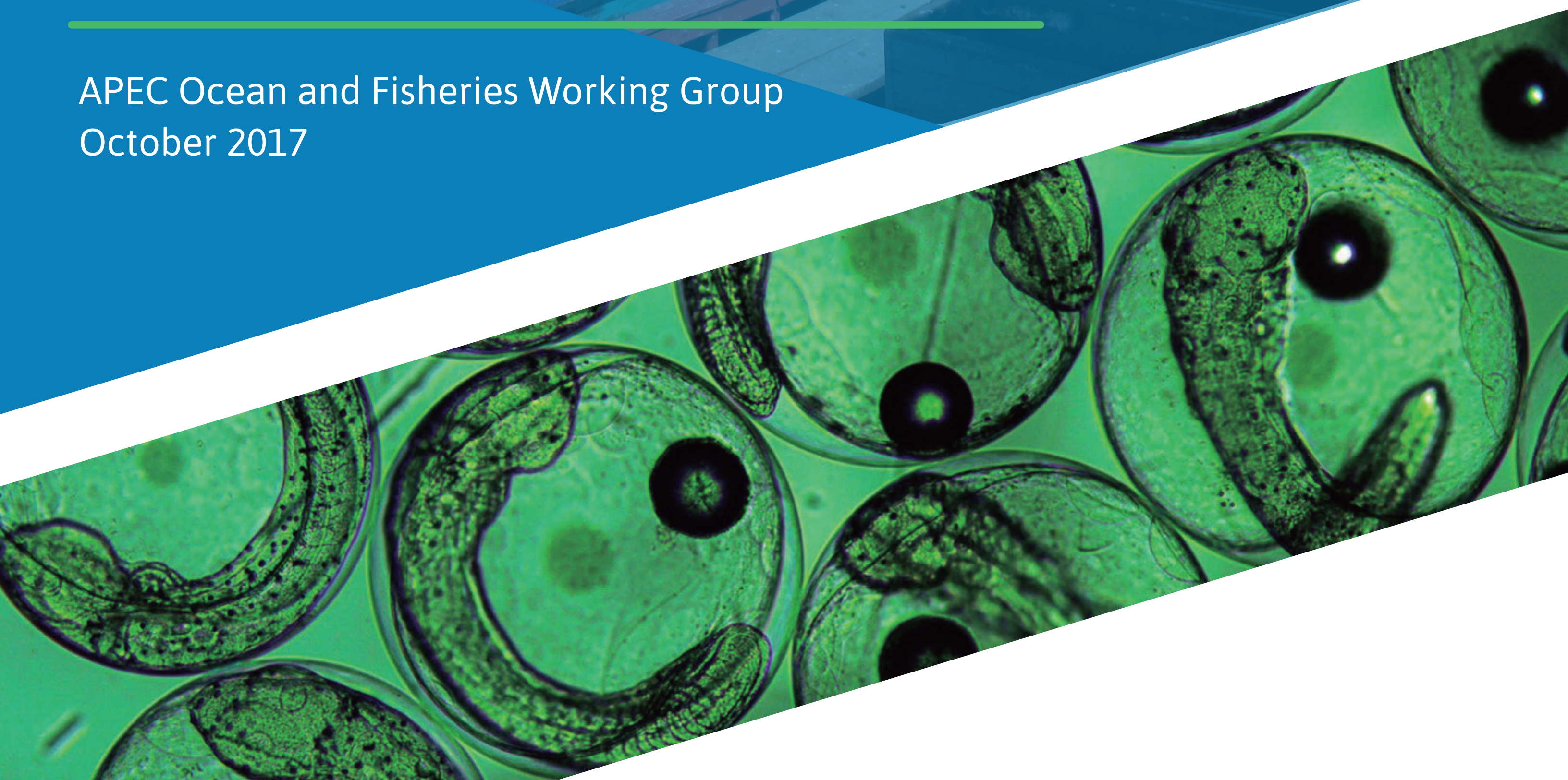

Ecological Risk Assessment of Impacts of Climate Change on Fisheries and Aquaculture Resources

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APEC Ocean and Fisheries Working Group

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Preface

Impacts of climate change are evident in all marine ecosystems of the globe, challenging the societies and nations to address their causes and socio-ecological consequences. Fisheries and aquaculture derive from key ecosystem production services which are put at risk by climate change, compromising food security and the socioeconomic benefits for the coastal communities. By building capacities to assess the vulnerability of fisheries and aquaculture resources to climate change, early warning of risks and opportunities will provide managers and other stakeholders with the best opportunity to adapt. This motivation led us to propose the APEC Secretariat to fund the international workshop "Development of Tools of Ecological Risk Assessment of Impacts of Climate Change on Fisheries and Aquaculture Resources", which was held in Lima, Peru, on 25 – 27 October 2017.

The local organization of the workshop was led by the Peruvian Marine Research Institute (IMARPE), duly supported by the Peruvian Ministry of Foreign Affairs and the Peruvian Ministry of Production and its Viceministry of Fisheries and Aquaculture. The project management was conducted by the APEC secretariat and its realization was done under the frame of the APEC Ocean and Fisheries Working Group. A total of eleven representatives from eight APEC economies, and twenty Peruvian observers with expertise on fisheries, aquaculture and climate change participated in the workshop. The main expected result was that the participants will be trained with the basic skills to implement a variety of objective, flexible and cost-effective frameworks that could be used to prioritise future research or management investment in adaptation responses in the face of resource constraints in their local economies.

Two distinguished experts on the workshop subjects were the speakers and led the activities of the event, Dr Gretta Pecl, from the Institute for Marine and Antarctic Studies at the University of Tasmania (UTAS), and Dr Ingrid Van Putten from The Commonwealth

Scientific and Industrial Research Organisation (CSIRO), both institutions of Australia. The structure of the workshop consisted on short economy reports on the knowledge of climate change impacts in local fisheries and aquaculture, ten sessions involving lectures, discussions and practical exercises, day-summaries and a final session of conclusions and recommendations.

We thank all the participants for their motivation and active participation for the successful achievement of the workshop. We specially thank to Ministry Raúl Salazar Cosío, APEC Senior Official of Peru and the team of the Ministry of Foreign Affairs for their full support and kind provision of the venue facilities. As well, we extend our acknowledgement to Mr Bernard Li and Ms Joyce Yong from the APEC Secretariat, for providing us guidance and orientation during all the phases of the workshop organization. We are confident that the outcomes of the workshop will significantly contribute to the overall goals of the APEC Ocean and Fisheries Working Group.

Dimitri Gutiérrez
Project Overseer
General Director of Research in Oceanography and Climate Change
Peruvian Marine Research Institute, IMARPE

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Executive Summary

The International Workshop on Ecological Risk Assessment of Impacts of Climate Change on Fisheries and Aquaculture Resources was conducted from 25 to 27 October 2017, held at the Ministry of Foreign Affairs of Peru located in Lima, Peru. The APEC workshop was organized by the Peruvian Marine Research Institute (IMARPE). Eleven representatives from eight APEC economies, and twenty Peruvian researchers from public institutions with expertise on fisheries, aquaculture and climate change participated in the workshop. The opening ceremony was led by the APEC Senior Official of Peru, Mr Raúl Salazar-Cosío, Ministry of Foreign Affairs of Peru, and the President of the Board of Directors of IMARPE, the Vice Admiral (r) Javier Gaviola.

Dr Dimitri Gutiérrez, General Director of Oceanographic and Climate Change Research of IMARPE was the Project Overseer. Associate Professor Gretta Pecl from the Institute for Marine and Antarctic Studies at the University of Tasmania, and Dr Ingrid Van Putten from The Commonwealth Scientific and Industrial Research Organisation of Australia were the plenary speakers and led the activities of the workshop. Dr Jorge E. Ramos from the Institute for Marine and Antarctic Studies of the University of Tasmania was the consultant responsible for the elaboration of the present report, including the indicators of monitoring and evaluation of the workshop.

The overarching aim of the workshop was to strengthen the capacity building regarding the existing ecological risk assessment tools for adaptation to climate change impacts of marine fisheries and aquaculture resources and their supply chains.

The specific objectives to attain this goal were:

1. To raise awareness through objective, flexible and cost-effective ecological risk assessment tools that will be used to prioritize future research and management investment for developing adaptation responses to climate change.

2. Socialize participants' local experience with different specialist and non-specialist stakeholders in the Asia-Pacific region, benefiting researchers of public, private and academic entities.
3. Increase knowledge about environmental parameters that determine potential impacts of climate change, and about life-history stages, habitats, fisheries and aquaculture resources that are more vulnerable to climate change.

The topics and activities of the workshop were structured in ten sessions as follow:

1. An overview of the key impacts of climate change for fisheries and aquaculture.
2. Introduction to vulnerability assessment.
3. Indicators, data gathering and expert elicitation methods.
4. Fisheries vulnerability assessment.
5. Practical session on fisheries vulnerability assessment.
6. Aquaculture risk assessment.
7. Social and economic vulnerability assessment.
8. Governance and supply chain assessment.
9. Communicating vulnerability assessment.
10. Group discussions.

The final recommendations provided by the APEC economies representatives were:

1. Climate Vulnerability Assessments must be adapted and applied to the particular situations of each economy/region.
2. Implementation of Climate Vulnerability Assessments at different levels (e.g. species, industries, areas) will allow a better understanding of the risks of the systems of interest.

3. It is key to include socio-economic vulnerability assessments, as livelihoods in several economies are already being threatened by Climate Change.
4. It is necessary to encourage a closer and permanent collaboration between ecologists, economists and sociologists, and other human dimension experts.
5. It is crucial to involve actively the local communities and other stakeholders, in particular policy makers, for co-planning assessments and adaptation measures.
6. Climate Change must be communicated better at the policy level to facilitate its perception and implementation.

Welcoming remarks

Thank you very much, good morning everyone. I would like to thank you for coming over to Peru. Thanks to the Peruvian organizing committee of this workshop, to the president of IMARPE, Javier Gaviola, and to Mr José Allemant from the Ministry of Production.

I would like to mention that there are two important factors for Peru, one is history and the other is geography. Peru has over 2,000 km of coasts along the Pacific Ocean, which has an impact in our intention to project our economy to the Pacific. The economic development since the 1970´s in Southeast Asia and North Asia including the famous economic tigers such as Japan, Korea, and China were important economies and important markets to us; these were our drivers to project our economy to the Pacific. The economic reports that Peru addressed since the 1990´s positioned our economy and were welcomed by the APEC economies, this is how we entered APEC. Before we entered to APEC, we asked for a guest membership into the fisheries working group. At that time there were two groups, one for research and the other for sustainable management of marine resources.

I want to encourage the strong participation because participation is already measured to review which groups are to be maintained and promoted over the years to come. The activities need to be more goal oriented given that we have developed a network in the working groups, some of which are distracting the attention from the original aims of APEC; I think it's not the fishing working group. All the economies that are gathered here are expressing their interest on the sustainable management of the marine resources.

The Pacific Ocean does not only condition the projections of the Asian Pacific Economies but also we can find common goals there. One of the common goals is to address the over exploitation of marine resources outside the national jurisdictions; sometimes also in the internal jurisdiction we have to be vigilant on over exploitation. These actions show the common interests of these economies to keep on working in the fisheries working group. In two different areas of the organization we are promoting these objectives, one of them directed towards your work; of course, we are going to keep working collectively to address these aims.

The APEC economy members account for 80% of global aquaculture production and more than 65% of the worlds fisheries catch; APEC economies represent 9 of the top 10 fisheries producers of the world. We have a very clear idea of the importance of these fisheries working group. I encourage you to keep attending and keep your interest on this work. I´m very glad that IMARPE and the Ministry of Production organized this event APEC 2017 that will be very important. We are going to attend the leaders week in Viet Nam in a week from now and we expect that we will review the importance of the working groups through the general process of APEC. I´m sure that the fisheries working group will be one of the most important groups.

Thank you very much, thank you IMARPE and thank you to the Ministry of Production for organizing this event.

Min. Raúl Salazar Cosío
APEC Senior Official of Peru
Minister of Foreign Affairs of Peru

Opening remarks

Good morning, Mr Raúl Salazar Minister of Foreign Affairs and High Functionary of Peru before APEC; Dr Dimitri Gutiérrez, project officer from Peru; officers from the Ministry of Production, and from the Peruvian Marine Research Institute. Very special greetings to our visitor representatives of the APEC economies, such as Chile, Indonesia, Malaysia, Papua New Guinea, Russia, Thailand, and Viet Nam. We extend our most cordial welcome with the confidence that the success of this meeting will be accomplished with your expertise and participation.

The Minister of Foreign Affairs, Mr Raúl Salazar, already addressed the position of Peru with respect of the Pacific basin and the importance of APEC economies on fisheries and aquaculture production. I would like to add the particularities of Peru, which is a region of considerable variabilities; the sea off Peru is one of the largest phytoplankton producers, characterized by upwelling and currents that allow such high productivity. Peru has a very important challenge due to the intense climatic variability in the region and due to the occurrence of the El Niño, which recently has been more intense and has affected not only the fisheries but all aspects of our geography, and nowadays with impacts throughout the planet. Therefore, for Peru it is crucial to count with the presence of experts like you today to carry out this type of workshops.

Fisheries is the second most important economic activity in Peru. The impact of climate change on our marine resources is important because marine resources represent an extraordinary source of food and of jobs. This is the reason of our concern and why we want to be ready for what is coming; hence, we have already been working on how climate change can affect this part of the ocean and especially how it can affect marine resources. For instance, an intense El Niño event can result in the occurrence of other species in the region. Therefore, we must also be ready to take advantage of the opportunities. In this sense, the idea of this meeting is to address these changes with all of you.

This workshop was envisaged from conversations of the Working Group of the Oceans and Fisheries of APEC. In 2015, some workshops were held for the countries to generate projects on the aforementioned topics. In 2016, the Peruvian Marine Research Institute proposed the workshop "Development and Tools for the Analysis of Ecological Risk for the Impacts of Climate Change on Fisheries and Aquaculture Resources". For this, the APEC working group for the fishing and aquaculture subsector was appointed within the Ministry of Production. Therefore, we have worked on this project over the last couple of years. We had a number of activities including a meeting in the city of Arequipa, and at the end of 2016 it was approved that this workshop would include the participation of Russia, Chile, Japan, Papua New Guinea, Thailand, and Korea; economies that we would like to thank for co-sponsoring this event. This workshop will last three days and will be led by Dr Gretta Pecl and Dr Ingrid Van Putten from Australia. We also have the support of Dr Jorge Ramos Castillejos from Mexico; we thank them for their participation.

The objective of this workshop is to learn tools to assess risks and vulnerabilities, so we can implement the required strategies. The program you have in your folders indicate the topics that will be covered, then we will have some practical activities, group discussions and round tables, looking forward to getting conclusions that will be helpful to the economies that are involved in this initiative. Having said this I wish success in achieving the goals of this workshop.

On behalf of the Vice-minister of Fisheries who was not able to attend today I would like to inaugurate this workshop and thank again the hospitality of the Ministry of International Affairs of Peru.

Many thanks.

Vice Admiral (r) Javier Gaviola Tejada
President of the Board of Directors of the Peruvian Marine Research Institute, IMARPE

Workshop Agenda

Day 1: October 25th , 2017	
09.30 – 10:00	Registration
10:00 – 10:15	Opening remarks ▪ APEC Senior Official of Peru, Mr Raúl Salazar-Cosío Ministry of Foreign Affairs of Peru ▪ President to the IMARPE Board of Directors Vice Admiral (r) Javier Gaviola **Official Photo**
10:15 – 10:30	Coffee break
10:30 – 10:45	**Background and goals of the Workshop** (Dr Dimitri Gutiérrez, Project Overseer)
10:45 – 12.45	**Economies Report: current knowledge of impacts of climate variations on local fisheries and aquaculture resources** ➢ Chile ➢ Indonesia ➢ Malaysia ➢ Papua New Guinea ➢ Peru ➢ Russia ➢ Thailand ➢ Viet Nam
12.45 – 14.15	Lunch
14.15 – 15.10	**Session 1:** An overview of the key impacts of climate change for fisheries and aquaculture. Dr Gretta Pecl & Dr Ingrid van Putten
15.10 – 15:30	Coffee break
15:30 – 16.55	**Session 2:** Introduction to vulnerability assessment. Dr Gretta Pecl & Dr Ingrid van Putten
16: 55 – 17: 50	Conclusions of 1st day
18:15 – 19:30	Welcome Cocktail
End of Day 1	

Day 2: October 26th , 2017	
09.00 – 10:30	**Session 3:** Indicators, data gathering and expert elicitation methods. Dr Ingrid van Putten
10:30 – 11:00	Coffee break
11:00 – 12:30	**Session 4:** Fisheries vulnerability assessment. Dr Gretta Pecl
12.30 – 14.15	Lunch
14.15 – 15:30	**Session 5:** Practical sessión. Dr Gretta Pecl,
15.30 – 16.00	Coffee Break
16.00 – 17:00	**Session 5 (cont.):** Practical session. Dr Ingrid van Putten
17:00 - 17.45	Conclusions of 2nd day
End of Day 2	

Day 3: October 27th , 2017	
09:00 – 10:00	**Session 6:** Aquaculture risk assessment Dr Gretta Pecl
10:00 – 10:45	**Session 7:** Social and economic vulnerability assessment Dr Ingrid van Putten
10:45 – 11:00	Coffee break
11:00 – 12:30	**Session 8:** Governance and supply chain assessment
12.30 – 14.15	Lunch
14.15 – 15:00	**Session 9:** Communicating vulnerability assessment Dr Ingrid van Putten & Dr Gretta Pecl
15.00 – 15.30	Coffee Break
15:30 – 16:15	**Session 10:** Group discussions
16:15 – 16.45	Conclusions and final remarks (Project Overseer)
16:45 – 17:00	Closing – Vice admiral (r) Javier Gaviola
End of Day 3	

List of Participants

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Vulnerability Assessments of the Impacts of Climate Change on Fisheries and Aquaculture Resources

Jorge E. Ramos
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The effects of climate change on marine life extend to all levels of organization, from individuals, populations, and communities, to entire ecosystems (Rijnsdorp et al. 2009; Hoegh-Guldberg and Bruno 2010; Walther 2010; Poloczanska et al. 2013). Environmental changes associated with climate change are projected to intensify over the following decades, e.g. oceanic warming, sea level rise, ocean acidification, altered ocean circulation, nutrient supply and stratification, and freshwater runoff, among others (Poloczanska et al. 2007; Stocker et al. 2013). As a consequence, impacts on marine species are expected to exacerbate (Burrows et al. 2011, 2014; Poloczanska et al. 2013, 2016).

Changes in distribution and abundance are some of the most documented responses as marine species, if capable, tend to track favourable temperatures (Dulvy et al. 2008; Sunday et al. 2012; Burrows et al. 2014). For instance, the abundance of key functional groups has already been negatively affected by climate change, such as the decline of the world's phytoplankton abundance by approximately 40% since the 1950's in response to oceanic warming (Boyce et al. 2010). The magnitude of phenological responses to climate change is variable across functional groups and trophic levels. Therefore, the decoupling of phenological events is expected to result in changes of trophic interactions, food web structures and in the function of the ecosystem (Edwards and Richardson 2004). Most aquatic animal species cultured for human consumption are poikilotherms and therefore are exposed to oceanic warming. Sea level rise, ocean acidification, changes in ocean productivity, in circulation patterns, and in the frequency and intensity of extreme climatic events (e.g. monsoons) are also important threats for the aquaculture industry via damage to port and aquaculture infrastructure (De Silva and Soto 2009).

Overall, whilst affecting marine biodiversity and resources, climate change related alterations in the physical and chemical features of the marine environment may have substantial implications for communities and industries that depend upon goods and services provided by marine ecosystems. Thus, changes in global climate present significant challenges and opportunities for societies and economies (Pecl et al. 2011).

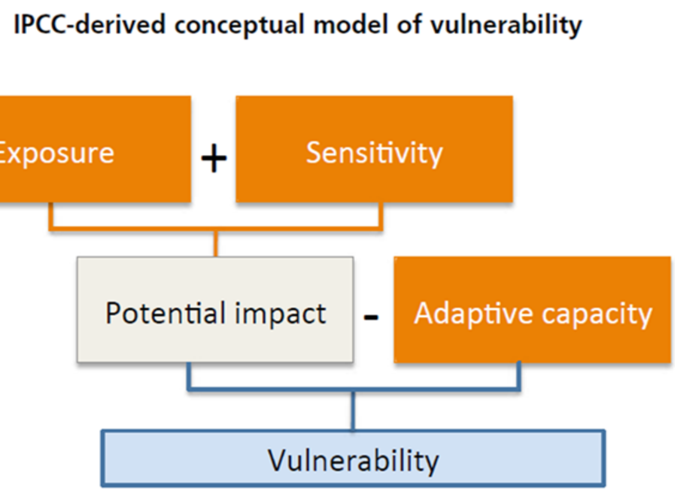
APEC economies contribute approximately 65% of the world's fisheries catch and 80% of the global aquaculture production. The consumption of fishery products per person in APEC economies is 65% higher than the world average. The fisheries and aquaculture sectors generate a significant source of revenue to APEC economies, provide employment in remote locations and supply an important source of animal protein to food-deficit countries. The fisheries and aquaculture sectors employ approximately 26.2 million fish harvesters and fish farmers In APEC economies, which comprise 60% of the world's total fisheries workforce (APEC 2009). In this sense, APEC economies are highly dependent on marine resources and are therefore likely to be affected by the impacts of climate change on marine resources.

Vulnerability assessments are structured approaches to identifying vulnerabilities in a given system. In the context of climate change, vulnerability can be defined as the degree to which a system is susceptible to damage due to the effects of climate change. Hence, vulnerability assessments can allow estimating the vulnerability of fisheries and aquaculture industries. Moreover, this type of assessment can offer a structured framework for effective adaptation through the realisation of opportunities that require social, economic and environmental consequences to be anticipated and addressed (Pecl et al. 2011). Vulnerability assessments are important to ensure that operational and strategic adaptation choices necessary to address ongoing climate change are appropriate for future conditions (Hobday and Pecl 2014), and can proceed despite the absence of complete mechanistic understanding and predictive capacity. Resource allocation to natural resource management, and investment in adaptation research, planning and implementation is limited. Therefore, these approaches can be used to determine where the investment returns to further adaptation related activities such as research, policy development, and communication are likely to be greatest (Pecl et al. 2014).

One of the many frameworks to assess vulnerability of ecological or social-economic systems is the Exposure-Sensitivity-Adaptive Capacity (E-S-AC) framework. The key concepts of the E-S-AC framework are:

- Exposure: Stimuli that have an impact on species or systems, e.g. climatic conditions.
- Sensitivity: Degree to which a system will respond to a given change in climate (includes beneficial and harmful effects).
- Adaptive capacity: Capability of a system to adapt to climate stimuli, their effects or impacts.
- Vulnerability: Degree to which a system is susceptible to damage (the detrimental part of sensitivity).

Exposure and Sensitivity determine the Potential Impact, and the Potential Impact less the Adaptive Capacity indicate the vulnerability of the system; this framework can be represented as (Soto and Quiñones 2013):



Adaptation planning at each component of the E-S-AC framework consist in 1) identifying adaptation measures that reduce the exposure of the individuals/populations/species to the physical effects of climate change, 2) identifying adaptation measures that reduce the sensitivity of the organisms to the physical effects of climate change, and 3) identifying adaptation measures that increase the adaptive capacity of the individual/species to the physical effects of climate change.

Indicators are required to do a vulnerability assessment; these are observations or calculations that can be used to track conditions or trends and that can help to find out how vulnerable and/or resilient systems are to climate change (Hinkel 2011). The E-S-AC approach has strengths and weaknesses that must be considered before implementing it. This approach relies on the assumption that vulnerability is influenced equally by each of its components, i.e. exposure, sensitivity, and adaptive capacity. However, some of the strengths of this framework are that it integrates, synthesises and summarises the information, highlights data and knowledge gaps, it is rapid, transparent and repeatable, and allows prioritising.

Fisheries Climate Vulnerability Assessments can be used for species within a fishery, for stocks within a fishery, or for species within a region. There are different approaches including the correlative, mechanistic, and the trait-based. The latter is less resource-intensive and therefore it is more widely used (Pacifici et al. 2015). The species trait-based approach examines sensitivity through traits that influence abundance, distribution, and phenology (Pecl et al. 2014), with specialized species more likely to be more sensitive to the impacts of climate change. Exposure can be examined through changes in physical and chemical factors, e.g. SST, rainfall, pH decline, salinity decline habitat changes, etc (Hare et al. 2016). Adaptive capacity often is not included in Ecological Vulnerability Assessments because there is not a clear cut between indicators for sensitivity vs adaptive capacity (Hare et al. 2016).

Aquaculture Climate Vulnerability Assessments examine all stages and methods of the farming process, considering all farming and life-history stages. This approach examines 9 attributes, including the degree of environmental control linked to broodstock availability and conditioning, spawning and fertilisation, larval and juvenile rearing, availability of alternative farm sites and systems, source of the food, diseases and pests. The sensitivity and an impact score are used to estimate the risk of the farming method (Doubleday et al. 2013). In both cases, fisheries and aquaculture, it is important to adapt the approach to the particular conditions of the system to be examined.

Like the Ecological Vulnerability Assessment, the Socio-Economic Vulnerability Assessments can implement the E-S-AC framework but adapted to the socio-economic exposure and sensitivity, and to the human and institutional adaptive capacity (Marshall et al.

2010; Cinner et al. 2013). The Social and Economic Vulnerability Assessments are used to know how vulnerable people are to climate change, under the premise that as the climate changes, ecosystem services, and people's livelihood and well-being can be affected.

Sustainable Livelihoods Frameworks provide a structured way to assess people's vulnerability with a focus on poverty. Social and Economic Vulnerability analysis can be conducted at different levels, e.g. household, individual, community, within a livelihood zone, administrative zone, national or global level. This approach also uses indicators; however, these vary according to the level the analysis is conducted. Socio-economic indicators need to be weighted according to their relative importance, which can be subjective. Moreover, indicators need to be adapted to each situation. Therefore, it is important to decide which indicators are meaningful to our assessment, and if they contribute to exposure, sensitivity or adaptive capacity.

Ecological and Social-Economic Vulnerability Assessments have proved useful tools to assess the impacts of Climate Change on fisheries and aquaculture resources and industries. Most important, these tools can provide valuable information for resource managers and policy makers considering the threats that Climate Change represents to marine resources and people whose livelihoods depend on them.

Outline of the workshop and presentation of speakers

Dimitri Gutiérrez

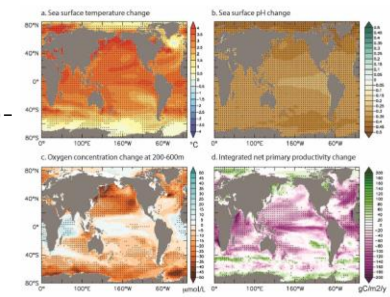
Project Overseer and General Director of Oceanographic and Climate Change Research – Peruvian Marine Research Institute

Background and goals of the Workshop

Dimitri Gutiérrez, Ph.D.
IMARPE
Project Officer

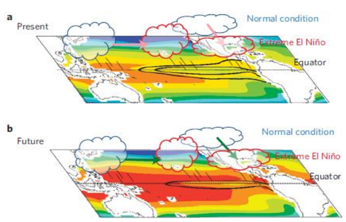
International Workshop "Development of Tools of Ecological Risk Assessment of Impacts of Climate Change on Fisheries and Aquaculture Resources"
25 – 27 October 2017, Lima – PERU

Projected changes (2090 – 2099) – (1990 – 1999), RCP8.5

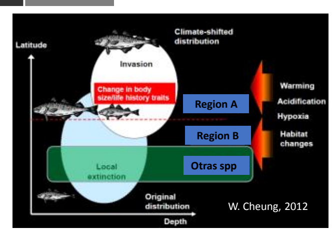


Breitburg et al., 2015

ENSO and extreme events (El Niño) under Climate Change



- A higher frequency of **extreme El Niños** is expected according to CMIP5/CMIP3 model simulations under climate change (Cai et al., 2014). Increased frequency arises from a projected surface warming over the EEP, facilitating more occurrences of atmospheric convection in the eastern equatorial region.
- Extreme EN events are also more likely due to the combination of mean state change + ENSO variability



Cheung et al. (2010): most vulnerable areas are the Equatorial región (higher risk of local extinctions) and polar regions (higher risk of species turnover).

Motivation

Impacts of climate change are evident in all marine ecosystems of the globe. Fisheries and aquaculture provide significant socioeconomic benefits for many coastal communities, and **early warning of potential changes to fish stocks, or risks for aquaculture operations, will provide managers and other stakeholders with the best opportunity to adapt**.

This three day workshop will explore a range of assessment methods that are available to estimate the various dimensions and measures of sensitivity, risk or vulnerability of marine species and of the associated fishery and aquaculture operations, to climate change.

General Objective

- Strengthen the capacity building regarding ecological risk assessments for mitigation and adaptation to climate change impacts in marine fisheries and aquaculture resources and their supply chains.

Specific Objectives

- Raise awareness on ecological risk assessment, and its application in the frame of research and management investment associated to adaptation responses to climate change.
- Socialize among participants in the Asia-Pacific region.
- Increase knowledge about fisheries and aquaculture resources that are more vulnerable to climate change; through the distribution of a technical report to all economies.

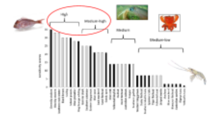
APEC "International Workshop on ecological risk assessment of impacts of climate change on fisheries and aquaculture resources"

25 – 27 OCTOBER 2017

Venue:
Ministry of Foreign Affairs of Peru

Expected results

1. For APEC Secretariat: A Technical Report of the project + a Final Report of the "International Workshop on ecological risk assessment of impacts of climate change on fisheries and aquaculture resources".
2. Participants will finish the course with the skills to implement a variety of objective, flexible and cost-effective frameworks that could be used to prioritise future research or management investment in adaptation responses in the face of resource constraints.



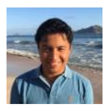
Speakers and workshop consultant

Dr Gretta Pecl

- Marine ecologist, Institute for Marine and Antarctic Studies - UTAS
- Director, CMS (December) (UTAS/CSIRO)
- Australian Research Council Future Fellow
- Editor in Chief of *Reviews in Fish Biology & Fisheries*
- Research Advisory Board *'Climate change and European Aquatic Resources'*, Horizon 2020 Blue Growth Project

Dr Ingrid van Putten

- Resource economist
- Research scientist CSIRO
- Scientific Steering Committee *Integrated Marine Biogeochemistry and Ecosystem Research* (**IMBER**)
- Chair Human Dimensions Working Group



Dr Jorge Ramos

- Consultant & IMAS Associate
- PhD on climate change ecology
- Risk assessments for Peru & Madagascar

CMS Centre for Marine Socioecology

IMAS

Structure of the Workshop

- Economies' reports (25.10.2017 morning; 15 min of duration)
- 09 sessions, with lectures, discussions and exercises
  - Sessions of Day 1 (after lunch)
    Overview of the key impacts of climate change for fisheries and aquaculture (Gretta & Ingrid)
    Introduction to vulnerability assessment (Gretta & Ingrid)

Structure of the Workshop

- Sessions of Day 2 (morning + afternoon)
  Indicators, data gathering and expert elicitation methods (Ingrid)
  Fisheries vulnerability assessment (Gretta)
  Aquaculture risk assessment (Gretta)
- Sessions of Day 3 (morning + afternoon)
  Social and economic vulnerability assessment (Ingrid)
  Governance and supply chain assessment (Ingrid)
  Communicating vulnerability assessment (Ingrid & Gretta)

APEC economies reports

Chile. The impact of Climate Change in Fisheries and Aquaculture Resources in Chile

Mónica Catrilao Cáceres and Nicole Maturana Ramírez
Undersecretariat For Fisheries and Aquaculture. Ministry of Economy, Development and Tourism. Chilean government

The Republic of Chile has 17 Million inhabitants, an Exclusive Economic Zone of 3,643,989 km2, and a coast line of 83,850 km. In 2016 exports reached US$60,597 million, of which extractive fisheries and aquaculture contributed US$5,376 million.

The last report of the Intergovernmental Panel on Climate Change (2013/14, AR5, IPCC) confirms with a high degree of certainty that "Climate Change is an unequivocal fact and this global warming phenomenon is mainly caused by anthropogenic activities of atmospheric pollution". The United Nations Framework Convention on Climate Change (UNFCCC) developed international strategies to face Climate Change; annual meetings (COP) are carried by the UNFCCC with focus on three strategic axes:

- Mitigation: Reducing greenhouse emissions and increasing their storage capacity.
- Adaptation: Avoiding or minimizing negative impacts of climate change and obtaining benefits from positive impacts.
- Training: Identifying and implementing appropriate mitigation and adaptation measures.

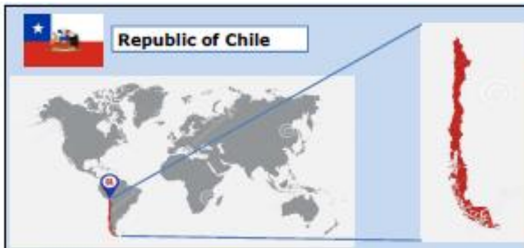
According to the UNFCCC, Chile is highly vulnerable to climate change and its socioeconomic systems are highly sensitivity to environmental variability. In consideration of the above, Chile has an "Adaptation Plan to Climate Change for Fisheries and Aquaculture" (APCCFA), which objective is to "Strengthening the adaptation capacity of the Fisheries and Aquaculture sector to climate change challenges and opportunities, taking into account a precautionary and ecosystem approach". Within the framework of the APCCFA, the project: "Strengthening Adaptation Capacity to Climate Change in Chilean Fisheries and Aquaculture sector Project GEF – SCCF – FAO" is currently under development and its objective is to "Improve adaptation capacity and reducing vulnerability to climate change in the Chilean Fisheries and Aquaculture sector".

APEC, OCTOBER, 25-29, 2017

"The Impact of Climate Change in Fisheries and Aquaculture Resources in Chile"

Undersecretariat for Fisheries and Aquaculture
Ministry of Economy, Development and Tourism
Chilean Government

Republic of Chile



- Exclusive Economic Zone (**3,643,989 Km^2**)
- Coast line (**83,850 Km)**
- **17 Million** inhabitants
- 2016 Exports: **US$ 60,597 million**

FISHERIES AND AQUACULTURE EXPORTS

- Total Export in 2016: **US$ 60,597 million**
- Extractive fisheries and aquaculture: **US$ 5,376 million**

1.FISHERIES SECTOR:

INDUSTRIAL SECTOR

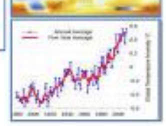
SMALL-SCALE SECTOR

2. AQUACULTURE SECTOR:

CLIMATE CHANGE

Last report of the Intergovernmental Panel on Climate Change *(2013/14,AR5,* IPCC,) confirms with a high degree of certainty that:

"Climate Change is an unequivocal fact and this global warming phenomenon is mainly caused by anthropogenic activities of atmospheric pollution"



Strategies at global level to face Climate Change

Strategies at international level to face challenges of Climate Change have been developed by the United Nations Framework Convention on Climate Change (UNFCCC). It addresses this subject at annual meetings (COP).
The three strategic axes are as follows:

Mitigation
Reducing greenhouse emissions and increasing their storage capacity

Adaptation
Avoiding or minimizing negative impacts of climate change and obtaining benefits from positive impacts

Training
In order to identify and implement appropriate mitigation and adaptation measures

Manifestations of Climate Change

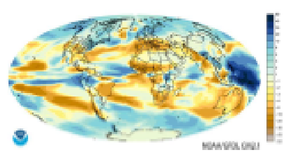
- **Climate Change is expressed both as:**
  - ✓ Air temperature
  - ✓ Sea temperature
  - ✓ Precipitation
  - ✓ Sea acidification
  - ✓ Sea level, etc.
- **And extreme events:**
  - Droughts
  - Floods
  - Fires
  - Hurricanes
  - Hot and cold waves
- **And also changes in seasonality of events**

According to the United Nations Framework Convention on Climate Change, **UNFCCC**

CHILE

1. Country highly vulnerable to climate change	✓ Has low-lying coastline areas ✓ Arid, semiarid and desertification areas ✓ Urban areas with atmospheric pollution issues ✓ Mountain ecosystems such as the Andes range and Coastal range
2. High sensitivity of socioeconomic systems to environmental variability	✓ Importance of coastal resources on local economies ✓ Historic and cultural link communities have with these natural resources

Chilean Policy on Climate Change



Ratifies UNFCCC

-Kyoto Protocol

1994 → **Commitment:** Submission of national communications

2000 → 1° National Communication

2006 → National Strategy C.C.** → **3 axes:** -Adaptation -Mitigation -Capacity building

2008 → National Action Plan C.C. → Priority Lines of adaptation action:

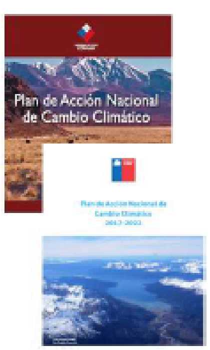
- Biodiversity
- Forestry and Agriculture
- Energy
- Fisheries and Aquaculture
- Health
- Infrastructure and Coastal Urban Areas

2011 → 2° National Communication

***UNFCCC:** United Nations Framework Convention on Climate Change

**C.C.: Climate Change

National Action Plan on Climate Change



General Objective of the Plan

The Plan is aimed at facing short and medium term challenges of climate change impacts on national territory and promoting implementation of commitments made by Chile within the UNFCCC.

Thus, this instrument provides a guiding framework for all the players involved and establishes the bases for the long-term actions regarding mitigation, adaptation and capacity building

UNFCCC: United Nations Framework Convention on Climate Change

National Adaptation Plan to C.C. Fisheries and Aquaculture

2014 → Nacional Adaptation Plan to C.C. → Guidelines for Chile's adaptation at different territorial administrative levels

2015 → National Adaptation Plan to C.C. Fisheries and Aquaculture → Strengthening adaptation capacity of the Fisheries and Aquaculture sector to climate change opportunities and challenges, taking into account a **precautionary and ecosystem approach**

2016 → 3° National Communication

2020 → Voluntary Commitment → Reducing Greenhouse emissions by 2020 in 20%

Adaptation Framework

Adaptation refers to activities conducted by individuals or systems to avoid, resist, or take advantage of current or expected climate changes or impacts.

According to IPCC, Adaptation is the adjustment process to actual or expected climatic stimuli or their effects. In human systems, adaptation moderates harm or exploits beneficial opportunities.

In the context of adaptation, different categories are distinguished:

- ✓ **Anticipatory adaptation,**
- ✓ **Reactive adaptation,**
- ✓ **Autonomous adaptation and**
- ✓ **Planned adaptation.**

☆

APCCFA (Adaptation Plan to Climate Change for Fisheries and Aquaculture)

ADAPTATION PLAN TO CLIMATE CHANGE FOR FISHERIES AND AQUACULTURE

GENERAL OBJECTIVE

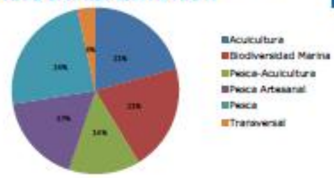
Strengthening the adaptation capacity of Fisheries and Aquaculture sector to climate change challenges and opportunities, taking into account a precautionary and ecosystem approach

SPECIFIC OBJECTIVES → **29 adaptation measures**

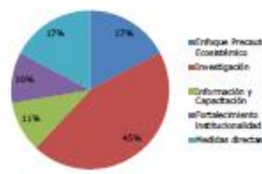
- Promoting precautionary and ecosystem approach in fisheries and aquaculture (5)
- Developing research for knowledge on climate change impacts and scenarios (13)
- Disseminating and informing about climate change impacts (3)
- Improving regulation, policy and administrative framework to address climate change challenges and opportunities in an efficient and effective manner (3)
- Developing direct adaptation measures aimed at reducing vulnerability (5)

29 adaptation measures: PROGRESSIVE AND ADAPTATIVE IMPLEMENTATION

Measures by Subsector



Measures by Specific Objective



Project in Progress

Strengthening Adaptation Capacity to Climate Change in Chilean Fisheries and Aquaculture sector
Project GEF – SCCF - FAO

GEF-SCCF-FAO Project

Fund
GEF's Special Climate Change Fund (SCCF).

Mandating Institutions
SUBPESCA (leading the project) and Ministry of the Environment

Implementing Institution
FAO (technical consultant in the project)

Project Duration: 36 months

Implementation beggining: March 2017

Project in Progress

Strengthening Adaptation Capacity to Climate Change in Chilean Fisheries and Aquaculture sector
Project GEF – SCCF - FAO

Objective

Improving adaptation capacity and reducing vulnerability to climate change in the Chilean Fisheries and Aquaculture sector.

Components

- Strengthening capacities of public and private institutions for effective adaptation to climate change
- Improving local adaptation capacity to climate change of fisheries and aquaculture sector
- Strengthening knowledge and awareness on climate change fisheries and aquaculture communities
- Monitoring, evaluating, and disseminating project information


Pilot Coves (Caleta = Small-scale Fishing Coves)
North
Caleta Riquelme
(Iquique)
Center North
Caleta Tongoy
(Coquimbo)
Center South
Caleta Coliumo
(Tomé)
Center South
Caleta El Manzano
(Hualaihué)


Thank you!

Indonesia. The impacts of climate change on aquaculture in Indonesia

Tajuddin Idris[1] and Hendri Kurniawan[2]
[1]Deputy Director, Directorate of Aquaculture Fish Production and Business, Directorate General of Aquaculture – MMAF, Republic of Indonesia. [2]International Cooperation Analyst, Cooperation and PR Bureau, Secretariat General – MMAF, Republic of Indonesia

In many countries, especially in the tropics, climate change has brought significant changes to the productivity of cultivation. Climate change affects aquaculture activities, in particular through the effects of significant temperature changes on fish growth performance, development of larvae, production performance, and decreased marine productivity. On freshwater, climate change will affect aquaculture activities through rising sea water temperature, decreasing oxygen levels, and increasing pollutant toxicity.

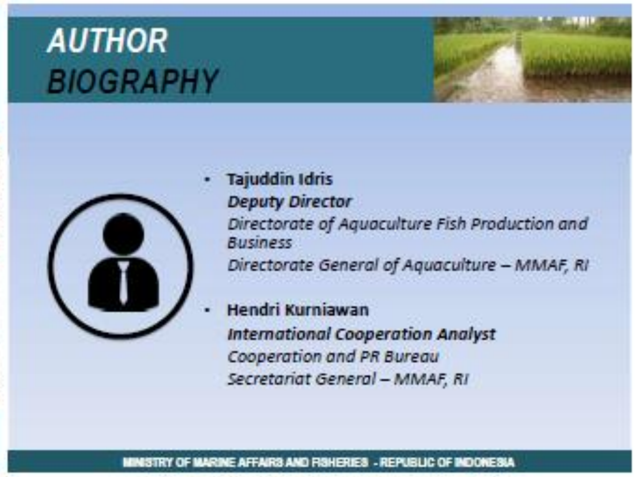
Indonesia has developed programs to anticipate to the impacts of climate change on the aquaculture sector by implementing the following strategies:

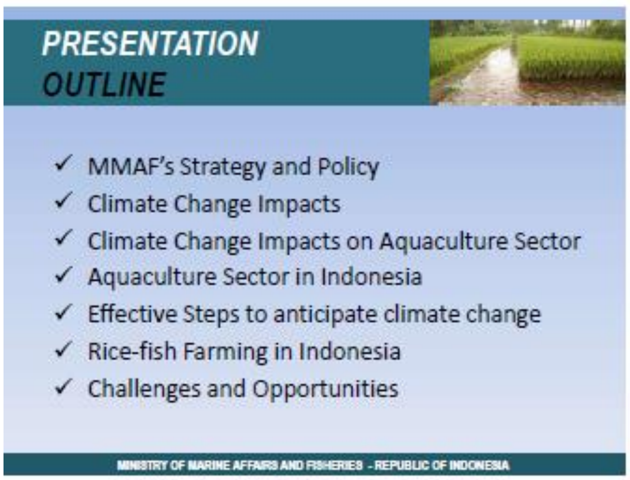
- **Insurance for Aquaculture Farmers (Asuransi Budidaya**): The objective is to help the farmers against the loss of aquaculture business due to the impacts of climate change. Farmers are encouraged to take out insurance, in particular against capital losses and damage to extreme climate-cultivating facilities.
- **Research and Technology Transfer:** Research becomes an important part especially in generating aquaculture engineering technology that is directly linked to mitigation/adaptation efforts to the impacts of climate change. Research related to the possibility of: emergence of new pests, preventive effort, physiology of fish, search of tolerant species of fishes (diversification of cultivated commodities), and environmentally friendly food, among others. The results of this research and engineering should be innovative, effective, efficient and applied at the farmer community level.
- **Determination of the Cultivation Zone**: Sufficient location selection from both technical and non-technical aspects can be an important adaptation step in anticipating climate change. In determining the location of cultivation, it is important to understand and identify through the risk assessment analysis the possibility of threats. This risk assessment involves how to assess the vulnerability of the location to be used for the development of the

aquaculture facilities. This step is important as a form of early anticipation for any potential risks.

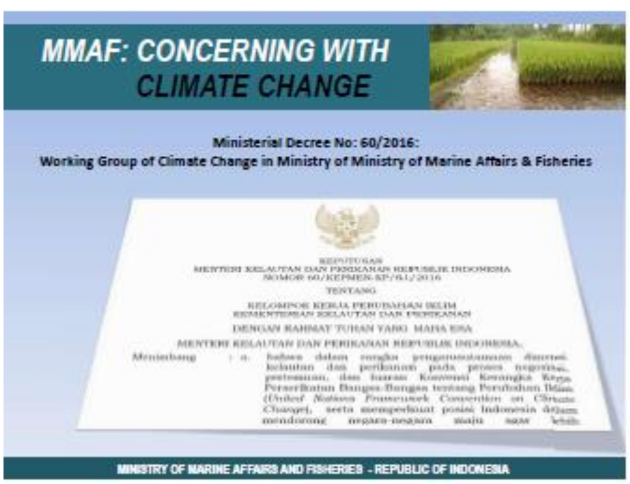
- **Minapadi (Rice-fish farming) Program**: The "Minapadi (Rice-fish farming) program’ aims to create synergy between the fisheries and farming sectors and its expected to help address the impact of climate anomalies. "The Minapadi program" is implemented to deal with low fishery and agricultural production levels due to extreme weather induced by climate change. The program could increase land productivity, farmers` income, boost agricultural product diversity, soil fertility, water supply to minimize agricultural pests. The fish growth in the Minapadi program are catfish, tilapia, carp, as well as prawns.

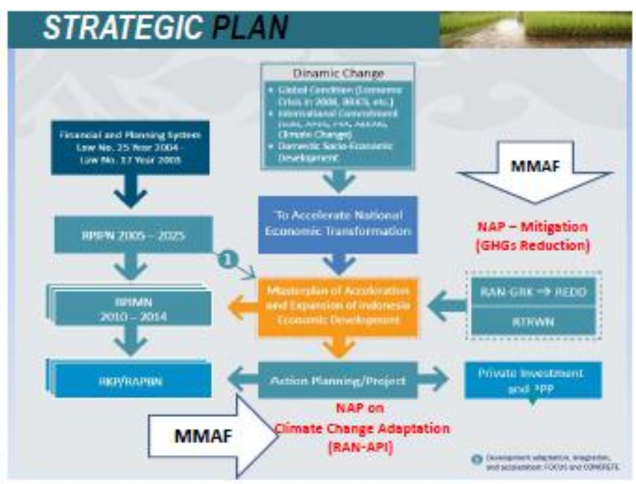

THE IMPACTS OF CLIMATE CHANGE
ON AQUACULTURE IN INDONESIA
APEC Workshop: Development of Tools of Ecological Risk Assessment of Impacts of Climate Change on Fisheries and Aquaculture Resources
Lima-Peru, 23-25 October 2017
MINISTRY OF MARINE AFFAIRS AND FISHERIES (MMAF)
REPUBLIC OF INDONESIA


AUTHOR
BIOGRAPHY
Tajuddin Idris
Deputy Director
Directorate of Aquaculture Fish Production and Business
Directorate General of Aquaculture – MMAF, RI
Hendri Kurniawan
International Cooperation Analyst
Cooperation and PR Bureau
Secretariat General – MMAF, RI
MINISTRY OF MARINE AFFAIRS AND FISHERIES - REPUBLIC OF INDONESIA


PRESENTATION
OUTLINE
✓ MMAF's Strategy and Policy
✓ Climate Change Impacts
✓ Climate Change Impacts on Aquaculture Sector
✓ Aquaculture Sector in Indonesia
✓ Effective Steps to anticipate climate change
✓ Rice-fish Farming in Indonesia
✓ Challenges and Opportunities
MINISTRY OF MARINE AFFAIRS AND FISHERIES - REPUBLIC OF INDONESIA

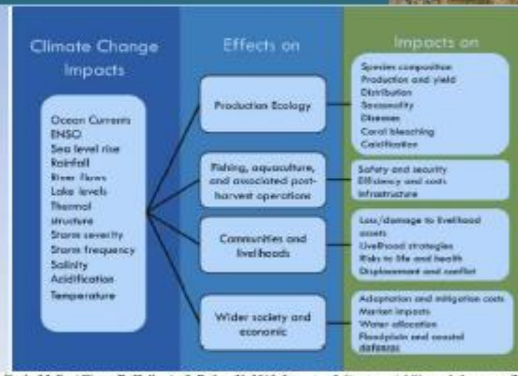

MARINE & FISHERIES SECTOR :
STRATEGY AND POLICY


MMAF: CONCERNING WITH
CLIMATE CHANGE
Ministerial Decree No: 60/2016:
Working Group of Climate Change in Ministry of Ministry of Marine Affairs & Fisheries
MINISTRY OF MARINE AFFAIRS AND FISHERIES - REPUBLIC OF INDONESIA


STRATEGIC PLAN
Dinamic Change
Financial and Planning System
RPJPN 2005 – 2025
To Accelerate National Economic Transformation
MMAF
NAP – Mitigation
(GHGs Reduction)
RPJMN
2010 – 2014
RAN-GRK → REDD
KTRWN
RKP/RAPBN
Action Planning/Project
Private Investment
NAP on
Climate Change Adaptation
(RAN-API)
MMAF

CLIMATE CHANGE IMPACTS ON MARINE & FISHERIES SECTOR

CLIMATE CHANGE IMPACTS



Badjeck, M-C., Allison, E. Halls, A. & Dulvy, N. 2010. Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy*, 34: 375–383.

CLIMATE CHANGE IMPACTS

SEA LEVEL AND SEA SURFACE TEMPERATURE RISE	COMMUNITY LIVELIHOOD	FISHERIES AND AQUACULTURE
1. COASTAL VULNERABILITY	1. LOSS OF HOME FOR 42 MILLIONS OF COASTAL COMMUNITIES IN 2050	1. CHANGES OF FISH MIGRATION PATTERN
2. COASTAL ECOSYSTEM DEGRADATION	2. LOSS OF INCOME RESOURCES	2. INCREASE NUMBERS OF STRANDED FISH
3. SINKING ISLANDS AND CITIES (2000 SMALL ISLANDS IN 2050)	3. UNCERTAINTY IN FISHING ACTIVITIES DUE TO SEASONAL CHANGES	3. INCREASE OF FISH DISEASES
4. CORAL BLEACHING	4. EMERGING DISEASES	

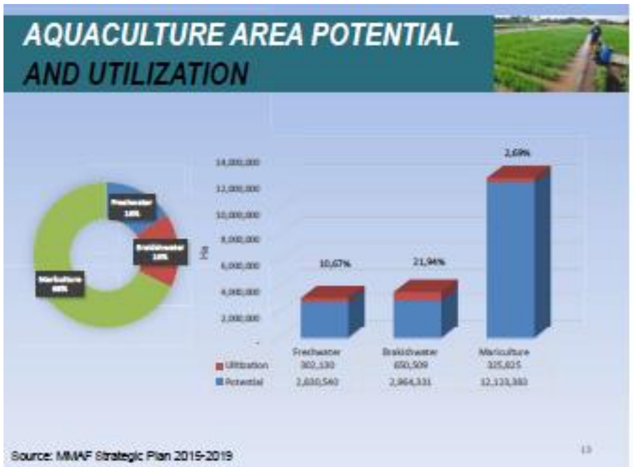
MINISTRY OF MARINE AFFAIRS AND FISHERIES - REPUBLIC OF INDONESIA

CLIMATE CHANGE IMPACTS ON AQUACULTURE SECTOR

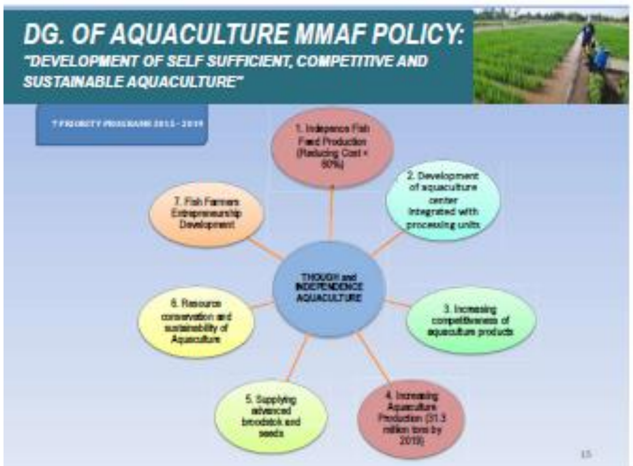
CLIMATE CHANGE IMPACTS ON AQUACULTURE SECTOR

- In many countries, especially in the tropics, climate change has brought significant changes to the productivity of cultivation;
- Climate change affects aquaculture activities in particular with the effects of significant temperature changes on:
  - fish growth performance (Jobling, 1997);
  - Development of larvae (Rombough, 1997);
  - production performance (Van der Kraak and Pankhurst, 1997).
  - decreased marine productivity (Schmittner, 2005);
  - on freshwater side will occur through rising sea water temperature, decreasing oxygen levels and increasing pollutant toxicity (Ficke, Myrick and Hansen (2007)).

AQUACULTURE SECTOR IN INDONESIA


AQUACULTURE AREA POTENTIAL
AND UTILIZATION
Freshwater 14%
Brackishwater 18%
Mariculture 68%
2,69%
10,67%
21,94%
Freshwater 302,130 2,830,540
Brackishwater 650,509 2,964,331
Mariculture 325,825 12,123,383
Utilization
Potential
Source: MMAF Strategic Plan 2015-2019
13


INDONESIA AQUACULTURE
PRODUCTION 2011 - 2015
INDONESIA AQUACULTURE PRODUCTION 2011 - 2015
FISH CONSUMPTION PER CAPITA (KG/KAP/YR)
Fisheries GDP in 2014 - 2015
14


DG. OF AQUACULTURE MMAF POLICY:
"DEVELOPMENT OF SELF SUFFICIENT, COMPETITIVE AND SUSTAINABLE AQUACULTURE"
1. Indepence Fish Feed Production (Reducing Cost ± 60%)
2. Development of aquaculture center integrated with processing units
3. Increasing competitiveness of aquaculture products
4. Increasing Aquaculture Production (31.3 million tons by 2019)
5. Supplying advanced broodstock and seeds
6. Resource conservation and sustainability of Aquaculture
7. Fish Farmers Entrepreneurship Development
THOUGH and INDEPENDENCE AQUACULTURE
15


INDONESIA AQUACULTURE
PRODUCTION 2016
BUDIDAYA TAWAR, 2,961,105.26
19 %
BUDIDAYA PAYAU, 2,498,905.72
16 %
BUDIDAYA LAUT, 10,174,013.87
65 %
AQUACULTURE FISH PRODUCTION 2016
16,67 Million Tones*
*Angka sementara
16


INDONESIA AQUACULTURE
POLICY
SOVEREIGNTY
SELF-SUFFICIENT
SUSTAINABILITY
PROSPERITY
The Development of Integrated Center for Marine Affairs and Fisheries (SKPT)
Self-sufficient of fish farmer group
Self-sufficient of production input
Self sufficient of business process
Self sufficient of area development
Regulation arrangement
Inland Water management
Fish health and environment management
Restocking
Increasing of Production and Productivity
Business partnership
17


EFFECTIVE STEPS
TO ANTICIPATE CLIMATE CHANGE

EFFECTIVE STEPS TO ANTICIPATE CLIMATE CHANGE

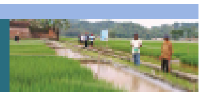
- There should be other comprehensive efforts including adaptation of the relevant institutional, policy and planning aspects, responsible and sustainable management patterns;
- **Perama (Ecosystem Approach based on Aquaculture)** is aims to integrate aquaculture activities within a broader ecosystem, so that a sustainable management pattern will exist in this respect;
- In the context of aquaculture, ecosystem-based approaching must take into consideration the ecological, social, and economic aspects of its development planning;

EFFECTIVE STEPS TO ANTICIPATE CLIMATE CHANGE (Cont'd)

Insurance for Aquaculture Farmers (Asuransi Budidaya)

- The cultivation insurance policy is part of the economic asymmetrical step. The objective is to help the loss of aquaculture business as a result of the impacts of climate change);
- Farmers are encouraged to take out insurance in particular against capital losses and damage to extreme climate-cultivating facilities;
- The government should consider making mandatory insurance policies for businesses on a given business scale to reduce long-term losses in production, livelihoods and environmental damage;

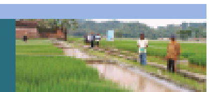
EFFECTIVE STEPS TO ANTICIPATE CLIMATE CHANGE (Cont'd)



Research and Technology Transfer

- Research becomes an important part especially in generating aquaculture engineering technology that is directly linked to mitigation/adaptation efforts to the impacts of climate change;
- Research related to the possibility of:
  - emergence of new pest genius;
  - preventive effort;
  - physiology of fish;
  - searching for species of tolerant fish (diversification of cultivated commodities);
  - environmentally friendly food and others.
- The results of this research and engineering should be innovative, effective, efficient and applicable applied at the farmer community level;
- Best Management Practices (BMP) in aquaculture management especially in small-scale enterprises can be consistently done by farmers, certainly based on EAA strategies.

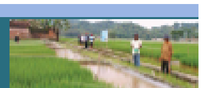
EFFECTIVE STEPS TO ANTICIPATE CLIMATE CHANGE (Cont'd)



Determination of the Cultivation Zone

- Sufficient location selection from both technical and non technical aspects can be an important adaptation step in anticipating climate change;
- In determining the location of cultivation is important to understand and determine the possibility of threats that will occur that is through the analysis of risk assessment (risk analysis assessment);
- This risk assessment involves how to assess the vulnerability aspect of the location to be used for the aquaculture development area;
- This step is important as a form of early anticipation to see possible potential risks that will occur;

EFFECTIVE STEPS TO ANTICIPATE CLIMATE CHANGE (Cont'd)



Monitoring

- Monitoring of biophysical parameters (biology, physics and chemistry) and oceanography to aquatic environments is an absolute thing to do at any time;
- Important as an early warning to see the changing trends happening to the environment;
- Integrated monitoring program should be encouraged as a strategic and important policy in the management of natural resources and the environment including aquaculture in it;
- Recording mechanism doing by fish farmers and can be accessed easily.

RICE-FISH FARMING "MINAPADI" IN INDONESIA

WHY RICE-FISH FARMING IS A SOLUTION FOR CLIMATE CHANGE

- ✓ Land Use Optimization;
- ✓ Effective Water Use;
- ✓ Organic Farming;
- ✓ Symbiosis Mutualism;
- ✓ No Chemical Substances;
- ✓ Less Production Cost;
- ✓ Minimum Human Resources Need;
- ✓ Producing Rice and Fish in One Field.

MINAPADI RICE-FISH FARMING

MINISTRY OF MARINE AFFAIRS AND FISHERIES - REPUBLIC OF INDONESIA

CENTRAL OF RICE FISH FARMING IN INDONESIA 2014

Source : Statistik Data, DGA, MMAF, 2014

MINAPADI DISSEMINATION IN INDONESIA 2011

No	Province	District	Name of group	Location
1	Bengkulu	Kepahiang	Karya Cipta	Penanjung Panjang village , Tebat Karai sub district
2	Central Java	Banjarnegara	Mina Sari Widodo	Blambangan village, Bawang sub district

MINAPADI (FRESH WATER PRAWN) IN INDONESIA 2012

No	Province	District	Name of group	Location
1	West Java	Sukabumi	Makmur Jaya Lima	Gunung Jaya village, Cisaat sub district
			Mina Bakti	Pondok Kaso Tangguh village, Cidahu sub district
2	Central Java	Banjarnegara	Mina Sari Widodo	Blambangan village, Bawang sub district
			Sri Rahayu	Mertosari village, Purwonegoro sub district
3	East Java	Probolinggo	Sababa	Ketompen village, Pajarakan sub district
		Kediri	Mina Pranggang Makmur	Pranggang village, Ploso sub district

MINAPADI DISSEMINATION IN BANJARNEGARA, INDONESIA 2012

MINAPADI (FRESH WATER PRAWN-GOURAME) IN INDONESIA 2013

No	Province	District	Name of group	Location
1	West Java	Cianjur	Tani Mukti	Cisaranggi village, Warung Kondang sub district
		Garut	Mitra Gemah Ripah	Lengkong Jaya village, Karang Pawitan sub district
2	Central Java	Sragen	Wardoyo Patin	Metep village, Sidoharjo sub district
		Temanggung	Mina Sumber Rejeki	Soropadan village, Pringsurat sub district
3	East Java	Malang	Ngudi Mulyo 3	Blayu village, Wajak sub district
			Raja Mina	Sepanjang village, Gondang Legi sub district
4	Banten	Pandeglang	Batu Lunjung	Cimanuk village, Cimanuk sub district

MINAPADI (FRESH WATER PRAWN) IN MALANG, INDONESIA 2013

MINAPADI (FRESH WATER PRAWN) IN INDONESIA 2014

No	Province	District	Name of group	Location
1.	Central Java	Boyolali	Mina Lestari	Cepoko Sawit village, Sawit sub district
			APOB	Cepoko Sawit village, Sawit sub district
2.	DI. Yogyakarta	Sleman	Mina Muda	Candi Binangun village, Pakem sub district
			Mina Jaya	Sendang Tirto village, Brebah sub district
3.	NTB	Central Lombok	Harapan Baru	Bilebante village, Pringgarata sub district
			Pade Senang	Selebma village, Batu Kleang sub district
		East Lombok	Joben Gesik	Pesenggarahan village, Montong Gading sub district
			Batu Tambun	Pringgasela village, Pringgasela sub

MINAPADI (FRESH WATER PRAWN) IN BOYOLALI & SLEMAN, 2014

MINAPADI (FRESH WATER PRAWN-GOURAME) IN INDONESIA 2015

Year	Province	District
2015	West Sumatera, lampung, South Sumatera, West Nusa Tenggara, South Kalimantan, West Java, Central Java, South Sulawesi, and Gorontalo	Tanah datar, 50 Kota, Pasaman, lampung Timur, Mussi Rawas, Ogan Ilir, Lombok Barat, Banjar, Bandung, Jepara, Pati, Enrekang, Bone Bolango, Gorontalo

DISSEMINATION MODEL OF MINAPADI (TILAPIA) IN SLEMAN, INDONESIA 2015 IN COOPERATION WITH FAO

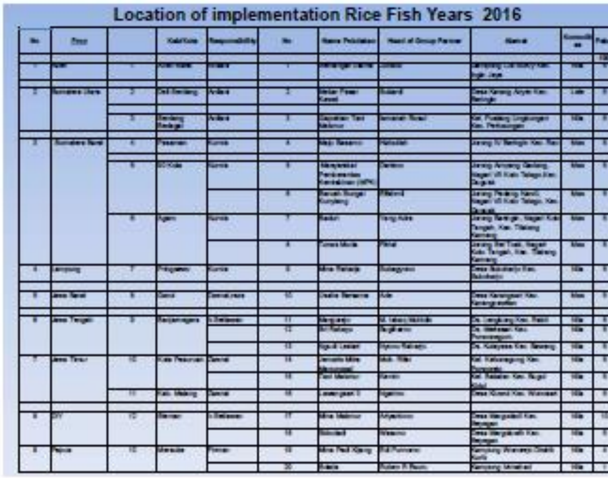
Planting with Jajar Legowo (TAJARWO) 2 : 1
To Produce Rice Fish Optimal

HARVESTING MINAPADI (TILAPIA) IN SLEMAN, IN COOPERATION WITH FAO, 2015

HARVESTING MINAPADI (TILAPIA) IN DISTRICT 50 KOTA, WEST SUMATRA, IN COOPERATION WITH FAO, 2015

MINAPADI LOCATION (SCALING UP) IN INDONESIA, 2016

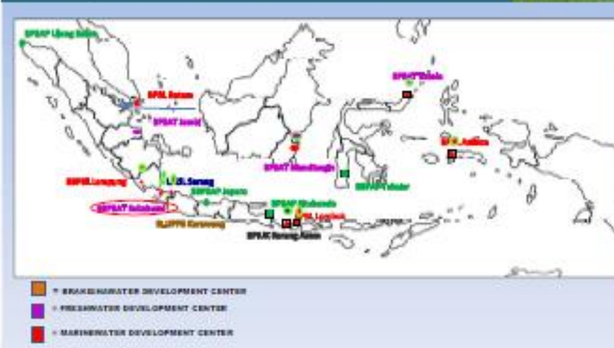
Location of implementation Rice Fish Years 2016

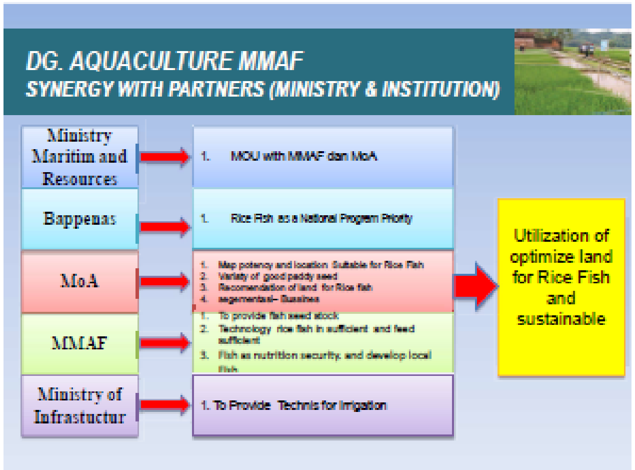


MINAPADI IN INDONESIA 2017

1. Conducting further analysis on market availability for the rice fish farming products (paddy and fish as well as other valuable plants and aquatic animal);
2. In 2017, there will be an integration of rice fish farming program between Ministry of Agriculture and Ministry of Marine Affairs and Fisheries:
   a) Ministry of Agriculture will provide assistance of rice seeds and fertilizer, and
   b) DGA - MMAF will provide infrastructure and facility of curren pond, fish seeds and fish feeds.
   c) Budget for Operasional Rice-Fish Farming 2017 allocated at Technical implementing (TIU) Directorate General of Aquaculture: TIU (Main Center) Sukabumi almost 160 Ha for Distric (Temanggung, Banjarnegara, Sukabumi dan Pangandaran) and TIU Jambi almost 50 Ha for Aceh, Serdang Bedegai, Pasaman Barat and Tanjung Jabung Barat.
   d) Technical Assistence by TIU of DGA, and market reponsibility by TIU Karawang and Perum PERINDO

LOCATION OF TIU DG. AQUACULTURE MMAF




DG. AQUACULTURE MMAF
SYNERGY WITH PARTNERS (MINISTRY & INSTITUTION)
Ministry Maritim and Resources
1. MOU with MMAF dan MoA
Bappenas
1. Rice Fish as a National Program Priority
MoA
1. Map potency and location Suitable for Rice Fish
2. Variety of good paddy seed
3. Recomendation of land for Rice fish
4. segmentasi– Bussines
MMAF
1. To provide fish seed stock
2. Technology rice fish in sufficient and feed sufficient
3. Fish as nutrition security, and develop local fish
Ministry of Infrastuctur
1. To Provide Technis for Irrigation
Utilization of optimize land for Rice Fish and sustainable


CHALLENGES AND OPPORTUNITIES
❑ CHALLENGES:
▪ Planting season;
▪ Lack of knowledge;
▪ Make a change: significant improvement in the practices—technical manual;
▪ Land acquisition (for housing and industry).
❑ OPPORTUNITIES
▪ Good cooperation between DGA-MMAF and DG-Crop of MoA;
▪ Variation of Species combination;
▪ Organic/healthy rice production.


TERIMA KASIH
THANK YOU
GRACIAS
ARIGATO
SHUKURIA
BIYAN
DANKSCHEEN
TASHAKKUR ATU
GRAZIE
MEHRBANI
BOLZİN
MERCI
JUSPAXAR

Malaysia. The effects of climate change in fisheries and aquaculture resources in Malaysia

Abdul Razak Bin Abdul Rahman
Department of Fisheries, Malaysia

In Malaysia, the two main fisheries-related economic activities are capture fisheries (marine and inland fisheries) and aquaculture (marine, brackish and fresh water). Although the world's marine capture production decreases every year, Malaysia´s fisheries production remains stable with a contribution of 71% of the total national production (1.43 mil tonnes) during the year 2010, with the value of RM6.65 (2012) at 1.3% national GDP. As fish remains the most important diet in Malaysia, besides the potential positive impact to Balance of Trade (BOT) and the abundance of land space and water bodies, the aquaculture industry has been given priority to expand with current target at 1,433 mil tonnes by 2020 instead of 500,000 tonnes produced today. Unfortunately, issues associated with climate change resulted in a great challenge to achieve the targeted value. Based on the sea surface temperature (SST) analysed using satellite data from the Pathfinder program, studies suggested that the average SST of the sea surrounding Malaysia has significantly increased over the last 29 years (1985–2014) from 28.9–29.1°C to 29.1–30.0°C which may affect fish distribution (e.g. mackerel sp.). The coral reef bleaching in Pulau Redang and Pulau Paya, and more frequent harmful algae blooms along Malaysia require deeper research solution finding.

In tropical areas like Malaysia, warmer waters may increase the susceptibility of fish to pathogens because they are already spending energy dealing with thermal stress; in addition, many of the pathogens are temperature-sensitive. For example, the growth rates of marine bacteria and fungi are positively correlated with temperature; therefore, there are more reports of disease related fish mortalities. The El Niño phenomenon from April 2014 to June 2014 affected 706 farmers (mainly of the freshwater aquaculture sector) in the Pahang district due to droughts, and resulted in RM25.16 mil of losses. The changes in monsoons and occurrence of extreme climate evens such rain pattern/heavy rain resulted in flood events. The unusual floods recorded between December 2014 and February 2015 in the districts of

Kelantan, Pahang and Johor affected 1,665 farmers´ aquaculture facilities and their fish; the estimated amount of losses reached RM45 million. More funding is therefore needed for further research to understand better the effect of climate change on the fisheries and aquaculture sectors.

THE EFFECT OF CLIMATE CHANGE IN FISHERIES & AQUACULTURE RESOURCES IN MALAYSIA

ABDUL RAZAK BIN ABD. RAHMAN, DEPARTMENT OF FISHERIES, MALAYSIA

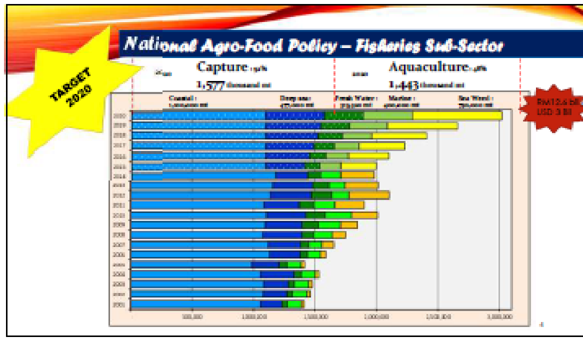
INTRODUCTORY FISHERIES ECONOMY ACTIVITIES IN MALAYSIA

Major activity divided to

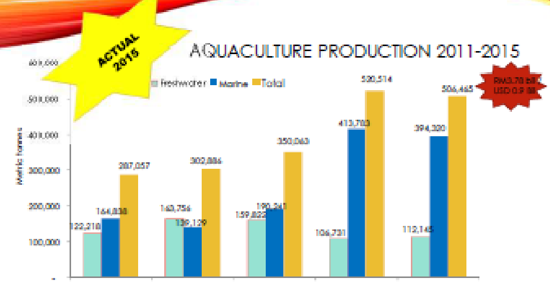
1. Capture fisheries
   - major contribution (71% of total national production)
   - increased by 16% from 1.23 mil tonnes (2001) to 1.43 mil tonnes (2010) ~ world marine captured production has decreased by 6% from 83.5 mil tonnes (2001) to 78.3 mil tonnes (2010)
   - consist of inshore and deep-sea fisheries production of value RM6.65 bil (2012)@ 1.3% of national GDP
2. Aquaculture – increasing pattern
   - Marine
   - Fresh water

POTENTIAL ECONOMIC REVIEW

- While fish remains an important diet for Malaysia, aquaculture industries have been given prioritise due
  - Productivity of fishing declining at average 3.8% per annum (reported by WWF Malaysia)
  - Positive value for Balance of Trade
  - Potential of food security
  - Having abundance of land space and water body (sea, river, lake, etc)
- therefore, instead of National Agro-Food Policy 3, DAN 3 (2011-2020), also introduce 50:50 aquaculture policy
  - Targeted production by 2020 (1,433 mil m.t.) – equally enough with capture fisheries



AQUACULTURE PRODUCTION 2011-2015



Source : Malaysia Fisheries Statistic

ISSUES AND CHALLENGES

CLIMATE CHANGE ????

CLIMATE CHANGE EFFECT

Sea surface temperature (SST) rise

El Niño-Southern Oscillation

Coral bleaching

Effects of rising sea levels

Drought / Floor

Calcification of coral

Disease

Impact of climate change to fish species

Sea surface temperature rise

- Main impact to capture fisheries
- Changes the sea surface resulting to
  - More frequent harmful algal blooms reported
  - Increase disease and parasites incident
  - Altering local ecosystems with changes in competitors, predators and invasive species
  - Changes in plankton composition
  - Damage to coral reefs (bleaching) that serve as breeding habitats
  - Less dissolved oxygen

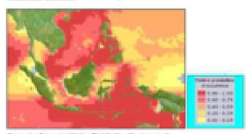
EXAMPLE 1

Abundance and species composition of stocks

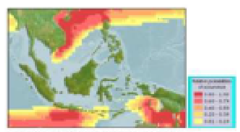
Climate change may alter the species distribution.
Climate change projection showing occurrence of mackerel in the region at present and in 2050. (under IPCC SRES A1B scenario)

Source: AquaMaps project (ACB-WFC-FRI); www.aquamaps.org) - mapping tools that display changes in the SEA marine biodiversity due to climate change, using a biogeography modeling approach (AquaMaps) linked to existing information systems

Rastrelliger kanagurta (ikan kembung)



Computer Generated Native Distribution Map (present)



Computer Generated Native Distribution Map (in year 2050)

Mustapha (2015) also shows the result of another study on understanding the spatial and temporal relationship of ocean biophysical parameters with habitat utilization of *Rastrelliger kanagurta* (Indian mackerel) off South China Sea shows that SST data estimated following temperature changes in next three decades (2010 – 2039) based on the Representative Concentration Pathways with SST increases of 1.8, 2.6 and 3.3 ºC will result in disappearance of *R.kanagurta* from the west coast of Peninsular Malaysian water

Further study are still needed to confirm these finding.

EXAMPLE 2

Disease

In tropical areas like Malaysia, warmer waters may increase the susceptibility of fish to pathogens because they are already expending energy dealing with thermal stress.
Many pathogens are temperature-sensitive. For example, growth rates of marine bacteria and fungi are positively correlated with temperature.
More disease related fish mortalities reported.

EMS (Early Mortality Syndrom) / AHPND (Acute Hepatopancreatic Necrosis Disease)in marine prawn culture

Leech in tiger grouper culture

EXAMPLE 3

Effects of rising sea levels

Based on the sea surface temperature (SST) analysed using satellite data from the Pathfinder program, Ku Kassim (2014) suggested the average SST of the sea surrounding Malaysia has significantly increase in 29 years (1985 – 2014) 28.9-29.1 ºC to 29.1-30.0 ºC.
Further analysis found out the SST have negative impact on the catch of anchovies on the west coast of Peninsular Malaysia while the catch of neritic tuna, pompret and mackerel have positive relationship.

EXAMPLE 4

Prolong drought / not in season
-April – June 2014 involving 706 farmers

Flood in Dis 2014 to February 2015
-affected 1,665 farmers with estimated losses around RM45 mil / USD 11 mil

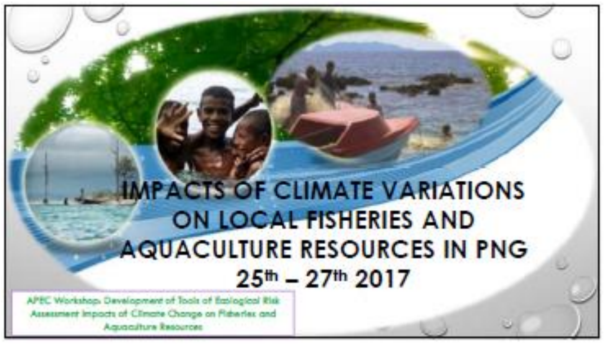
Fish for ALL

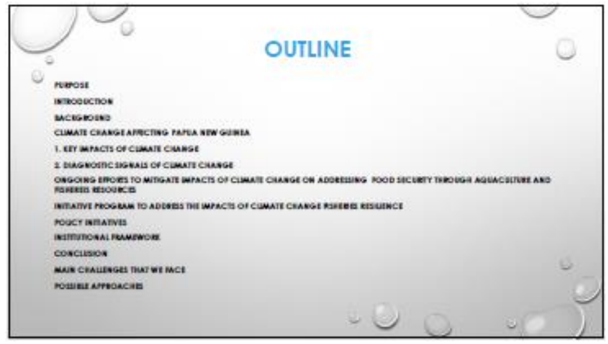
Thank you for attention

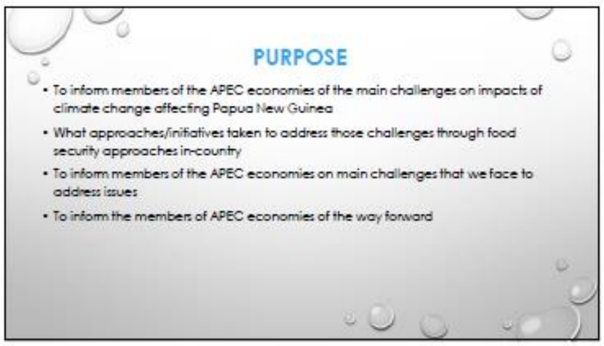
Papua New Guinea. Impacts of climate variations on local fisheries and aquaculture resources in PNG

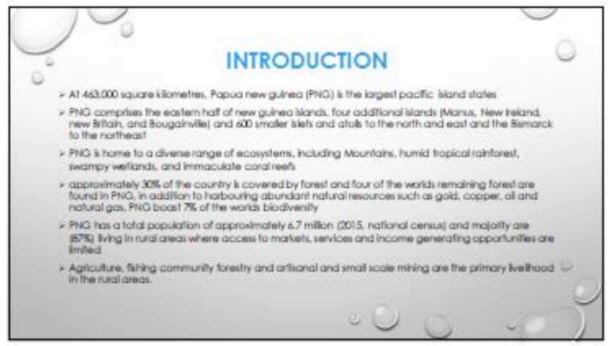
Paul Kandu
National Fisheries Authority, Papua New Guinea

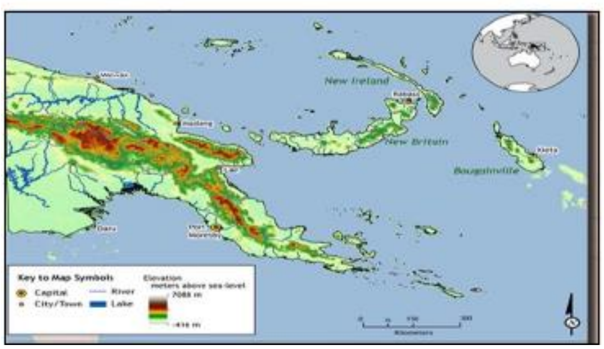
Papua New Guinea (PNG) is one of the world's most vulnerable economies to climate change. Increasing frequency of storms, rainfall, flooding, as well as rising ocean temperature has resulted in greater vulnerability of livelihoods and food security globally but remarkably higher for the Pacific Islands economies including PNG. Sustainable production of food resources and stability of livelihood is increasingly challenged by the predicted impacts of climate change, and extreme climate events. Intensity of tropical cyclones, extreme drought, fires, flooding and landslides threatens terrestrial ecosystems and agriculture. Ocean warming, acidification, sea level rise and floods have negative impacts on mariculture and fisheries in coastal regions. Food security, especially access to dietary protein, is at risk due to the effects of climate change. Social indicators reveal that 87.5% of the population is rural-based with most involved in subsistence agriculture for their livelihood. PNG is not the exception, with many people being vulnerable to the vicissitudes of the natural environment mostly because of coastal and inland flooding, landslides and soil erosion that have important consequences on food security, which is a national issue on the rise in PNG. The diagnostic signals often are sea level rise, sinking islands, deteriorating of maritime resilience infrastructure lacking accessibility, food security (drought), declining of fish stock, increasing water salinity, and change in weather conditions. Despite the negative consequences, there are also opportunities from which we must take advantage. To increase our adaptive capacity, APEC economies need to work together in sub-regional and regional groups in order to thrive in the face of the rapid climatic change.

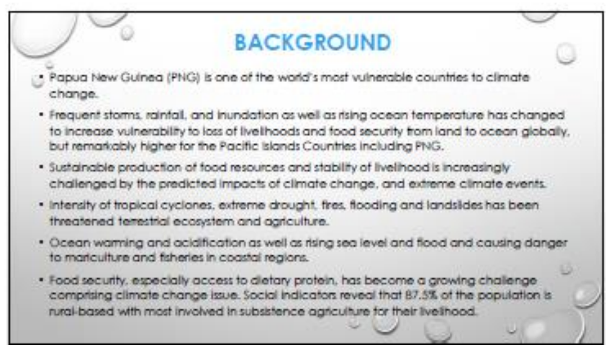

IMPACTS OF CLIMATE VARIATIONS
ON LOCAL FISHERIES AND
AQUACULTURE RESOURCES IN PNG
25th – 27th 2017
APEC Workshop: Development of Tools of Biological Risk Assessment Impacts of Climate Change on Fisheries and Aquaculture Resources


OUTLINE
PURPOSE
INTRODUCTION
BACKGROUND
CLIMATE CHANGE AFFECTING PAPUA NEW GUINEA
1. KEY IMPACTS OF CLIMATE CHANGE
2. DIAGNOSTIC SIGNALS OF CLIMATE CHANGE
ONGOING EFFORTS TO MITIGATE IMPACTS OF CLIMATE CHANGE ON ADDRESSING FOOD SECURITY THROUGH AQUACULTURE AND FISHERIES RESOURCES
INITIATIVE PROGRAM TO ADDRESS THE IMPACTS OF CLIMATE CHANGE FISHERIES RESILIENCE
POLICY INITIATIVES
INSTITUTIONAL FRAMEWORK
CONCLUSION
MAIN CHALLENGES THAT WE FACE
POSSIBLE APPROACHES


PURPOSE
• To inform members of the APEC economies of the main challenges on impacts of climate change affecting Papua New Guinea
• What approaches/initiatives taken to address those challenges through food security approaches in-country
• To inform members of the APEC economies on main challenges that we face to address issues
• To inform the members of APEC economies of the way forward


INTRODUCTION
➢ At 463,000 square kilometres, Papua new guinea (PNG) is the largest pacific island states
➢ PNG comprises the eastern half of new guinea islands, four additional islands (Manus, New Ireland, new Britain, and Bougainville) and 600 smaller islets and atolls to the north and east and the Bismarck to the northeast
➢ PNG is home to a diverse range of ecosystems, including Mountains, humid tropical rainforest, swampy wetlands, and immaculate coral reefs
➢ approximately 30% of the country is covered by forest and four of the worlds remaining forest are found in PNG, in addition to harbouring abundant natural resources such as gold, copper, oil and natural gas. PNG boast 7% of the worlds biodiversity
➢ PNG has a total population of approximately 6.7 million (2015, national census) and majority are (87%) living in rural areas where access to markets, services and income generating opportunities are limited
➢ Agriculture, fishing community forestry and artisanal and small scale mining are the primary livelihood in the rural areas.


New Ireland
New Britain
Bougainville
Key to Map Symbols
Capital
City/Town
River
Lake
Elevation
meters above sea-level


BACKGROUND
• Papua New Guinea (PNG) is one of the world's most vulnerable countries to climate change.
• Frequent storms, rainfall, and inundation as well as rising ocean temperature has changed to increase vulnerability to loss of livelihoods and food security from land to ocean globally, but remarkably higher for the Pacific Islands Countries including PNG.
• Sustainable production of food resources and stability of livelihood is increasingly challenged by the predicted impacts of climate change, and extreme climate events.
• Intensity of tropical cyclones, extreme drought, fires, flooding and landslides has been threatened terrestrial ecosystem and agriculture.
• Ocean warming and acidification as well as rising sea level and flood and causing danger to mariculture and fisheries in coastal regions.
• Food security, especially access to dietary protein, has become a growing challenge comprising climate change issue. Social indicators reveal that 87.5% of the population is rural-based with most involved in subsistence agriculture for their livelihood.

CONT…

- **INTERNATIONAL ORGANIZATIONS**
- United Nations Sustainable Development Goal 13: Climate Action
- APEC climate change on
- the action plan to implement the multi-year framework program on food security and climate change is to realize the APEC food security roadmap towards 2020 and BOGOR goals 2020.
- Works done on climate change and food security in the past by APEC economies
- **DOMESTIC PRIORITIES**
  - PNG vision 2050 - pillar 5: environmental sustainability and climate change

Environment sustainability and develop mechanisms to enable resilient communities

a. improve the knowledge and understanding of the impact of climate change on PNG. develop the capability to predict future trends.

b. improve climate change mitigation and adaptation measures.

c. develop plans for sustainable use of natural resources and mechanisms to regulate

d. develop clear roles and responsibilities for all stakeholders with established focal points research clusters and international and international partnerships

- PNG development strategic plan (2010-2030) –

to promote links more specific national instruments and plans across specific sectors that links weather and climate including water; agriculture; energy; forestry; land use; health; coastal zone management; marine ecosystems; ocean management; tourism and transport.

CLIMATE CHANGE AFFECTING PAPUA NEW GUINEA AND ITS FISHERIES AND AQUACULTURE RESOURCES

FACTS OF CLIMATE CHANGE IN PAPUA NEW GUINEA

- Many people in Papua New Guinea are today vulnerable to the vicissitudes of the natural environment.
- coastal flooding;
- inland flooding;
- landslides and;
- soil erosion;

Consequently, these natural and human induced events are the opening for food security; which is currently a national issue on the rise in the country.

KEY IMPACTS OF CLIMATE CHANGE

- As an island state, PNGs coastal communities are under threat to the impact of climate change. this has created several major problems within PNG;
- Internally deforestation has contributed to the excessive carbon emissions, over exploitation of natural resource pollution and land use waste disposal as PNG works towards industrialization.

DIAGNOSTIC SIGNALS OF CLIMATE CHANGE

ONGOING EFFORTS TO MITIGATE IMPACTS OF CLIMATE CHANGE ON ADDRESSING FOOD SECURITY THROUGH AQUACULTURE AND FISHEREIS RESOURCES

Initiative program to address the impacts of climate change through fisheries resilience

BUILDING RESILIENCE THROUGH CLIMATE CHANGE

Capacity Building on addressing climate change through resilient fisheries and aquaculture resources development.

- the aim of the project is to stabilize and address the key impacts caused by climate change in the region and establish food security

MAP OF TARGETED SITES

Activities

Inputs

Outputs

Project beneficiaries

POLICY INITIATIVES

- Building a Climate Change-Resilient Freshwater Aquaculture System using climate information in Papua New Guinea (2018-2020). (Collaboration between Korea and PNG, NFA)
- Fisheries Management Policy
- National Climate Compatible Development and Management Policy

INSTITUTIONAL FRAMEWORK

ADAPTIVE STRATEGIES

- **Quantifying & Prioritising Hazards:**

Identify communities and sectors most at risk to climate change impacts (e.g., coastal and inland flooding, landslides, marine ecosystem health, agricultural yield change, vector borne diseases)

- **Identifying & Selecting Interventions:**

In conjunction with relevant sectoral stakeholders, analyze potential losses and benefits and examine feasibility of available adaptation measures

- **Monitoring & Evaluation:**

Review and measurement of intervention outcomes relative to baseline information based on evaluation results, identify lessons learned and apply to successive interventions.

MITIGATION STRATEGIES

- **Sustainable land use planning:**

Promote establishment of nation-wide sustainable land use planning, starting from community-ward-LLG level, to district-provincial and national levels.

Ensuring collaboration of all relevant government departments in considering climate change resilience and;

Maximising payment for ecosystems services under REDD+ management as national land use priorities.

CONCLUSION

There are many consequences through challenges that are faced today

Therefore if we do not start now, ongoing consequences will be:

- acceleration of sea level,
- harm caused to human
- ocean acidification and; leading depleting of aquaculture, fisheries and marine stocks
- extinction of animals

And if it continues, more common impacts of natural disaster will likely to be tremendous

So, in general we need to work together in **sub-regional** and **regional** to stop Global Warming from continuing if not; living organism shall soon be eradicated from all faces of the earth.

MAIN CHALLENGES THAT WE FACE

- Technical capacity issues
- Real policies and tools as instruments that will be workable
- Human resource capacity
- Technology know how/transfer

POSSIBLE APPROACHES

- Learn from this workshop on establishing a coordinated framework for sharing experiences and scientific knowledge and best practices to strengthen institutions in supporting agriculture and fishing by enhancing the skills and knowledge of male and female farmers and fishermen will yield significant returns.
- Enhancing the awareness in the region of increasing vulnerability of fisheries and aquaculture resources;
- Strengthen and promote policy initiatives to ensure that there is coherence in the ecosystems based management relating to economic opportunities;
- Enhance successful stories from this workshop to in adapting social mitigation and impacts of climate change;
- Learn and enhance approaches relevant to APEC economies in addressing the relationship between food-security and climate change.

EM TASOL NA TENK YU TRU

Peru. Current knowledge of impacts of climate variations on local fisheries and aquaculture resources in Peru

Jorge Tam[1] and Nena Gonzales[2]
[1]General Direction of Oceanographic and Climate Change Research – Peruvian Marine Research Institute (IMARPE), [2]Ministry of Production of Peru (PRODUCE)

The Peruvian upwelling ecosystem is characterized by cold waters and a subsurface oxygen minimum zone with low pH. In the last decades, from Central Peru to Northern Chile a cooling trend of coastal waters has been detected, these conditions could strengthen upwelling and turbulence, however these trends could continue until large scale ocean warming will override coastal upwelling. Under a warming scenario, oceanic resources such as tuna and dolphinfish could expand their distribution towards the coast. First oceanic and biological modelling scenarios predict changes in winds and currents, deepening of the thermocline and stratification of column water, reducing oxygen ventilation and nutrient fluxed, resulting in a decline of nursery grounds for fish larvae. Artisanal communities along the Peruvian coast are the most vulnerable to changes in catch of fishes due to exposure and sensitivity to climate change, dependence of livelihoods and food security on fish, and limited adaptive capacity. In order to reduce the vulnerability of artisanal communities to climate change, it is necessary to apply adaptation measures, such as the use of selective fishing methods towards human consumption and to diversify economic activities like sustainable aquaculture and ecotourism. In this context, the Peruvian Marine Research Institute (IMARPE) and the Ministry of Production (PRODUCE) are leading adaptation to climate change efforts through National Determined Contributions in adaptation and projects in pilot areas to implement: early warning - modelling system, vulnerability and ecological risk assessments to climate change, selective fishing gears, natural banks restoration and co-management, sustainable aquaculture, bioconversion of fisheries and aquaculture residues, vivential ecotourism, capacity building of artisanal fishery communities and ecosystem based governance.

Current knowledge of impacts of climate variations on local fisheries and aquaculture resources in Peru

Jorge Tam [1] and Nena Gonzales [2]

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[2]Ministry of Prodution (PRODUCE)

APEC "International Workshop on ecological risk assessment of impacts of climate change on fisheries and aquaculture resources"

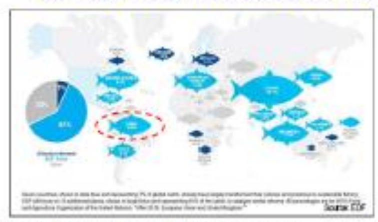
October 25th, 2017

Outline

- Past impacts of climate variations
- Future impacts on fisheries and aquaculture resources
- Climate change adaptation efforts for Peruvian fisheries and aquaculture
- Conclusions

Past impacts of climate variations

Challenges of climate change for Peruvian fisheries



- Peru has one of the **most diverse and abundant fisheries** in Latin America, significantly contributing to the country's food security and socio-economic development.
- Peru is found among the 10 **most vulnerable fisheries** to climate change.

The fisheries and aquaculture sector in Peru is:

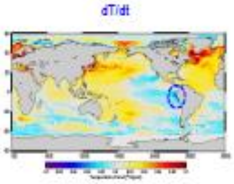
- Key in the local and national socioeconomic dynamics
- Source supplier of seafood products for humans and animals
- Great generator of jobs

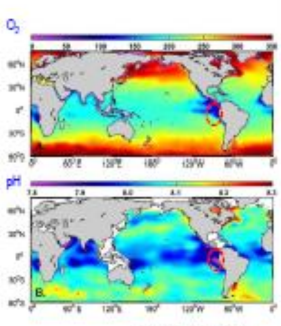
(Allison et al. 2009)

Particularities of the Peruvian upwelling ecosystem

There is a great uncertainty about the response of the Southeast Pacific to global warming. Last decades observations support a trend of **coastal cooling** and **upwelling intensification**, associated to low oxygen and pH.

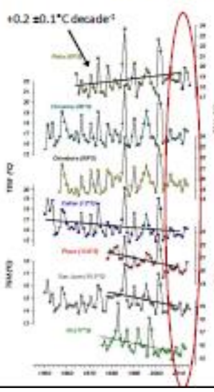
dT/dt



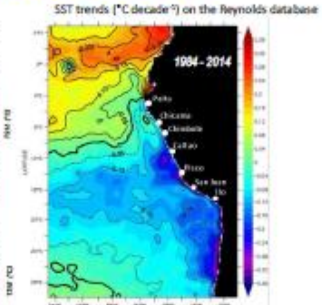


(Chávez *et al.* 2008)

SST trends in the South Eastern Pacific

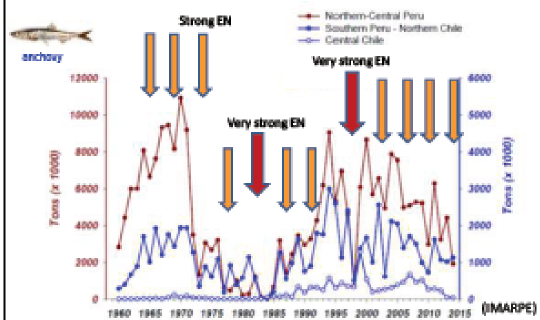


SST trends (°C decade-1) on the Reynolds database



Pier records: significant linear fits are over-imposed on the time-series; negative SST trends until 2010 are -0.3±0.1 C decade-1 (Gutiérrez et al., 2016).

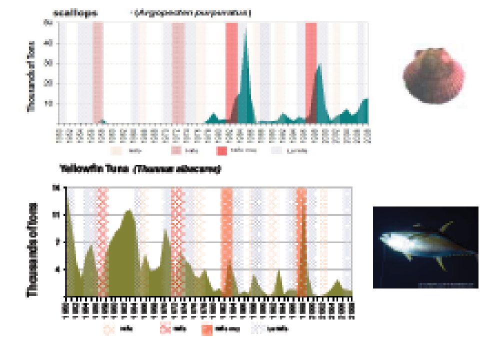
Impact of El Niño on fisheries: warming lessons



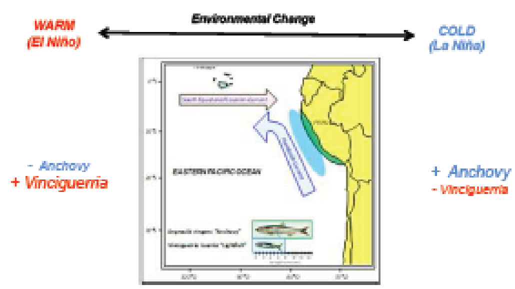
1972/1973: strong El Niño appeared during a vulnerable anchovy stock by overfishing.
1997/1998: very strong El Niño appeared during a healthy anchovy stock and recovered.

Positive impacts of El Niño

Species increasing during warming events: scallops and tuna.

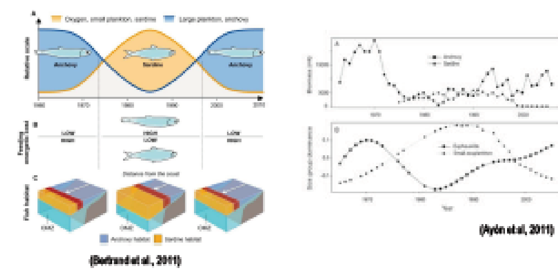


Response of dominant species in the coastal and oceanic zones off Peru



Regime shifts: role of oxygen and food type under climate variability

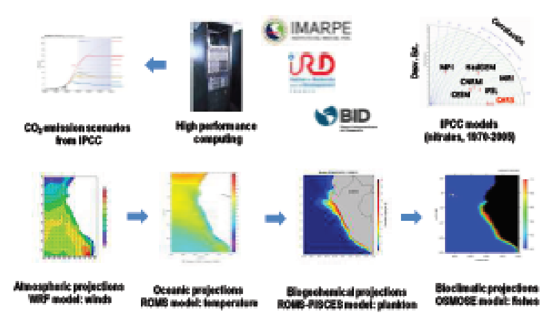
- Warm period (1976 – 1995) was characterized by more oxygenation, weaker upwelling and small copepods.
- Cool period (1996-present): stronger OMZ, stronger upwelling larger copepods and euphausiids. Anchovy prefer **larger copepods and euphausiids** as food.



Future impacts on fishery and aquaculture resources

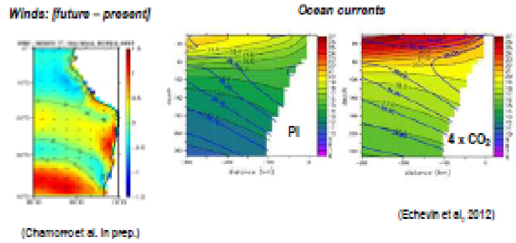
Modelling climate change scenarios

Atmospheric, oceanic, biogeochemical and bioclimatic models are used to develop climate change scenarios as an early warning and forecast system (LMOECC-IMARPE).

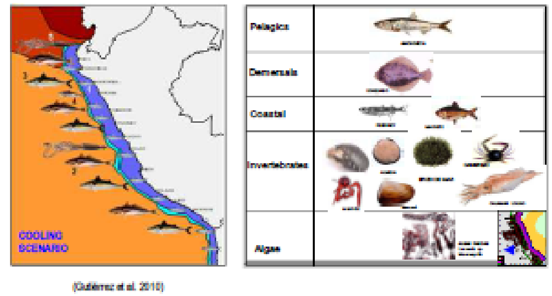


First generation regional models

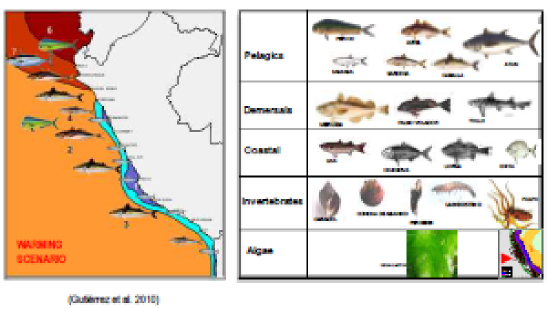
First modelling simulations forecast a reduction in winds and productivity under a pessimistic $4xCO_2$ scenario. However, these models will require a **higher spatial resolution** in coastal areas to better simulate the upwelling processes.



Species in a cooling scenario

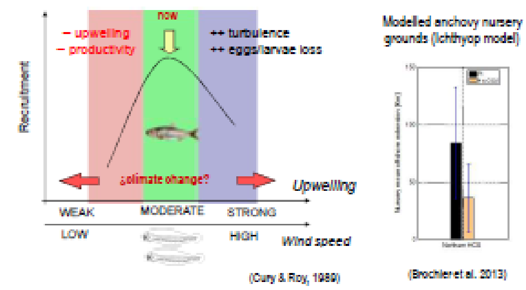


Species in a warming scenario



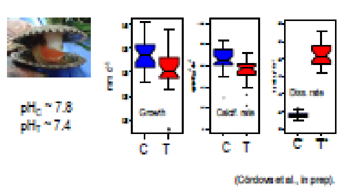
¿Shifting along the optimal environmental window (OEW)?

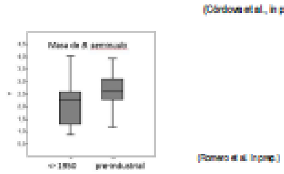
Climate change could intensify winds increasing turbulence or it could weaken winds reducing productivity, both outside the OEW, decreasing recruitment.



Resources' vulnerability to multiple climatic stressors

- Growth & calcification rates at risk to ocean acidification (Peruvian scallop *Argopecten purpuratus*).
- Paleoecological studies show mass reduction in foraminifers since pre-industrial period to the present.
- Synergic impact of ocean **acidification, global warming, and expanding hypoxia** will compress the habitable depth range of the species (species at risk: small pelagics and jumbo squid).

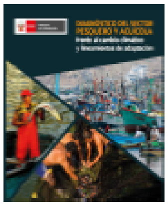




Climate change adaptation efforts for Peruvian fisheries and aquaculture

Climate Change Vulnerability Assessments

Ministry of Production (PRODUCE) has carried out vulnerability assessments for the Fisheries and Aquaculture Sector in Peru (2016).



- Piura – Artisanal fishing
- Ancash – Industrial fishing
- Ica – Artisanal fishing
- Puno - Aquaculture

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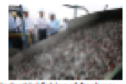
The National Determined Contributions (NDC) on Fisheries and Aquaculture Adaptation

Artisanal fishing

Artisanal fishing of Mahi-Mahi

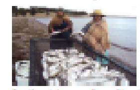


Industrial fishing of Anchovy

OBJECTIVE

Reduce vulnerability to climate change and increase resilience of fishing and aquaculture activities in Peru

Continental fishing



Continental aquaculture of trout

Marine aquaculture of scallops

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The NDC on Fisheries and Aquaculture, ¿where are we?

Stage	Activities	Date
Risk analysis	• Identification of hazards and risks of climate change on fisheries and aquaculture	Jul 2017
Problem and means analysis	• Problem analysis and validation process for Artisanal Fishing, Industrial Fishing and Aquaculture	Sep 2017
Adaptation alternatives	• Identification of existing instruments and potential alternatives for climate change adaptation	Oct 2017
Identification of indicators and goals	• Formulation of indicators • Validation of NDC goals	Nov 2017
Baseline	• Baseline and climate change strategy proposal for NDC implementation	Dec 2017

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Prospects and next steps

- Future Vulnerability Analysis 2016-2017
- Adaptation Strategy - Action Plan 2018
- Implementation and Follow-up Plan of Action 2018-2021

Technical meetings with all relevant stakeholders

Ongoing Vulnerability Assessments

Socialization and validation studies and workshops

Project implementation and collaboration opportunities

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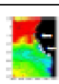
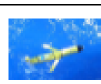
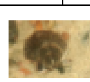
IMARPE BID ADAPTATION FUND

Peruvian projects on climate change adaptation on coastal marine ecosystems and fisheries

	BID	FA
Project	Adaptation to climate change of fishery sector and marine coastal ecosystem of Peru	Adaptation to the impacts of climate change in the marine coastal ecosystem of Peru and its fisheries
Duration	30 months (2014 – 2017)	48 months (2016 – 2020)
Budget (US$)	2,500,000	6,950,239
Main actors	IMARPE, PRODUCE, MINAM	IMARPE, PRODUCE, MINAM, SERNANP, GORES, PROFONANPE
Components	3 (science, transversality, interventions)	4 (interventions, surveillance, capacity building, governance)







Conclusions

- In the Peruvian upwelling system in the last decades a **cooling trend** has been detected. These conditions could continue until **large scale warming** override coastal upwelling.
- Under a warming scenario, **oceanic resources** as tuna and dolphinfish could extend its distribution towards the coast.
- IMARPE and PRODUCE are leading adaptation to climate change efforts through **National Determined Contributions** in adaptation and **projects in pilot areas** to implement: early warning - modelling system, vulnerability and ecological risk asessments to climate change, selective fishing gears, natural banks restoration and co-management, sustainable aquaculture, bioconversion of fisheries and aquaculture residues, vivential ecotourism, capacity building of artisanal fishery communities and ecosystem based governance.


IMARPE
! Thank you !
(jtam@imarpe.pe)

Russia. Climate change and fish resources in the western Bering Sea

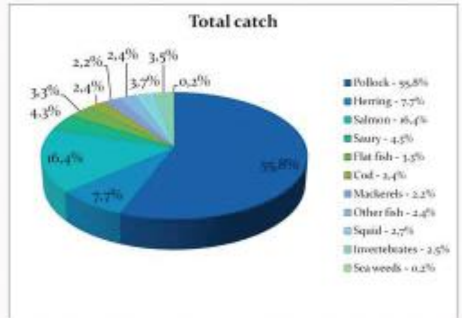
Vitaliy Samonov
Pacific Fisheries Research Center (TINRO-Center)

The Bering Sea is one of the most important fishery areas in the Far East of Russia; pollock, salmon, herring and saury are the main target species of the commercial catch. Since the year 2007, the northward inflow of Pacific waters has increased, suggesting that much larger volume of Pacific water directly flowed into the Commander Basin. Rise in temperature was accompanied by increase in biomass of codfishes, flatfishes and sculpins in the western Bering Sea. Downward trends in biomasses in the late 2000s coincided with recent cooling. Spatial distributions and migration patterns of salmon have also changed during the recent decade. A number of oceanographic factors are being monitored and studied in the Bering sea such as temperature patterns, salinity, oxygen and phosphate content along with changes in commercial species abundance and distribution. However, observed trends do not necessarily imply cause-and-effect relationships. Unfortunately, mechanisms of down-scaling planetary changes to the ecosystem level, in particular in the Bering Sea are poorly understood. A more thorough study of events, which occurred in the late 1980s and early 1990s, is required in order to understand how planetary and regional changes of environmental conditions influence marine ecosystems and their components.

Climate change and fish resources in the western Bering Sea

Presented at ESAS conference in Seattle 2011 by G. Khen et all

Catch of fish, invertebrates and algae in the Russian Far East



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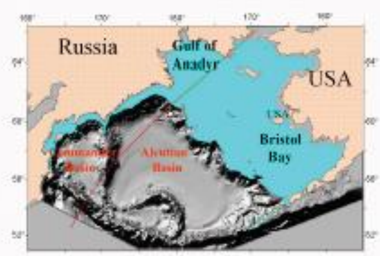
The Bering Sea: deep-sea basins and shelf area



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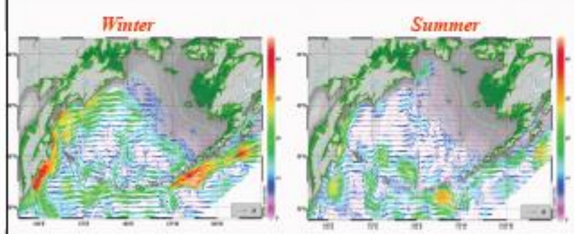
Bering Sea currents, their direction and speed in winter and summer (40 m depth) Data from 510 drifters averaged for 1986-2007



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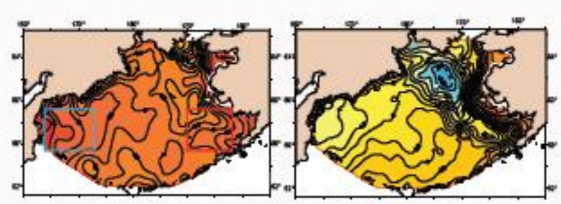
Sea surface temperature in summer (August)

Temperature at the temperature-minimum surface in summer (August)



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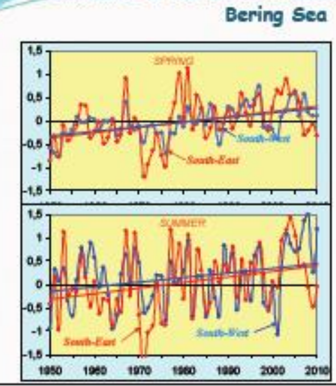
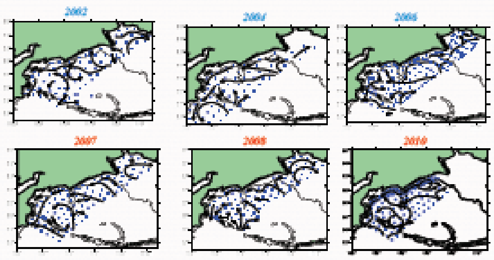
Interannual variability of sea surface temperature anomalies in the southwestern and southeastern Bering Sea



On the background of total warming, several cooling periods can be recognized: in the 1970s, late 1990s, and mid of current decade. The last cooling has been observed only the Bristol Bay where temperature fell below normal. In the southwest, it practically has not changed, remaining above the normal values.

Major geostrophic currents in the western Bering Sea in warm half-year

thick lines show current with speed >5 cm/s relative to 1000 dbar



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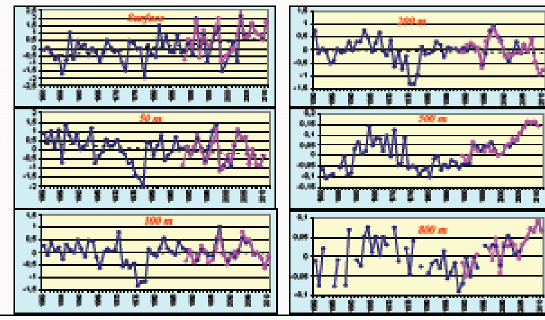
Interannual variability of the temperature anomalies from surface to 800 m in the deep area within the Russian EEZ

blue lines - data from Climatic Atlas ... (2009), 1950-2004

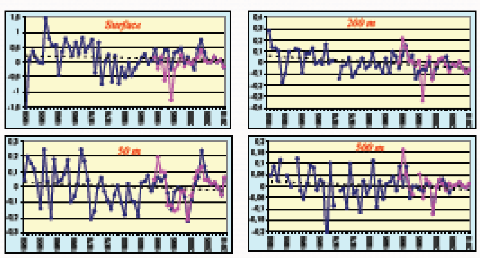
pink lines – our data, 1986-2010



Interannual variability of salinity anomalies from the surface down to 500 m in the deep area within Russian EEZ

blue lines – data from Climatic Atlas ... (2009), 1950-2004

pink lines – our data, 1986-2010



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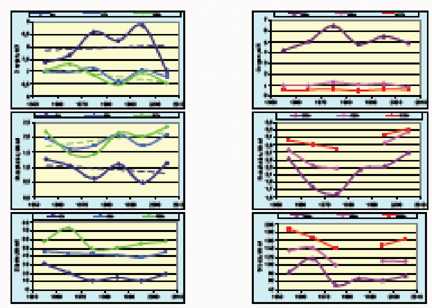
Interannual variability in Oxygen, Phosphate and Silicate from the surface down to 1000 m



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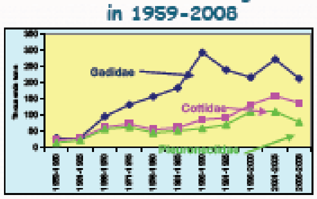
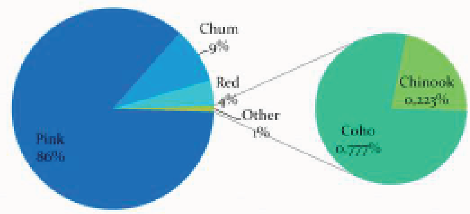
Biomass of bottom fish families in the western Bering Sea in 1959-2008



Biomass (thousand tons) of mezopelagic fish and squid in the upper pelagic layer (0-50 m)

	1991	1992	1993	1995	2003	2005	2007	2009
Mezopelagic fish	4.6	1.5	13.2	9.0	15.8	14.8	150.9	40.9
Squid	70.1	5.1	95.0	48.1	99.3	203.7	243.3	231.2

Salmon species catch proportions in the Russian Far East



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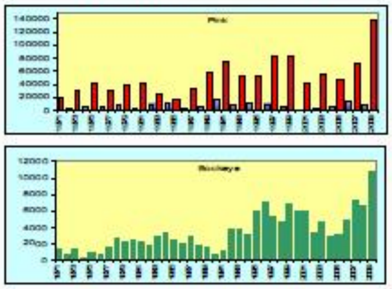
Catch (thousand tons) of Pink and Sockeye salmon off eastern Kamchatka



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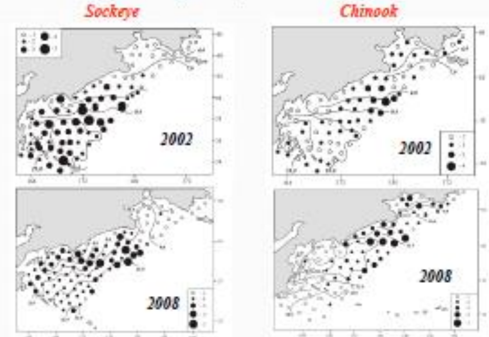
Distribution of Sockeye and Chinook salmon in different types of current systems

Sockeye *Chinook*



Annual biomass (thousands tons) of immature Chum, Sockeye and Chinook salmon in the upper epipelagic (0-50 m) western Bering Sea during September-October

	Chum	Sockeye	Chinook
2002-2006	283.0	132.7	17.9
2007-2009	178.8	62.8	5.5

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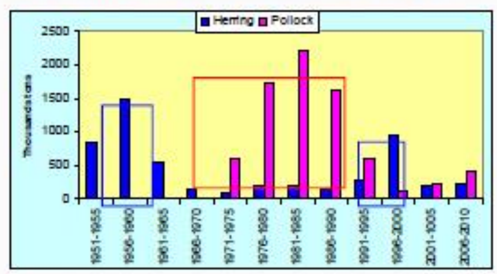
Changes in biomass of walleye pollock and Pacific herring in the western Bering Sea



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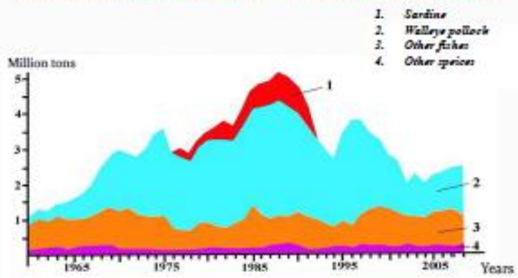
Dynamic of fish and non-fish catches within the Russian EEZ in the northwestern Pacific



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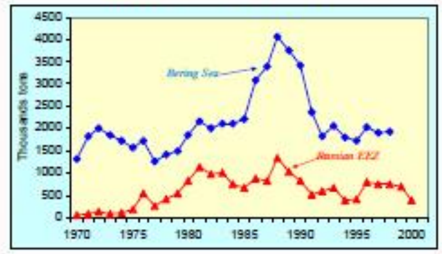
Walleye pollock catches by all countries in the Bering Sea:

blue line **– total catch**
red line **– catch in the Russian EEZ**



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Biomass of fish and squid within 0-50 m in different years

	1980-1990	1991-1995	1996-2005	2006-2010
All fish, 0-50 m, million tons	5.0	1.34	2.19	2.14
Squid, 0-50 m, million tons	0.14	0.09	0.21	0.28

Fish biomass on the northwestern Bering Sea shelf and in the Gulf of Anadyr in different years

	1980	1990	2000-2002	2005-2008
Northwestern shelf and Gulf of Anadyr	700	524	275	1163

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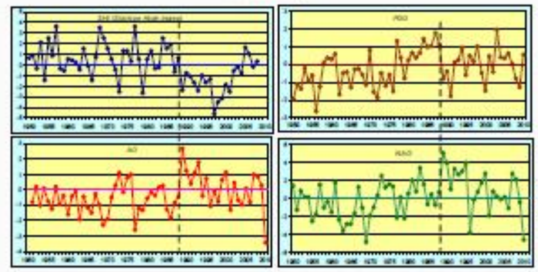
Climate indexes:

SHI (Asian continent), and AO (relation between moderate and polar latitudes), PDO (North Pacific), NAO (North Atlantic)



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Major outcomes:

- 1. The mechanisms of down-scaling planetary changes to the ecosystem level, in particular, in the Bering Sea are poorly understood.
- 2. More thorough study of the events, which occurred in the late 1980s and early 1990s is necessary, to understand how planetary and regional changes of environmental conditions influence marine ecosystems and their components.

Thailand. The Effect of Climate Change on Fisheries and Aquaculture Resources in Thailand

Boonsong Sricharoendham
Department of Fisheries, Thailand

Thailand is located at the south-eastern part of the Indochina peninsula, with latitude between 5°N and 20°N and longitude between 97°E and 105°E. It has an area of 513,120 km2 with a coastline of 2,614 km and 3,750 km2 of inland water area. Fisheries and aquaculture in Thailand play very important roles in food security, income generation, livelihood, and exportation. Thailand´s fish production declined from 4.12 million tons in 2005 to 2.43 million tons in 2015. During 2011–2015, the total fisheries production was estimated at 2.43–3.04 million tons per year. During this period of time, capture fisheries contributed about 61.75% of the production, of which 54.38% was from marine capture and 7.37% from inland capture. Aquaculture production contributed about 38.25%, of which 23.02% was from coastal production and 15.23% from inland production. Climate change impact is an additional pressure to many fisheries and aquaculture activities due to changes in distribution and abundance, loss of habitat, pollution, disturbance, etc. Monthly rainfall data over Thailand is examined to analyse rainfall variability; wind circulation and sea level pressure maps also are examined to better understand the mechanisms associated with this phenomenon. Those changes will affect fisheries and aquaculture via shift of temperature, hydrological cycles, the frequency and severity of extreme events, and sea-level rise. Notable changes in climate extremes in Thailand, particularly temperature and rainfall, are expected to have substantial socio-economic and ecological impacts in the coming decades. The risks associated with these climate extremes will increase and affect the biophysical environment, socio-economic activities, and millions of people. Impacts on the distribution and productivity of populations of targeted species, on habitats, and on food webs, as well as impacts on fishery and aquaculture costs and productivity and fishing community livelihoods are expected. Therefore, further studies on vulnerability and risk assessments are great scientific challenges to shed more light on adaptation strategy and disaster preparedness, and to move forward as climate resilient sustainable societies.

APEC International Workshop on ecological risk assessment of impacts of climate change on fisheries and aquaculture resources

The Effect of Climate Change in Fisheries and Aquaculture Resources in Thailand

Boonsong SRICHAROENDHAM

Department of Fisheries, THAILAND

OUTLINE

- Thailand and their fisheries & aquaculture
- Impact from climate change
- Recently activities of Thai DoF concerning to climate change

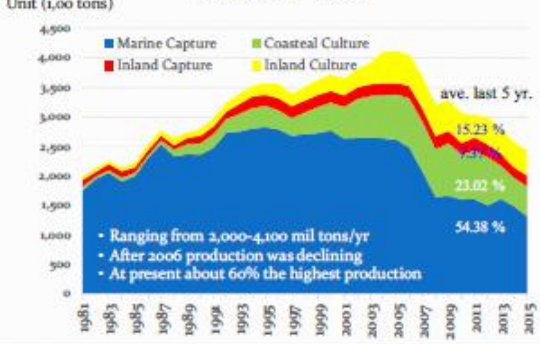
THAILAND

- Location: center of Indochinese peninsula in SE Asia
- Area: Prox. 513,115 km²
- Population: 69 million
- Water resource: 25 River basins & 2 Coastal lines
- Season: rainy (Jun-Oct), winter (Nov-Feb) summer (Mar-May)
- Temperature: 18-40 °C
- Rainfall: 1,200-1,600 mm/yr, some area>4,500 mm/yr

THAILAND

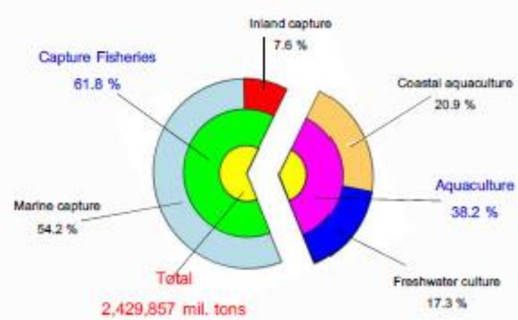
Fisheries & Aquaculture Production

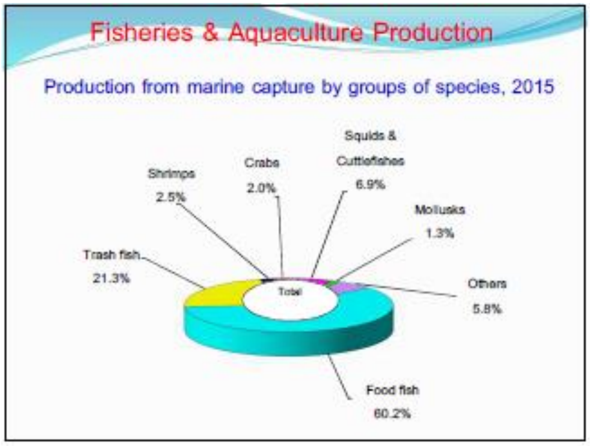
during 1981 - 2015

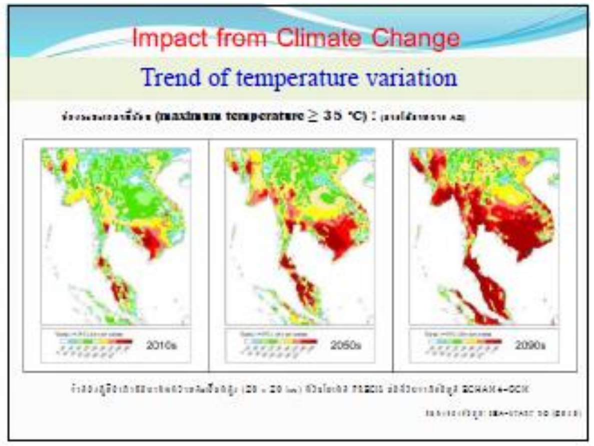


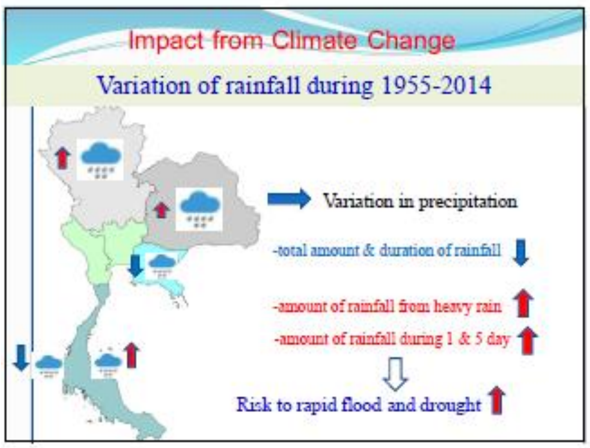
Fisheries & Aquaculture Production

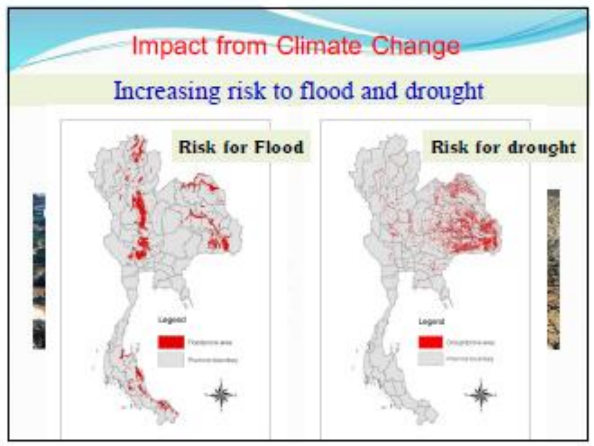
Detail of production in 2015

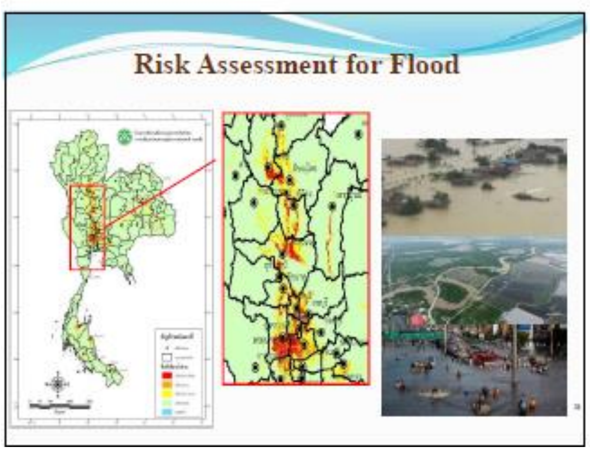


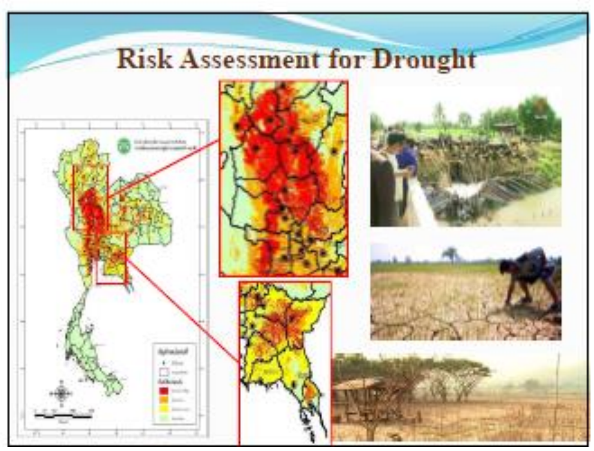

Fisheries & Aquaculture Production
Production from marine capture by groups of species, 2015
Squids & Cuttlefishes 6.9%
Crabs 2.0%
Shrimps 2.5%
Mollusks 1.3%
Trash fish 21.3%
Total
Others 5.8%
Food fish 60.2%

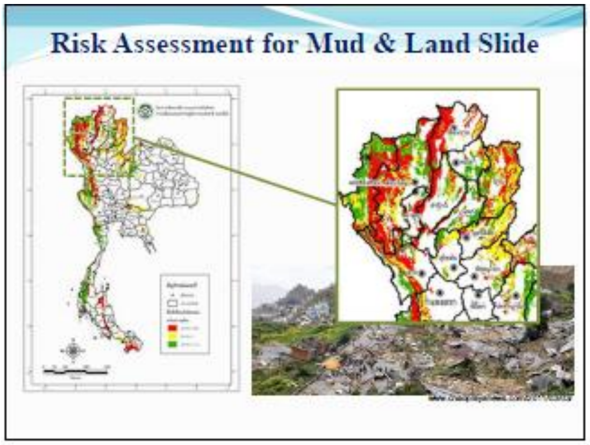

Impact from Climate Change
Trend of temperature variation
(maximum temperature ≥ 35 °C)
2010s
2050s
2090s

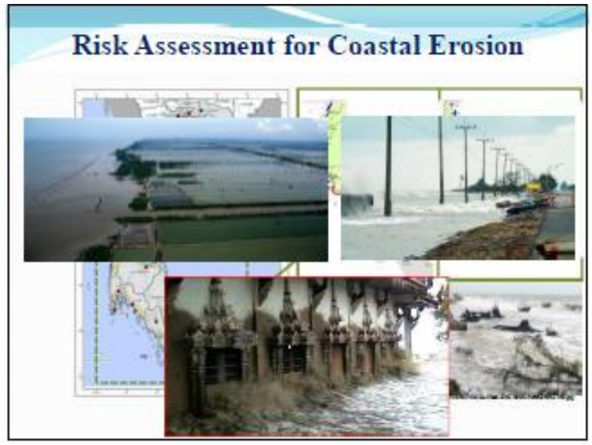

Impact from Climate Change
Variation of rainfall during 1955-2014
Variation in precipitation
-total amount & duration of rainfall
-amount of rainfall from heavy rain
-amount of rainfall during 1 & 5 day
Risk to rapid flood and drought

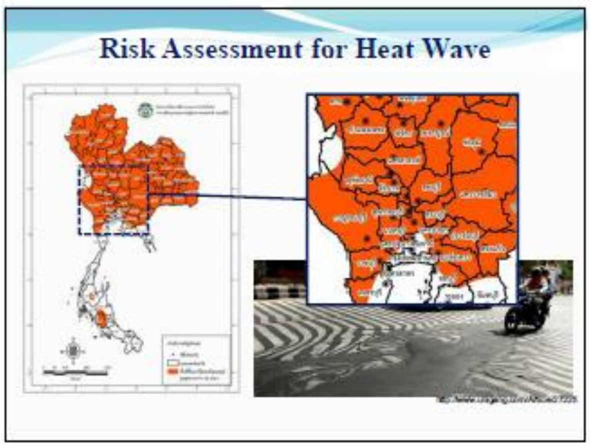

Impact from Climate Change
Increasing risk to flood and drought
Risk for Flood
Risk for drought
Legend
Legend

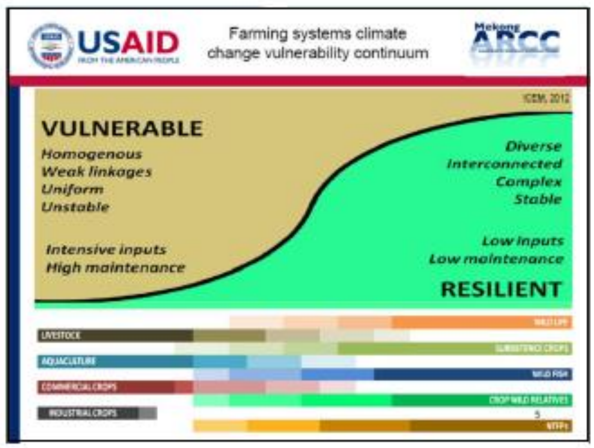

Risk Assessment for Flood


Risk Assessment for Drought

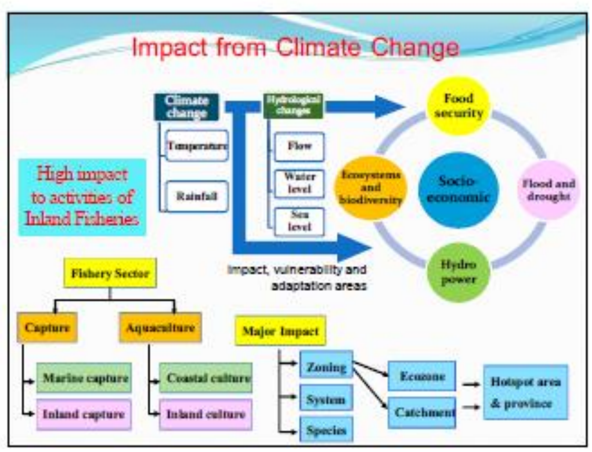

Risk Assessment for Mud & Land Slide


Risk Assessment for Coastal Erosion


Risk Assessment for Heat Wave


USAID
Farming systems climate change vulnerability continuum
Mekong ARCC
ICEM, 2012
VULNERABLE
Homogenous
Weak linkages
Uniform
Unstable
Intensive inputs
High maintenance
Diverse
Interconnected
Complex
Stable
Low inputs
Low maintenance
RESILIENT
LIVESTOCK
AQUACULTURE
COMMERCIAL CROPS
INDUSTRIAL CROPS
WILD LIFE
SUBSISTENCE CROPS
WILD FISH
CROP WILD RELATIVES
NTFPs


Impact from Climate Change
USAID
Mekong ARCC
Climate change threats to LMB Capture Fisheries & Aquaculture
How will these affect the sector?
Temperature increases
Timing of the monsoon
Increased rainfall
Longer dry periods
Increased erosion
Increased CO2 levels
Increased sea levels


Impact from Climate Change
Climate change
Temperature
Rainfall
Hydrological changes
Flow
Water level
Sea level
Food security
Ecosystems and biodiversity
Socio-economic
Flood and drought
Hydro power
High impact to activities of Inland Fisheries
Impact, vulnerability and adaptation areas
Fishery Sector
Capture
Aquaculture
Marine capture
Inland capture
Coastal culture
Inland culture
Major Impact
Zoning
System
Species
Ecozone
Catchment
Hotspot area & province

Risk Assessment on Inland Aquaculture

Intensive pond/cage monoculture

	Change	Impact
↑	Inc in temperature	high
↑	Inc in precipitation	low
↓	Dec in precipitation	medium
↓	Dec in water availability	very high
↑	Inc in water availability	-
↑	Drought	very high
↑	Flooding	very high
↑	Storms & flash floods	high
↑	Sea level rise	-
↑	Inc salinity	-

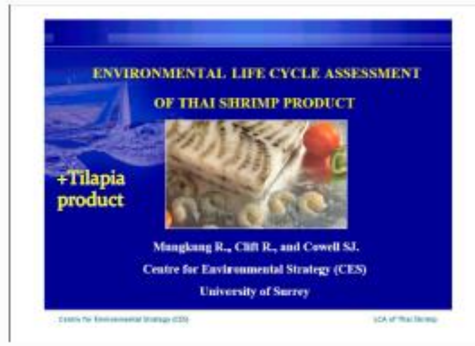
Semi-intensive pond polyculture

	Change	Impact
↑	Inc in temperature	high
↑	Inc in precipitation	medium
↓	Dec in precipitation	very high
↓	Dec water availability	medium
↑	Inc water availability	-
↑	Drought	high
↑	Flooding	very high
↑	Storms & flash floods	high
↑	Sea level rise	-
↑	Inc salinity	-

Extensive pond polyculture

	Change	Impact
↑	Inc in temperature	medium
↑	Inc in precipitation	low
↓	Dec in precipitation	medium
↓	Dec water availability	high
↑	Inc water availability	-
↑	Drought	high
↑	Flooding	high
↑	Storms & flash floods	medium
↑	Sea level rise	-
↑	Inc salinity	-

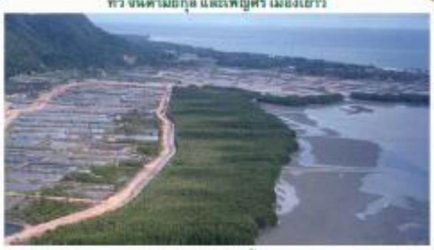
Thai DOF Activities concerning to Climate Change



Carbon Dynamics in Shrimp Farm

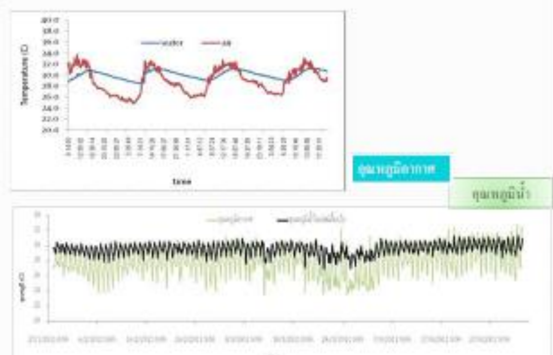
การจัดการพลวัตคาร์บอนในฟาร์มเลี้ยงกุ้งทะเล เพื่อลดการสูญเสีย
และลดการผลิตและปลดปล่อยก๊าซคาร์บอนไดออกไซด์

จุฑารัตน์ กิตติวานิช พุทธ ส่องแสงจินดา วิวรรธน์ สิงห์ทวีศักดิ์
ทวี จินดามัยกุล และเพ็ญศรี เมืองเยาว์

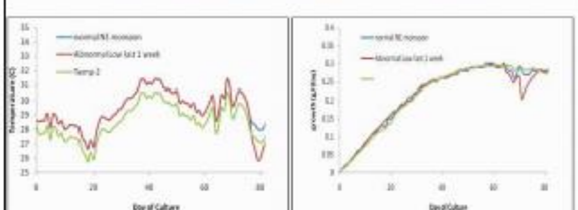


สถาบันวิจัยและพัฒนาการเพาะเลี้ยงกุ้งทะเล กรมประมง

WATER TEMPERATURE VARIATION IN SHRIMP POND

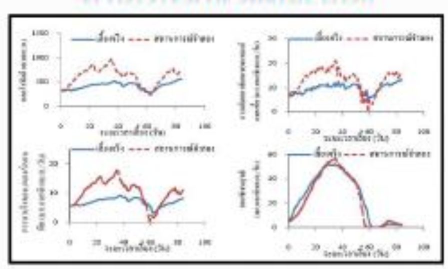


IMPACT OF WATER TEMPERATURE VARIATION TO GROWTH OF SHRIMP IN EARTHEN POND



- การเปลี่ยนแปลงจากฝนตกหนัก ส่งผลต่อการการเติบโตทันที
- การเปลี่ยนแปลงของอุณหภูมิน้ำเพียงเล็กน้อย ถึงแม้ต่อเนื่อง แต่กุ้งสามารถปรับตัวได้
- ในเวลากลางวันอุณหภูมิของน้ำเพิ่มสูงขึ้น กุ้งกินอาหารชดเชยได้

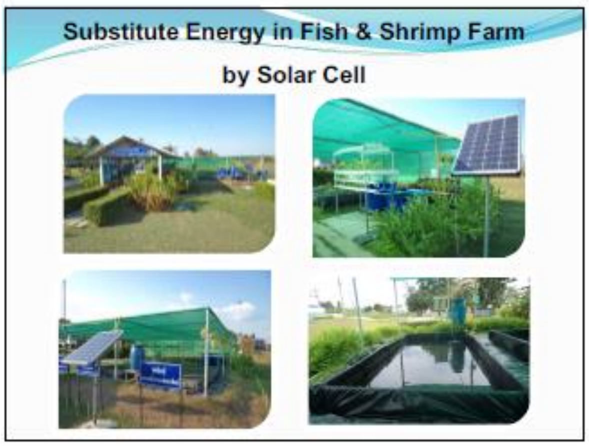
IMPACT OF WATER TEMPERATURE VARIATION TO ECOSYSTEM OF SHRIMP POND



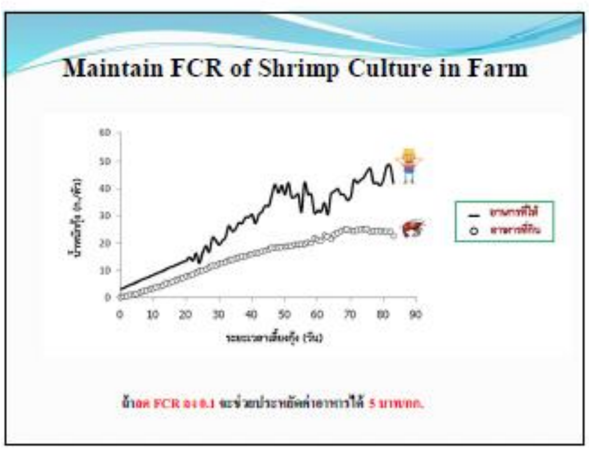
- ปริมาณแสงแดดได้รับผลกระทบต่อการเปลี่ยนแปลงสภาพภูมิอากาศมากกว่าอุณหภูมิ
- มีผลการเติบโตของแพลงก์ตอนพืช การสังเคราะห์แสง และออกซิเจนสุทธิในน้ำ
- มีผลให้ออกซิเจนสำหรับกุ้งเหลือน้อยลงและต้นทุนพลังงานเพิ่มสูงขึ้น


Project on
Green Agriculture City for Fisheries
ZERO WASTE


Extension of Oyster Farming


Substitute Energy in Fish & Shrimp Farm
by Solar Cell


Reduce Chemical Use in Farm


Maintain FCR of Shrimp Culture in Farm
0
10
20
30
40
50
60
70
80
90


Thanks for listening

Viet Nam. The effect of climate change in fisheries and aquaculture resources in Viet Nam

Nguyen Dang Kien
Department of Capture Fisheries Viet Nam

Viet Nam has a long coastline of 3,260 km and a large EEZ of more than 1 million km^2. The number of fishing boats is 108,706 units (2016) and more than 4 million workers directly involved in fishing and marine aquaculture. In addition, Viet Nam is an APEC economy with many river systems, lagoons, ponds and lakes that are favourable for aquaculture. There are over 1 million hectares of water surface for aquaculture. Being a coastal state, annually, fisheries and aquaculture are heavily affected by climate change associated storms, flooding and changes in rainfall pattern that result in natural disasters. The area and quality of land used for aquaculture, and fishing infrastructure can also be affected, with additional impacts caused by increased average temperature, and the change in distribution and production of marine species. In order to adapt to climate change, it is crucial to: 1) Improve investigation and forecasting capacity, 2) diversify culture species, improving appropriate aquaculture technology, 3) develop and implement adaptive management action plans and reduction of impacts of climate change, especially high vulnerability areas, 4) develop fisheries information systems and policies to support fishermen, identifying new fishing grounds, 5) promote the implementation of credit policy to help poor fishermen, 6) increase adaptability and rehabilitation for local people, 7) exploit and use local knowledge and experience, 8) raise awareness, providing training courses for community on the climate change, 9) develop a fisheries co-management model, building capacities and community-based management regulation, and fisheries resource sustainable exploitation.

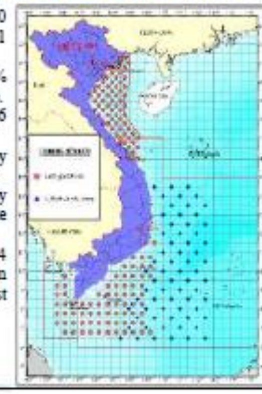
MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT
DIRECTORATE OF FISHERIES

THE EFFECT OF CLIMATE CHANGE IN FISHERIES AND AQUACULTURE RESOURCES IN VIETNAM

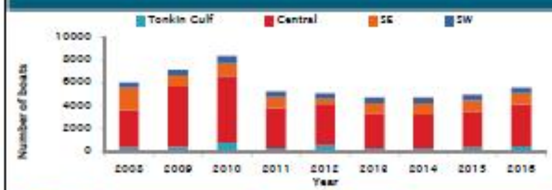
Dr. Nguyen Dang Kien
Officer, Department of Capture Fisheries Vietnam, D-FISH

OVERVIEW OF MARINE CAPTURE FISHERIES

- Viet Nam has a long coastline of 3,260 km; and a large EEZ of more than 1 million km²;
- Marine economic contributes about 47% of GDP (of which seafood is 14% GDP).
- The number of fishing boats is 108,706 units (2016);
- Vietnam fisheries are characterized by multi-species and multi-fishing gears.
- More than 4 million workers directly involve in capturing fish and marine aquaculture.
- The marine waters are devided into 4 management areas, including: Tonkin Gulf, Central, Southeast and Southwest and many estuaries, gulves, lagoons.



FISHING BOATS & ZONES



Year	Numbers of fishing boats				
	Tonkin Gulf	Central	SE	SW	Total
2008	29,582	36,342	23,815	12,492	102,231
2009	34,611	45,186	24,570	15,959	120,326
2010	39,511	47,220	21,490	19,800	128,021
2011	42,659	42,580	26,368	16,756	128,363
2012	40,167	40,713	25,163	17,082	123,125
2013	38,836	38,734	24,065	15,381	117,016
2014	30,860	38,144	21,311	14,771	105,086
2015	32,377	38,339	21,771	14,821	107,308
2016	34,490	37,397	22,140	14,679	108,706

OVERVIEW OF AQUACULTURE RESOURCES

- Vietnam is a country with dense river systems, many lagoons, ponds and lakes that are favorable for aquaculture.
- Vietnam has over 1 million hectares of water surface for aquaculture, now. Of which, water surface for brackish water aquaculture accounted for 69%, fresh water accounted for 31%.

THE TURN-OVER OF FISHERY EXPORT

- The total fishery production increases steadily annually (especially from aquaculture). The output of 2016 was over 6.7 million ton.
- The turn-over of fishery export increases steadily over years, by the end of 2016, the export value reached over USD 7 billion;

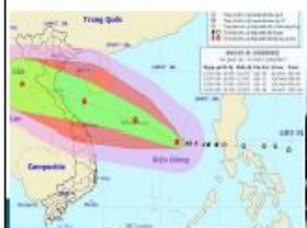
THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

MAIN INFLUENCES:

- The calamity, storm, flood and changes of the rainfall.
- The variation of aquaculture area and quality of land using for aquaculture.
- The rising of tides and sea levels, saline intrusions;
- The average temperature is increasing, the drought;
- Changing in distribution of marine species and decreased productivity.
- The infrastructure, fishing port, moorings area are damaged;

THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

- Every year, Vietnam experiences, in the average, 5 - 15 storms, 2 - 8 tropical depressions. Particularly, from the beginning of 2017 until now, there are 11 storms and 7 tropical depressions, which heavily influence the socioeconomic in general and the aquaculture and fishery in particular.



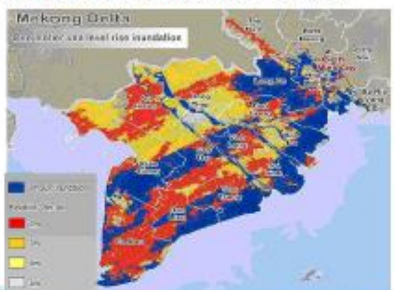
THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

- The loss of coastal lowlands, landslides, saline intrusions;
- According to the study results, it is estimated that in the period 2012-2015, there were 104,930 ha of extremely vulnerable aquaculture lands and 437,830 ha of vulnerable aquaculture lands.
- The increase of lands that are inundated, soils that are eroded, washed away and the decrease of qualities of lands.

THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

- Increasing the phenomenon of the rising tides. Especially in the southern provinces, the rising of tides increases the river stage from 10 - 40 cm.
- The brine rising, saline intrusions impact on coastal ecosystems;

Map showing the impact of a one-metre sea-level rise in the Mekong Delta area. (Source: challengetochange.org, 2016)



THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

- Influences of Temperature: The increase and decrease of temperature reduces the output of fishery products in fish ponds and shrimp ponds. As the temperature increase, Oxygen in the water can influence the growth and development of species; therefore, they can die or grow slowly.
- The drought of ponds,lagoons, and inert bottoms; the number of rainless months increases steadily annually from 3-6 months/year, the temperature can reach 39 - 40 degrees Celsius.

THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

- The index map of assessments of vulnerabilities that are caused by the climate change at provinces across the country.

Classification of figures:
- **Less vulnerable**
- **Medium vulnerable**
- **Vulnerable**
- **Extremly vulnerable**

THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

- Climate change cause also many aquatic diseases caused by Vibrio bacteria, and viruses such as MBV, HPV and BP).

THE IMPACTS OF THE CLIMATE CHANGE ON FISHERIES AND AQUACULTURE RESOURCES

- The influence of the climate change on marine fisheries resources and offshore fishing:
+ Affect on marine ecosystems and change the fishing ground and resources of fisheries;
+ The increase of the temperature causes the dispersal and decrease of resources.
+ Many offshore fishing vessels must be located on shore, cannot operation.
+ Many anchorage areas, fishing ports are severely damaged by storms, floods and the rising of tides.

METHODS TO REDUCE THE DAMAGE CAUSED BY CLIMATE CHANGE ON THE FISHERIES AND AQUACULTURE RESOURCES

1. **Technical solutions including:**

- Improving the capacity of researching and forecasting;
- The reinforcement (increasing of height) of aquaculture ponds at coastal areas (avoiding the brine rising and the climate change).
- To research on diversified productions, appropriate objects, technical improvements and appropriate aquaculture technology;
- Investments of Infrastructure: Upgrading significant dykes works systems, irrigation.
- Planting and protecting mangroves, restoring coastal ecosystems and river;
- Supporting and building capacities for adaptations and mitigations through disasters managements and preventions models of the community and stakeholders;

METHODS TO REDUCE THE DAMAGE CAUSED BY CLIMATE CHANGE ON THE FISHERIES AND AQUACULTURE RESOURCES

2. **Policies and solutions including:**

a) Aquaculture activities

- Planning for adaptations of the interdisciplinary climate change;
- To develop and implement adaptive actions plans and to mitigate losses because of the climate change, prioritizing high vulnerable areas;

METHODS TO REDUCE THE DAMAGE CAUSED BY CLIMATE CHANGE ON THE FISHERIES AND AQUACULTURE RESOURCES

b) Aquatic resource exploitation activities

- The establishment of ara fisheries information system;
- Developing policies to support fishermen, identifing new fishing grounds, promoting the implementation of credit finance policy to help poor fishermen;
- Calling for responsibilities, encouraging to increase adaptations and rehabilitations for local people;
- To exploit, utilize local knowledge and experience;
- The propaganda of awarenesses, training cognitive sources for the community on the climate change;
- Developing a fisheries co-management model, building capacities and participatory management regulation of the community, and exploitations and protection sustainable of fisheries resources;

RECOMMENDATIONS

- To coordinate with international organizations in the timely forecast of natural disasters and the climate fluctuations, to develop standard models to respond to the climate change;
- Propagandizing and educating the local the community on environmental protections and responding to the climate change;

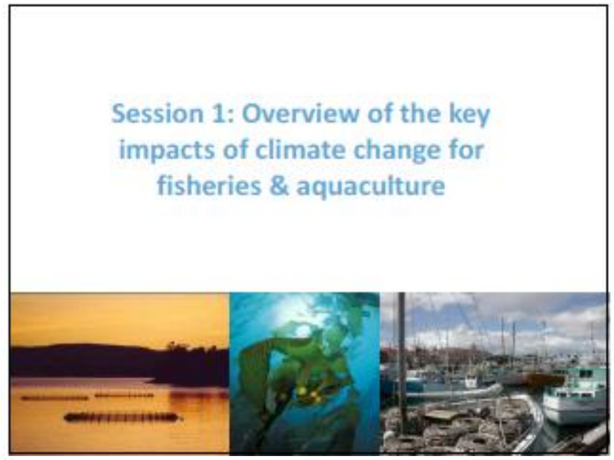
DIRECTORATE OF FISHERIES

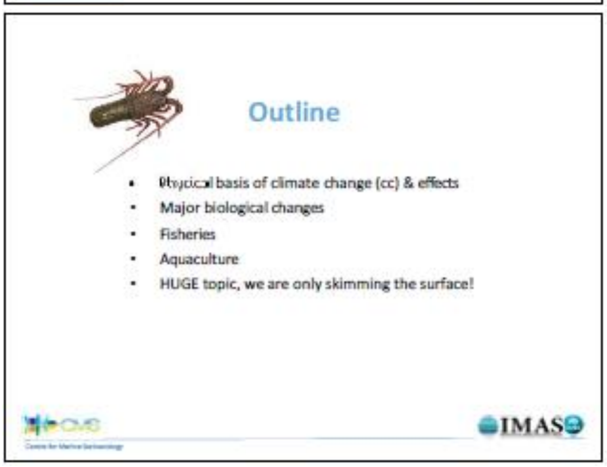
Thanks for your attention!

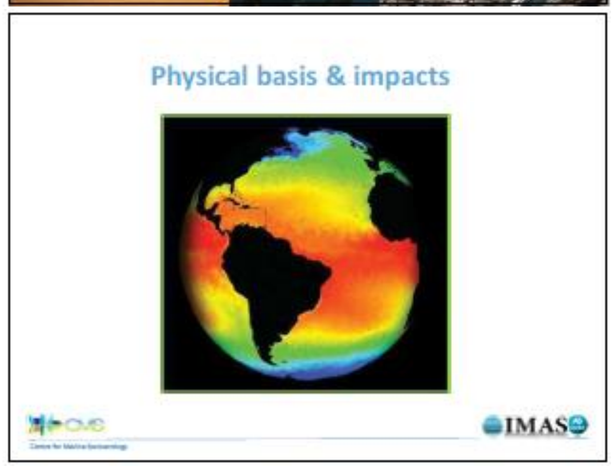
Note: the pictures from the individual and reference at the article and journal

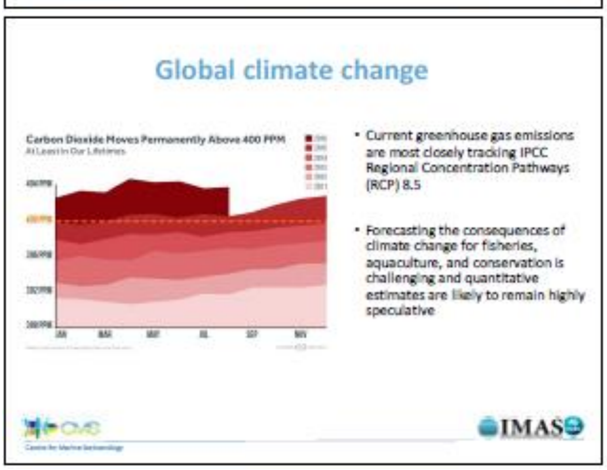
Session 1: An overview of the key impacts of climate change for fisheries and aquaculture

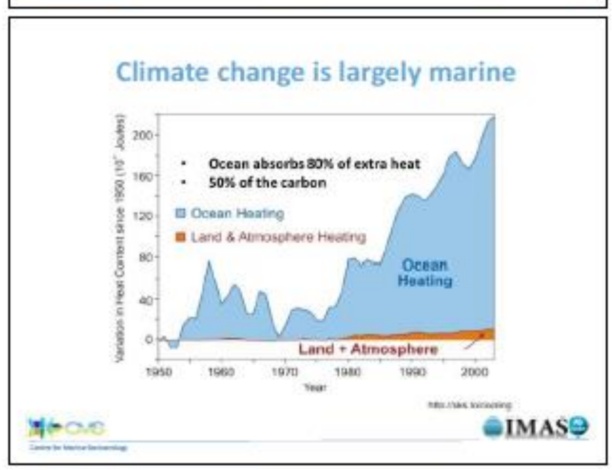
Gretta Pecl[1] and Ingrid Van Putten[2]
[1]Institute for Marine and Antarctic Studies – University of Tasmania, [2]Commonwealth Scientific and Industrial Research Organisation (CSIRO)











Changes in global temperatures over time

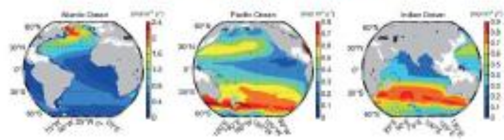
Vast majority of this warming is in the ocean

This animation is available here: https://www.youtube.com/watch?v=wXrYvd-LBu0

Ocean acidification

Mean pH of surface waters: 7.8 – 8.4 but decreasing

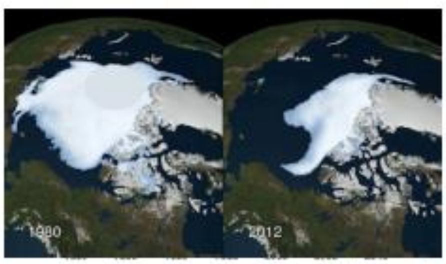
pH drop of 0.1 = oceans 26% more acidic in approximately 150 years



Storage rate distribution of anthropogenic carbon (mol m^{-2} yr^{-1}) for the three ocean basins averaged over 1980–2005.

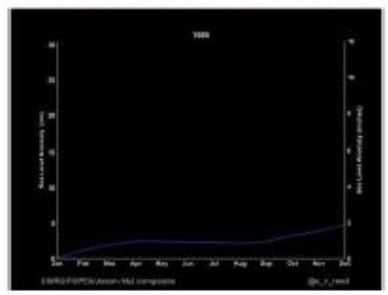
Khatiwala et al., 2009; Rhein et al., 2013

Changes in polar sea ice



http://climate.nasa.gov/

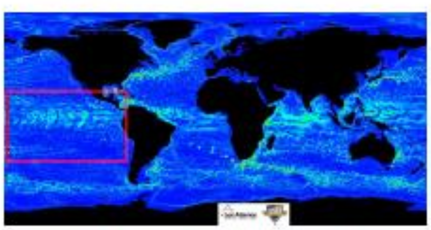
Sea Level Rise 1880- 2017



Globally averaged sea level has risen with a mean rate of 1.7 mm yr^{-1} between 1900 and 2010, and 3.2 mm yr^{-1} between 1993 and 2010.

This animation is available: http://emmavreed.com/2017/10/06/global-sea-level-rise-updated/

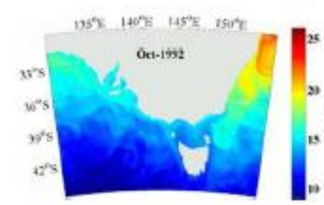
Changes in oceanic circulation



It is very likely that the subtropical gyres in the North Pacific and South Pacific have expanded and strengthened since 1993.

Rhein et al., 2013

Changes in oceanic circulation in the East Australian Current (EAC)



- Westerly winds south of Australia are intensifying & 'spinning up' the anticlockwise circulation or gyre around the South Pacific
- One of the fastest warming regions globally and will likely remain so in the future
- Extensive changes in current = major ecological changes = driven extensive research in the region

Animation courtesy of CSIRO

Extensive global marine changes

- Primary direct consequences of increasing atmospheric CO_2
  - ↑ ocean temperatures
  - ↑ acidity (reduction in pH)
  - ↑ sea level rise
- ↑ temperatures create a host of additional changes:
  - increased ocean stratification
  - decreased sea-ice extent
  - altered patterns of ocean circulation, precipitation, and freshwater input
  - changes in salinity
- Warming and altered ocean circulation act to reduce O_2 concentrations
- Increases in frequency and/or intensity of extreme events

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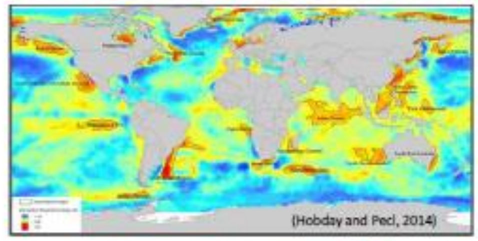
Animation courtesy of CSIRO

Large regional variation in environmental changes

- Areas of rapid ocean warming (top 10% change in SST)



A Global Network of MARINE HOTSPOTS

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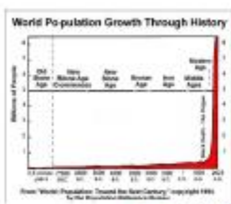
Important factors to consider

- Rates of physical and chemical change will almost certainly accelerate
- Anticipated rate of change over the next century - at least 10 times quicker than any climate shift in the past 65 million years (Diffenbaugh & Field 2013)
- Regional differences in rates/magnitude of physical changes & sensitivity to change
- Climate change does not act in isolation:
  - habitat degradation
  - invasive species
  - Pollution
  - over exploitation
  - human population increase etc



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Small environmental changes lead to large biological impacts

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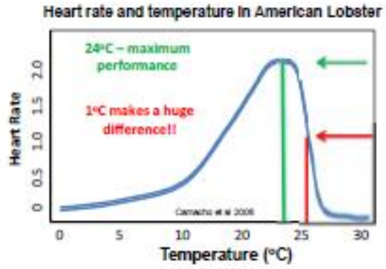
Species performance and temperature

Heart rate and temperature in American Lobster



Copyright Massachusetts Marine Fisheries Institute

Warming water can lead to either improved or decreased species' performance, depending on whether the individual/population currently lives at the upper or lower limits of its thermal tolerance

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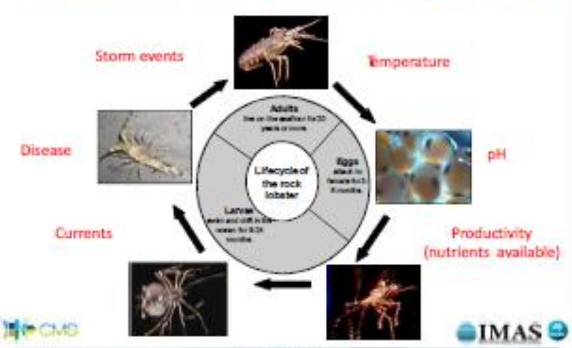
Species life cycles are complicated, different exposure and sensitivity at different life cycle stages



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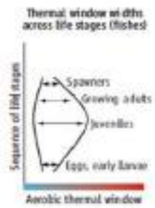
Pecl et al 2009

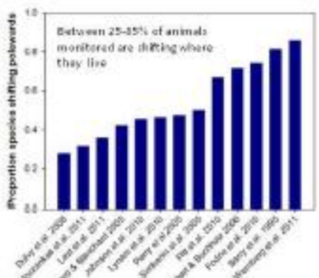


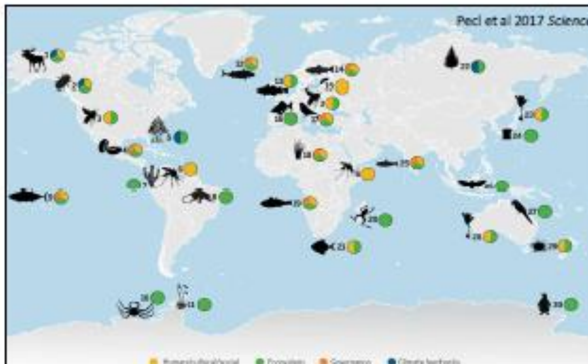
Eggs, early larvae and spawners are more vulnerable to oceanic warming
(Portner & Farrell, 2010)

Climate-driven changes in distribution

- Species can adapt where they are, die or shift
- Some of the largest shifts in species ranges have come from the ocean
- 'Range shifts' greatest where climate has warmed the most
- On average leading range edges shifting
  - 17km dec^{-1} on land
  - 72 km dec^{-1} in ocean (Poloczanska et al. 2013)
- Not simply tracking thermal preferences
  - Influence of species traits
  - Complex ecological interactions
- Many other responses to climate change – but changes in distribution a major one

Large variation in % of animals shifting within a region





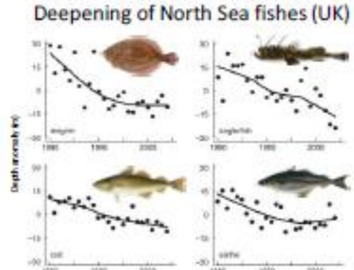
Climate-driven redistribution of species part of a global; pattern. Impacts of shifts are already extensive.

Impacts of climate-driven distribution changes

Madin et al. 2012

Species are moving deeper as well as polewards

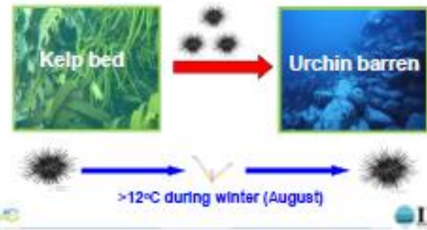
Deepening of North Sea fishes (UK)



Dulvy et al 2008

Not just 'shuffling' species, changes habitat

- Poleward expansion of sea urchins linked to loss of kelp beds in Tasmania (Ling et al 2009)
- Destructive grazing and formation of 'barrens' habitat
  - loss of seaweeds / invertebrates
  - loss of production
  - crash in key fisheries (rock lobster and abalone)
  - difficult to reverse
- Complex system but unpinned by thermal threshold for urchin larvae



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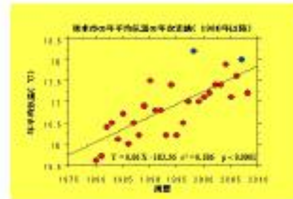
Shifts from algal/seaweed communities to coral reefs



Region off Southern Japan

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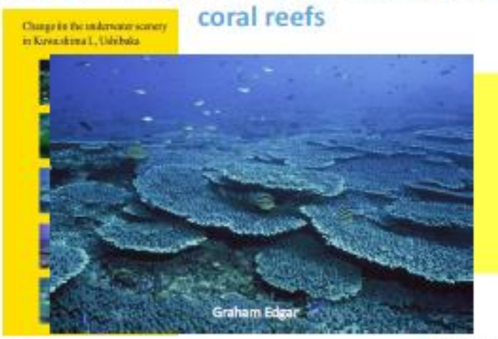
Shifts from algal/seaweed communities to coral reefs



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Flow on effects & ecosystem consequences

- Temperature will affect an animal DIRECTLY via thermal tolerance and INDIRECTLY through changing the outcome of species interactions
- Changing and new interactions, DIRECT and INDIRECT effects of species redistribution on ecosystem dynamics and coastal industries
- Ecological, economic and social consequences of range shifts can be large
- Current research focusses on individual species rather than collective impacts of multiple shifters

Considering the urchin example from Tasmania
- Other interacting species ALSO extending into the region
- Existing interacting species also declining in abundance/performance
- $10m research on urchin & lobster
- Qualitative modelling system – new octopus species REINFORCING negative role of the urchin (Marzloff, van Putten, Pecl et al 2016)

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Ecological implications for fisheries & aquaculture

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Changing conditions will bring opportunities as well as negative implications

- Some increases (and decreases) in abundance will be favourable
- Some changes in distribution will positive
- HOWEVER, even opportunities may require management to ensure maximising these
- There will be 'winners' and 'losers' (countries, fisheries, communities)
- Who wins and who loses may be in the eye of the beholder

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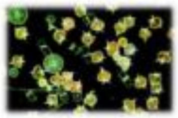
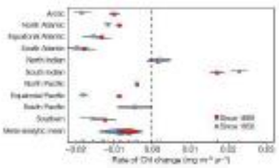
Changes in primary producers

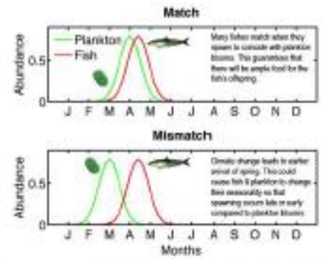


- Phytoplankton produces 50% of the planet's oxygen
- Phytoplankton abundance has declined in 40% since the 1950's, very likely due to oceanic warming
- Variation in productivity location, timing, intensity has implications for both fisheries and much of aquaculture



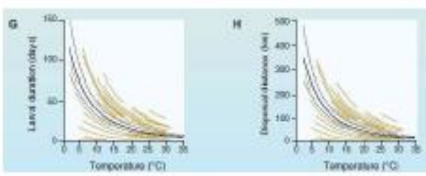
Boyce et al., 2010

Potential for productivity or predator-prey mismatch



http://www.nereusprogram.org/under-the-seasons-of-the-sea-rebecca-asch-on-climate-change-patterns/

Altered recruitment and dispersal

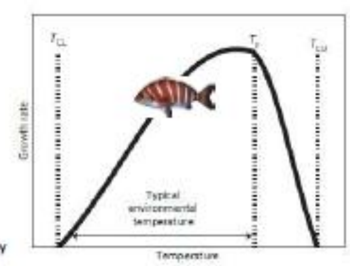


- Decreasing larval duration and decreasing dispersal potential associated with increasing temperatures in 72 marine species
- Significant effects on population links and connectivity – source & sink populations that support fisheries

Hoegh-Guldberg & Bruno, 2010

Specific effects location dependent, eg growth

- Species often distributed over wide area & impacts of climate driver depend of <u>where</u> that occurs within species range
- ↑ temperatures result in:
  - **Increased growth at middle of species range**
  - **Reduced growth** at warm **equatorward** edge of range
- Banded morwong - temperatures may have already reached levels associated with increased metabolic costs



TCL) Lower critical temperature; TP) Pejus temperature; TCU) Upper critical temperature (Neuheimer et al 2011)

Specific effects location dependent, eg growth

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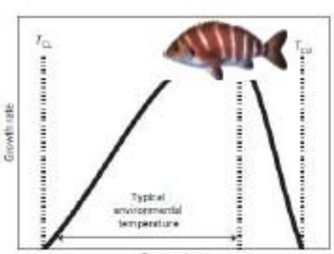
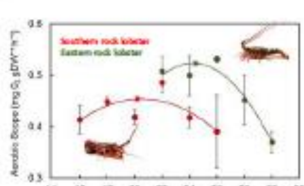


TCL) Lower critical temperature; TP) Pejus temperature; TCU) Upper critical temperature (Neuheimer et al 2011)

Increased temperature raises metabolic demands

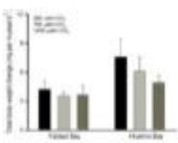
- Animals use MORE energy to breathe
- LESS energy available to reproduce
- Warmer water holds LESS oxygen
- Higher temperatures place greater STRESS on animals
- More stress makes animals more susceptible to disease



Decreased performance of lobsters as temperature increases (Twiname, Fiedl et al in prep)

Ocean acidification

- Shellfish are considered among the most vulnerable organisms due to reliance on calcium carbonate ($CaCO_3$) shell
- Physiological challenges to compensate for low pH by upregulating calcification internally, impacting growth, reproduction and other processes
- Increasing mortality risk in current changes in pH conditions (North America), as well as risk of diseases and parasites



Duarte et al., 2014; Clements et al., 2016

- Not 'just' calcifiers that are impacted by pH
- Work by Philip Munday, Sue-Ann Watson & co, demonstrating wide range of impacts on fish
  - Predator-prey
  - Habitat choice

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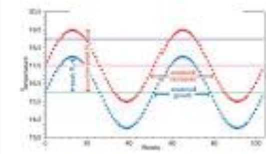
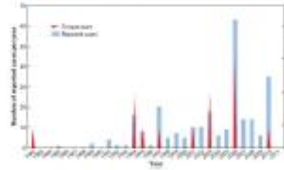
Increased susceptibility to disease, parasites

Climate warming may:

- Increase pathogen development rates, transmission, and number of generations per year; and
- Modify host susceptibility to infection
- These changes may cause pathogen range expansions and host declines.



Response of pathogen growth to 1.5 degree of warming (Harvell et al 2002, Burge et al 2014)



Number of reported *Vibrio* cases in the Baltic Sea area from 1982 to 2010 (Burge et al 2014)

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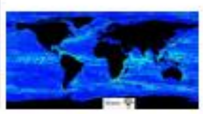
Changes in ocean productivity and circulation patterns

- Aquaculture & fisheries can be affected by changes in nutrient supply due to altered vertical stability and exchange
- Changes in runoff patterns also increase nutrient supply to coastal areas
- Harmful algal blooms (HABs) and jellyfish blooms can increase due to ocean warming
- East coast of Tasmania for example, both commercial and aquaculture operations temporarily halted because of HAB's



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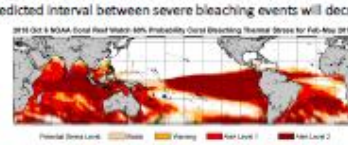
Extensive coral bleaching

- Recently had our third major global bleaching event
- Bleaching can lead to coral death, destruction of habitat for fisheries species
- Long recovery times
- Predicted interval between severe bleaching events will decrease over time



Good summary https://theconversation.com/coral-bleaching-comes-to-the-great-barrier-reef-as-record-breaking-global-temperatures-continue-56570

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Changes in monsoon patterns and occurrence of extreme events

Impacts on aquaculture:

- Physical destruction of facilities
- Loss of stocks
- Escape of cultured exotic species
- Spread of diseases.

Open salmon pen after post-tropical storm Arthur, Nova Scotia, Canada

Damaged inshore cages after a typhoon in China

(http://thechronicleherald.ca/opinion/1226209-what-open-pen-salmon-can-learn-from-landlubber-lobster

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Direct physical impacts of climate change on aquaculture

FAO, 2006

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Indirect impacts of climate change on aquaculture

FAO, 2006

FAO, 2006

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Summary of fisheries & aquaculture impacts

Depending on the fishery, system (e.g. Arctic, reef, open water etc), or the aquaculture production methods, specific impacts will be important to differing degrees – but there is much overlap

- Changes in **productivity - phytoplankton abundance** has **declined in 40%** since the 1950's
- **Altered recruitment and dispersal** (currents, temperature, and larval duration)
- **Altered growth and reproduction**
- Changes in **distribution, abundance, phenology and physiological performances of species will** affect trophic interactions, food-web structures, and the ecosystem
- Changes in **distribution are already extensive** with impacts on the structure and function of the ecosystem, human health, and economic activities
- Considerable **impacts on habitat forming organisms**, i.e. coral reefs, mangroves, etc
- Oceanic warming causes **stress in animals**, some of them already living near their thermal limits
- Increased **susceptibility to disease, parasites and physiological stress**

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Where does climate change leave fishers & farmers & the communities & industries they support?

- Accelerating threat to the delivery of essential services worldwide
- As magnitude and speed of climate change accelerates, greater understanding of climatic vulnerability is critical to guide effective management action
- However, many uncertainties remain regarding the degree and variability of climatic risk – species, regions, systems
- Climate change is leading to a future where past experience and knowledge is of reduced value
- In many cases, past patterns may not be repeated - novel combinations of physics, chemistry, biology & ecology
- Need to make decisions that are 'generally ok', even if the details change, based on the best available information at the time
- RISK MANAGEMENT

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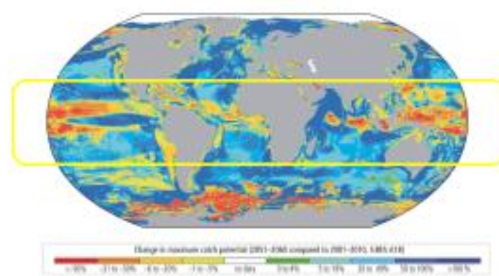
Climate risk & effect on fish catches



Currently, about 80 percent of the fish produced globally is consumed by people as food.

Cinner, J.E., McClanahan, T.R., Graham, N.A.J., et al. (2012) Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. Global Environmental Change 22, 12-20.

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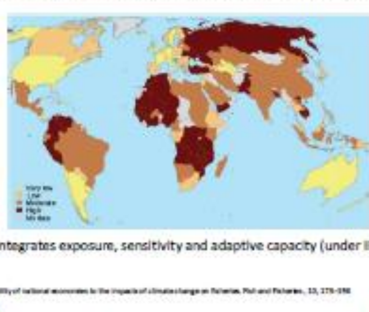
Vulnerability of national economies to the potential climate change impacts on fisheries

(assuming there is some local development and lower emissions between now and then)



Vulnerability integrates exposure, sensitivity and adaptive capacity (under IPCC scenario B2)

Allison et al 2009 Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries, 10, 173-196

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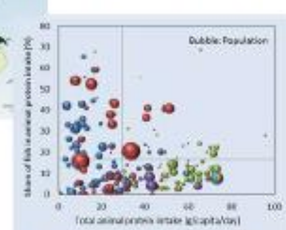
Relationship between climate vulnerability and fish consumption

Fish especially important to countries with low animal protein intake



GLOBAL AVERAGE
≈ 300 grams per person per week
HIGHEST CONSUMPTION
Japan at over 150 grams per DAY!
LOWEST CONSUMPTION
India at not even 100 grams per week

World resources institute & FAO Stats

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Many more mouths to feed

Current world population is around 7,5 billion

The world population will reach 9.7 billion around 2050 (11.2 billion in 2100)

The population of the more developed regions will remain mostly unchanged, at 1.2 billion.

Almost all growth will take place in the less developed regions (from 5.3 billion to 7.8 billion in 2050)

India is going to be the biggest country and surpass China in 2022.

Nigeria could be larger than the US in 2050 (could be 3rd largest country in the world)

Under nourishment

Population density

http://www.worldometers.info/world-population/

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Socio-economic impacts of climate change on marine systems will not be equally distributed

Some geographic areas will be worse off than others (mainly around the equator and low latitudes)

People already disadvantaged (due to poverty and high reliance on fish for protein) will be most affected

Geographic areas most affected are also predicted to have the fast(est) growing populations – so the number of disadvantaged will be proportionally large

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Global fish supply and demand projections (to 2030)

(fish supply = wild catch and aquaculture together)

World Bank
FISH TO 2030
Prospects for Fisheries and Aquaculture

Demand for fish as food will grow by ≈40,000t

from 142,285 rising to 186,842 (000 tons) in 2030

Supply of fish for food will grow by ≈42,000t

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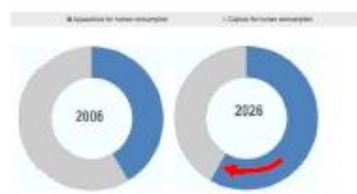
Global fish supply & consumption (increasingly from aquaculture)



Aquaculture – or fish farming – will provide close to two thirds of global food fish consumption by 2030 as catches from wild capture fisheries level off (but do not decline)

Source: OECD/FAO (2017), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database)

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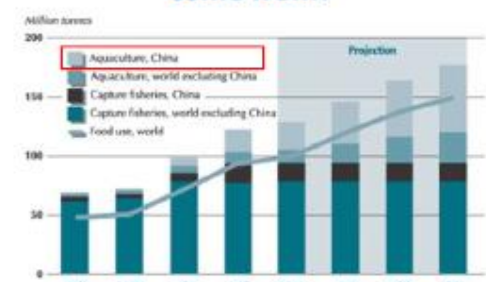
Where will the extra fish supply come from?



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Global *adaptation* to climate change

Poverty (as measured by GDP) most serious obstacle to adaptation

Dark red: highest GDP per capita,
Light red: lowest GDP per capita

High correlation between GDP and vulnerability to general food insecurity

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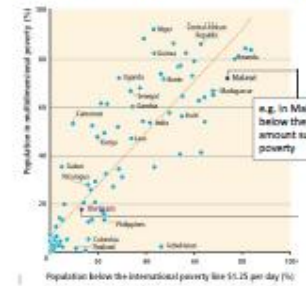
Poverty is multidimensional
and climate change will compound drivers of poverty



Poverty is not just about income (poverty line is $1.25 per day)

Multidimensional poverty includes:
...er;
...th,
lack of credit,
lack of legal services;
social exclusion; and
disempowerment

Olsson, L., M. Opondo, P. Tschakert, A. Agrawal, S.H. Eriksen, S. Ma, L.N. Perch, and S.A. Zakieldeen, 2014: Livelihoods and poverty. In: Climate Change 2014

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Who will be most affected and least able to adapt
by compounding impact of climate change?

Low income nations (multidimensional poverty)

Unequal distribution within the low income nations

- Urban poor (in low- and middle-income countries)
- People in Rural Drylands (> 2 billion people - 90 percent in developing countries)
- Women ★
- Indigenous people (just over 5% of the worlds population but caring for around 22% of the earth's surface)
- Children and older people (especially in terms of the health impacts)

Robin Mearns and Andrew Norton editors 2010 Social dimensions of climate change equity and vulnerability in a warming world
Neumayer and Plumper 2007 Annals of the Association of American Geographers The Gendered Nature of Natural Disasters: The Impact of Catastrophic Events on the Gender Gap in Life Expectancy, 1981-2002

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The impact of climate change on fishing underestimates the effect on women

The definition of "fishing" is often limited to refer to those individuals who go out to sea on fishing vessels and use specialized gear to capture fish.

As a result, this narrow outlook of "fishing" generally excludes women from the definition.

Men and women take on different roles in the fishing industry, studies estimate that women make up 47% of the global fishing workforce

Women often work in the downstream components of the supply chain (i.e. the processing industry & fish trading)

Image: "Women in fisheries, Bangladesh." by WorldFish, CC BY-NC-ND 2.0

http://www.neneaprogram.org/the-modern-fisherwoman-how-gender-plays-a-role-in-fisheries/

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Disproportional effect of sea level rise on the urban poor

Percentage of national populations who live in places that will be drowned by a rise in long-term sea levels (even if global warming is held at 2 degrees)

Guardian graphic from Nature Climate Change

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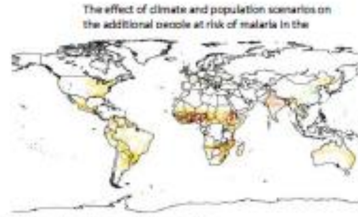
Disproportional health impact of climate change

Unequal distribution of health impacts from climate change

WHO estimates that between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress. Mostly in developing countries

The effect of climate and population scenarios on the additional people at risk of malaria in the



Caminade et al 2014 PNAS Impact of climate change on global malaria distribution
WHO 2009 and Patz et al 2007

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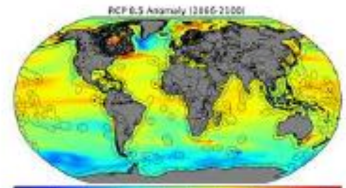
Vulnerability of marine fisheries to sea surface temperature increases

What can a global study tell us



Predicted sea surface temperature change

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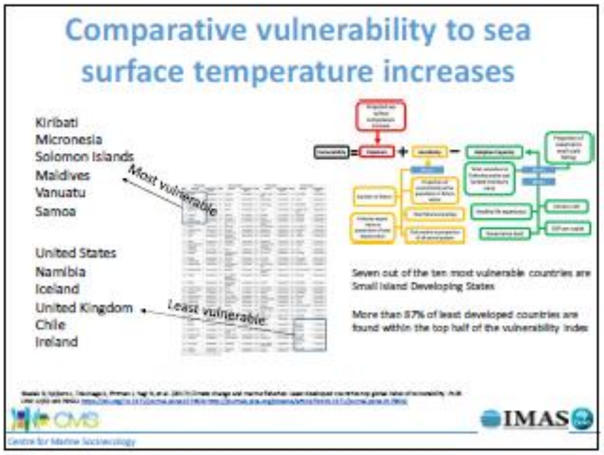
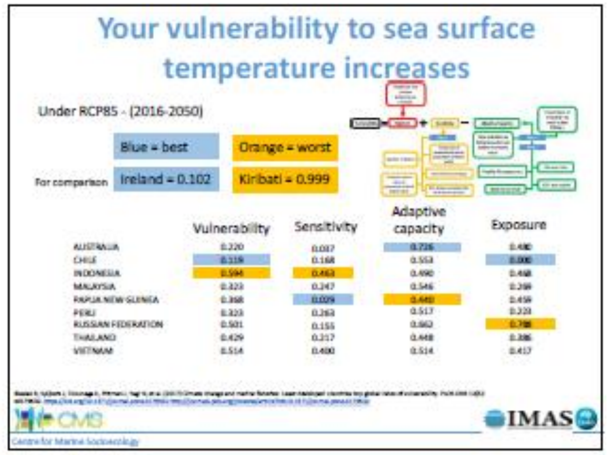
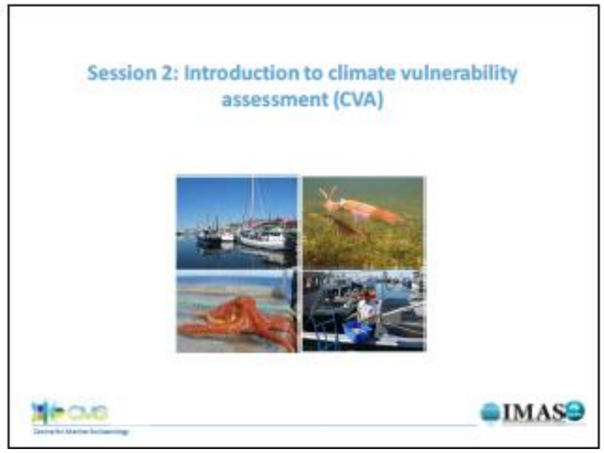


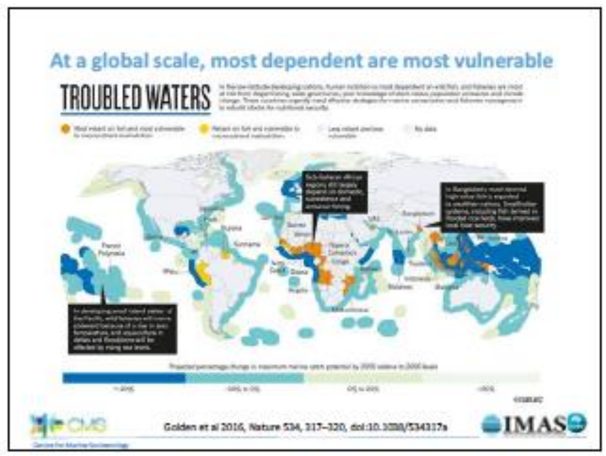


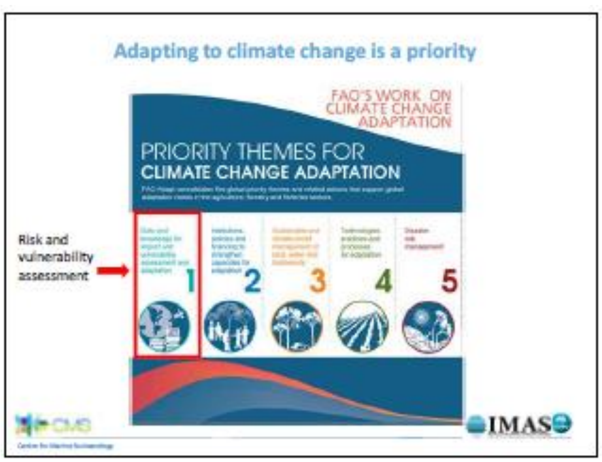
	Vulnerability	Sensitivity	Adaptive capacity	Exposure
AUSTRALIA	0.220	0.037	0.726	0.480
CHILE	0.119	0.168	0.553	0.000
INDONESIA	0.594	0.463	0.490	0.468
MALAYSIA	0.323	0.247	0.546	0.269
PAPUA NEW GUINEA	0.368	0.029	0.440	0.459
PERU	0.323	0.263	0.517	0.223
RUSSIAN FEDERATION	0.501	0.155	0.862	0.798
THAILAND	0.429	0.217	0.448	0.386
VIETNAM	0.514	0.400	0.514	0.417

Session 2: Introduction to vulnerability assessment

Gretta Pecl[1] and Ingrid Van Putten[2]
[1]Institute for Marine and Antarctic Studies – University of Tasmania, [2]Commonwealth Scientific and Industrial Research Organisation (CSIRO)







What exactly is adaptation?

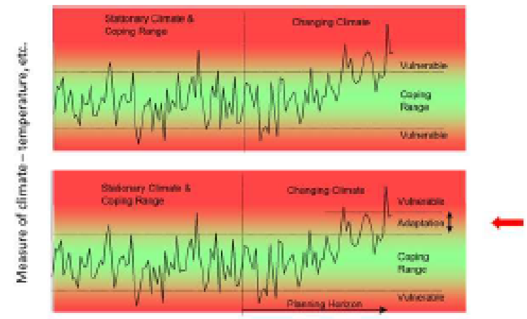
Process to enhance, develop, and implement strategies to moderate, increase the resilience to, minimise or take advantage of the consequences of climatic events.

↓

Manage risks – Minimise losses – Maximise opportunities

Necessary compliment to measures to reduce greenhouse gas emissions

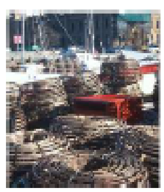
Adaptation increases our coping range



Jones & Mearns, 2005

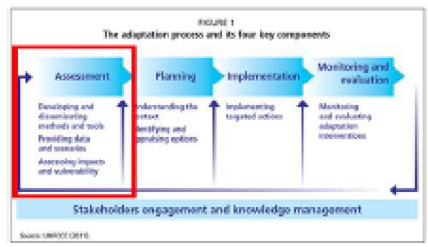
Identifying and developing adaptation options

1. Ad-hoc
   – Expert/experience driven
2. Structured/framework driven
   – E.g. based on scenarios, models, vulnerability assessments



Vulnerability assessments offer a structured framework for adaptation

- Can inform adaptation planning
- Often 1st step of adaptation planning
- Many CVA frameworks



What exactly is a vulnerability assessment?

Vulnerability: Degree to which a system is susceptible to damage

Vulnerability assessment: Structured approach to identifying vulnerabilities in a given system

Risk and vulnerability assessment can have many different specific goals

What might you want a CVA to do?

Who would use such a CVA?

Some of the other ways vulnerability assessment can be used

CVAs based on systematic vulnerability ranking of marine assets or human communities can support important actions:

- Prioritizing research on the most vulnerable fish stocks/aquaculture systems
- Incorporating climate information into fish stock assessments
- Raising awareness within marine industries
- Identifying possible adaptation actions
- Evaluating adaptation barriers
- Highlighting what coastal infrastructure needs changing
- Identifying key knowledge gaps that may affect planning for future change and sustainability of ecosystems and human communities
- Monitoring success of adaptation policy

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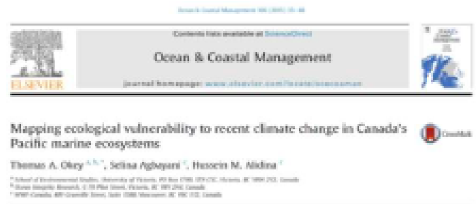
Can also examine habitat vulnerability


Ocean & Coastal Management

Mapping ecological vulnerability to recent climate change in Canada's Pacific marine ecosystems

Thomas A. Okey, Selina Agbayani, Hussein M. Alidina

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Identifying key vulnerabilities

IPCC list of criteria to aid in identifying key vulnerabilities:

- **Magnitude:** Impacts are of large scale and/or high-intensity.
- **Persistence/Reversibility:** Impacts result in persistent damage or reversible damage.
- **Likelihood/Certainty:** Projected impacts are likely, with a high degree of confidence. The higher the likelihood, the more urgent the need for adaptation.
- **Importance:** Systems at risk are of great importance or value to society.

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Methods of vulnerability assessment have been developed over the past several decades

- Initial formation for natural hazards (notably White and Haas 1975)
- Recently encompass more 'social ecological systems' (Blaikie et al 1992) and sustainable livelihoods (Turner et al 2003)

Growing demand among stakeholders across public and private institutions for spatially-explicit information regarding vulnerability to climate change at the local scale.

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(Very!) brief history of Climate Vulnerability Assessment (CVA)

- Complexity in encompassing and measuring dimensions of vulnerability:
  - Geographical
  - Spatial
  - Temporal
  - Social (Barsley et al 2013, FAO report 1083).
- Challenges associated with assessing vulnerability to climate change are non-trivial, both conceptually and technically
- Rapidly changing research area, requiring increasing integration of disciplines

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(Very!) brief history of Climate Vulnerability Assessment (CVA)

- CVAs have a much longer history of use in social science (mapping relative impacts on people/communities) than in fisheries and aquaculture (ranking relative impacts on fish and shellfish)
- CVA initially adopted by the United Nations Framework Convention on Climate Change (UNFCCC) parties to negotiate need for adaptation funds to be appropriated to different nations
- Use of CVA grown in recent years as tool to understand, guide, and convey need for climate change adaptation and mitigation
- Concept to connect with policy makers and other decision makers about projected impacts of climate change on an ecological/biological or social system

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CVA's and fisheries and aquaculture

- Fisheries and aquaculture sector now gained considerable experience in applying the CVAs (particularly using the IPCC framework, Barsley et al., 2013)
- Guides for the application of vulnerability assessments for fisheries and aquaculture have been developed (FAO, 2013)
- CVAs have been conducted at very different scales
  - Tropical fisheries and aquaculture across island nations in the Pacific (Bell et al 2011)
  - Joint ecological and socio-economic vulnerability assessment of 10 coastal communities in Kenya (Cinner et al 2013)
  - Global-scale analyses of potential changes in capture fisheries across 132 national economies to potential (Allison et al 2009)
- ..

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CVA's in fisheries & aquaculture served different purposes

- Inform science-based advice on the management of specific stocks regarding the potential effects of climate change
- Highlight priorities for investment (targeted impact or adaptation research)
- Contribute advice in relation to policy initiatives designed to maintain productive fisheries and aquaculture industries in remote regions and adapting to the challenges and opportunities brought by climate change.

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Frameworks and approaches to assess vulnerability

- ★ Scenario based
- ★ SWOT
- ★ Sustainable livelihoods analysis
- Diagnostic
- Fuzzy logic (Cheung)
- ★ Risk Assessment
- Ethnographic
- Correlative
- Mechanistic
- ★ Traits-based
- ★ Exposure-Sensitivity-Adaptive Capacity

Can be based on:

- Indicators
- Mapping
- Modelling
- Stakeholder input

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Between & within frameworks – great variation

- Specific purposes of CVA
- Scientific understanding & data availability shaped assessment structure
- How biological vs social components conducted & integrated
- How uncertainty is included (or not) & propagated
- How stakeholders are engaged & consulted
- How results and communicated and used
- Strengths and weaknesses

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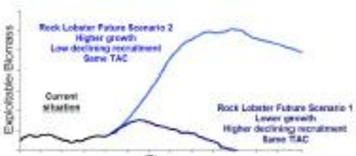
Scenario-based CVA & adaptation

Scenarios: Possible alternative views future

- Description of the external environment into which we are moving
- Can range from pictures to words to equations

Why generate scenarios?

- Valuable approach to explore the context for decision-making
- Provides a structure for making sense of future change, trends, uncertainties
- Not only about possible futures but how we can respond today



Pecl, Frusher, Hobday, Jennings, van Putten et al 2009

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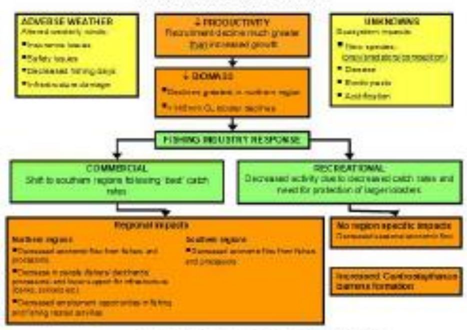
Scenario-based CVA

Rock Lobster Future Scenario 1



Pecl, Frusher, Hobday, Jennings, van Putten et al 2009

Fisheries governance
- Fisheries management policy
- Fisheries management legislation:
  - Fisheries legislative objectives
- EBFM policy
- Market-based governance

Fishery management
- Management Plan:
  - Fishery-specific management objectives
  - Rules and regulations
  - Management instruments and tools
- Compliance and enforcement
- Property rights arrangements
- Co-management arrangements
- Allocation arrangements

Operational framework
- Harvest strategy:
  - Operational objectives
  - Performance indicators
  - Limit and target reference points
  - Defined acceptable levels of risk for the fishery
  - Monitoring strategy
  - Decision rules that control the intensity of fishing activity
- Stock assessment

Strengths, Weaknesses, Opportunities, Threats (SWOT)

1. Identify likely key effects of climate change on each species, particularly where may impact the harvest strategies.
2. Identify options for improving assessment frameworks to ensure performs effectively under likely climate change scenarios.
3. Evaluate options for adjusting management arrangements:
   - reduce negative impacts
   - maximise uptake of opportunities
   - improvements in coordination and consistency among jurisdictions
4. Identify improvements to current monitoring systems for species & habitats to ensure suitable for measuring likely impacts of climate change and other drivers.
5. Other stressors!! Fisher/manager perceptions, observations, values

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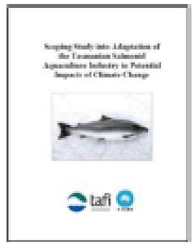
(Pecl et al 2014, SEAP FRDC Report)

Strengths, Weaknesses, Opportunities, Threats (SWOT)



Relatively quick project led to clear directions for industry.

- Reduce exposure to threats through predictive modelling
  - What locations might be suitable?
  - What environment is expected at a range of time scales? Coming months, years, decades..
- Genetic selection- Improve salmon performance (at higher temperatures)
  - Minimize impact of potential emerging pathogens and diseases
  - Improve growth and feed conversion at higher temperatures

Battaglene, Hobday et al

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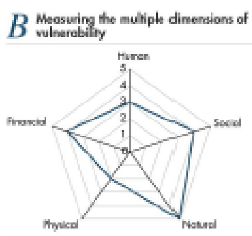
Sustainable livelihoods analysis- measuring vulnerability



Nelson et al 2005

More on this framework later

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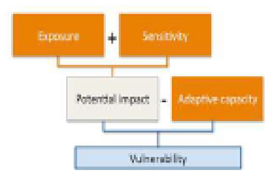
IPCC framework & approach to assess vulnerability

In 2001, the Intergovernmental Panel on Climate Change (IPCC) developed a generic model to assist in understanding the multiple facets of vulnerability

IPCC-derived conceptual model of vulnerability



Source: Adapted from McCarthy et al. 2001.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (eds). 2001. Climate change 2001: impacts, adaptation, and vulnerability. Cambridge University Press, Cambridge.

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IPCC framework & approach to assess vulnerability

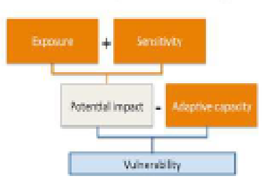
Exposure: Stimuli that have an impact on species or systems, e.g. climatic conditions.

Sensitivity: Degree to which a system will respond to a given change in climate, (including beneficial and harmful effects)

Adaptive capacity: Capability of a system to adapt to climatic stimuli, their effects or impacts.

Vulnerability: Degree to which a system is susceptible to damage (the detrimental part of sensitivity).

IPCC-derived conceptual model of vulnerability



Source: Adapted from McCarthy et al. 2001.

CMS Centre for Marine Socioecology http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=650; Soto & Quiñones, 2013 IMAS

CVA & Adaptation planning

- **Exposure**
  - Identify adaptation measures that reduce the exposure of the individuals/populations/species to the physical effects of climate change
- **Sensitivity**
  - Identify adaptation measures that reduce the sensitivity of the organisms to the physical effects of climate change
- **Adaptive capacity**
  - Identify adaptation measures that increase the adaptive capacity of the individual/species to the physical effects of climate change

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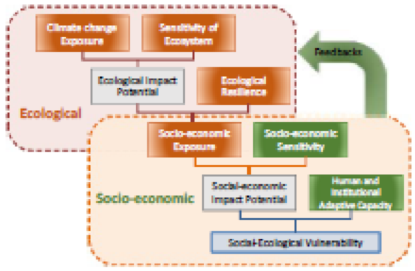
Linked socio-ecological framework for vulnerability analysis



Marshall et al., 2007; Cinner et al., 2013

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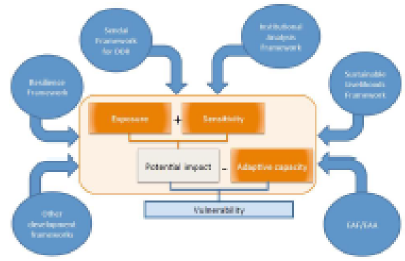
Complimentary frameworks for the study of vulnerability



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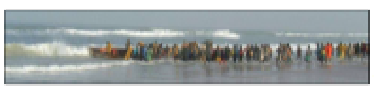
Vulnerability analysis needs:

- Clear aims (vulnerability of who to what?)
- Clear understanding of impact pathways
- Clear conceptualization: defined frameworks
- Good indicators – theoretical and empirically tested
- Strong stakeholder engagement
- Appropriate communication and discussion of findings
- Clear recommendations for adaptation action



Via Eddie Allison, 2017

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Interdisciplinary and integrated

- 'Next generation' CVAs require a highly interdisciplinary and spatial approach that recognizes the unequivocal connections between marine systems and prosperity of human communities/industries
- The integration of physically-driven natural science indicators with community-driven social science indicators is necessary to advance CVAs
- Team with expertise for each dimension

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Importance of scale

Distinguishing between scales helps simplify the conceptual and analytical issues:

- International comparisons - tend to focus on national indicators, to group or compare progress in human development among countries with similar economic conditions
- National/regional level -contribute to setting sectoral/geographical priorities and monitoring progress
- At a local or community level, vulnerable groups can be identified and coping strategies implemented, often employing participatory methods

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Other factors change along with scale

- Stakeholder can change with scale!
- Relevance of indicators/data/methods changes with scale

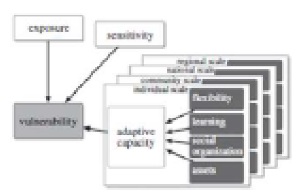

Figure 2. Conceptual framework for understanding components of social vulnerability to climate change. Exposure, sensitivity and the four components of adaptive capacity operate at local, regional, national and regional scales to varying degrees, depending on conditions. Adaptive capacity includes aspects of governance, education, health and wealth as aspects of the four components. Based on Cinner *et al.* (2009*b*).

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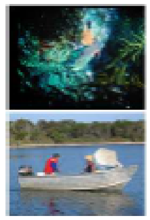
Decisions you need to make with any CVA

- Goals of the vulnerability assessment
- Framing of assessment
- Vulnerability of whom
- Vulnerability to what
- Temporal and spatial scale
- Methods and approaches to use
- Resources and data available
- Hierarchical approach??e.g. a detailed local scale embedded within broader more general and rapid analysis?
- How will you use assessment to facilitate change, how translate into action?? i.e. how will you engage stakeholders?



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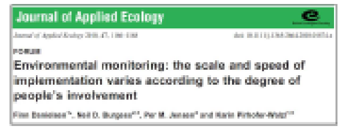
Relationship between participation, scale & implementation speed?



Journal of Applied Ecology

FORUM

Environmental monitoring: the scale and speed of implementation varies according to the degree of people's involvement

- Role of 'local involvement' in generating rapid policy changes at local scales has high potential
- Community based monitoring lead to policy changes within 0-1 years

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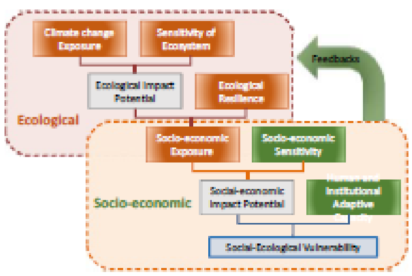
Linked socio-ecological framework for vulnerability analysis



Marshall et al., 2007; Cinner et al., 2013

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(Some) strengths and weaknesses of the Exposure-Sensitivity-Adaptive Capacity approach

Weaknesses
- Common assumption - vulnerability is influenced equally by exposure, sensitivity, and adaptive capacity
- Precise thresholds of indicators not usually known

Strengths
- Transparent
- Repeatable
- Can use qualitative & quantitative inputs

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Summary

- Climate change is in addition of existing impacts and demands (pollution, disease and habitat loss)
- Understanding the response of species, ecosystems, fisheries and aquaculture will be challenging but **we can't wait for all the answers**
- There are examples of planned adaptations or responses that industries can start to think about that will minimise impacts and maximise opportunities
- Collaboration, engagement and good will is crucial
- **Industries, regions, countries that engage in CVA & adaptation will be ahead of the others!**

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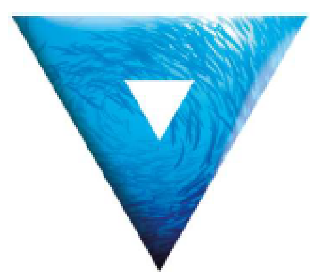

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Conclusions of the first day

Jorge E. Ramos
Institute for Marine and Antarctic Studies-University of Tasmania

Asia-Pacific Economic Cooperation

APEC "International Workshop on ecological risk assessment of impacts of climate change on fisheries and Aquaculture resources"

Conclusions

Day 1, 25th October 2017

Jorge E. Ramos (jeramos@utas.edu.au)

- **Climate change**
- Primary direct consequences of increasing atmospheric CO_2
  - ↑ ocean temperatures
  - ↑ acidity (reduction in pH)
  - ↑ sea level rise
- ↑ temperatures create a host of additional changes:
  - Increased ocean stratification
  - Decreased sea-ice extent
  - Altered patterns of ocean circulation, precipitation, and freshwater input
  - Changes in salinity
- The oceans absorb approximately 80% of the worlds heat, and 50% of the carbon.
- Oceans are 26% more acidic in approximately 150 years.
- Globally averaged sea level has risen with a mean rate of 1.7 mm yr^{-1} between 1900 and 2010, and 3.2 mm yr^{-1} between 1993 and 2010.

- **The biological impacts of climate change**
  - Warming water can lead to improved or decreased species' performance, depending on where species occur and on their thermal tolerance.
  - The impact of warming will vary across different life stages, e.g. early stages and spawners are more vulnerable.
  - Changes in distribution, i.e. 72 km $decade^{-1}$ in ocean. About 25–85% of animals monitored are changing where they live, mostly towards the poles.
  - Deepening of some species.
  - Changes in growth rates, reproduction, phenology, interactions, community and ecosystem changes.
  - Changes in habitat, e.g. coral bleaching, sea urchin barrens in kelp forests.
  - Increased susceptibility to diseases, parasites.
  - Ocean acidification will impact species with calcium carbonate and highly active species of fishes and invertebrates.

- **Socio-economics of climate change**
  - About 80% of the fish produced globally is consumed by people as food.
  - Fisheries of APEC economies gathered in this workshop have low to high vulnerability to the potential impacts of climate change.
  - Demand for fish as food will grow by ≈ 40,000t from 142,285 rising to 186,842 t in 2030.
  - Aquaculture – or fish farming – will provide close to two thirds of global food fish consumption by 2030 as catches from wild capture fisheries level off (but do not decline). Most extra fish supply from China by 2030.
  - Low income nations will be mostly affected and least able to adapt by compounding impact of climate change.
  - The participation of women in fisheries is underestimated, and therefore it is the impact of climate change on their quality of life.
  - Between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress. Mostly in developing countries.

- **Vulnerability Assessment (CVA)**
  - Structured approach to identifying vulnerabilities in a given system.
  - Manage risks – Minimise losses – Maximise opportunities
  - Magnitude, persistence/reversibility, likelihood/certainty and importance.
  - Rapidly changing research area, requiring increasing integration of disciplines.
  - Inform science-based advice on the management, highlight priorities for investment, contribute advice in relation to policy initiatives designed to maintain productive fisheries and aquaculture industries.
  - Wide range of approaches to assess vulnerability.
  - Important to integrate biological and socio-economic components.
  - Collaboration, engagement and good will is crucial.
  - Industries, regions, countries that engage in CVA & adaptation will be ahead of the others!

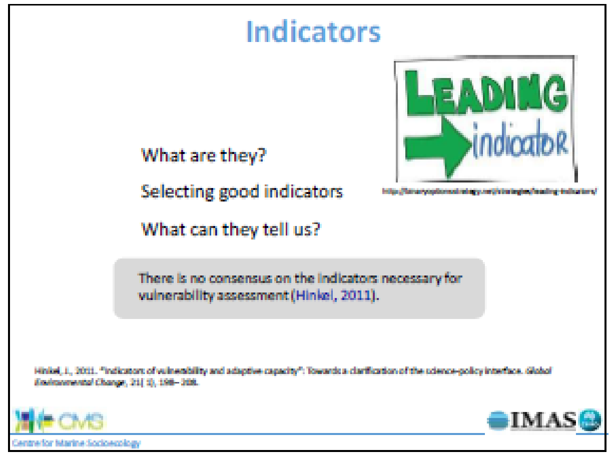
- **APEC economies**
- APEC economies gathered in this meeting have important contributions to the world´s fisheries and aquaculture production.
- Environmental variability associated to climate change in APEC economies include:
  - Oceanic warming,
  - Sea level rise,
  - Ocean acidification,
  - Increasing tides,
  - Warmer air temperatures,
  - Monsoons, heavy rain,
  - Drought,
- The effects of climate change already had impacts or are expected to have impacts on fisheries and aquaculture industries, as well as on livelihoods:
  - Changes in species distribution,
  - Increased mortality of commercially important species,
  - Loss of coastal habitats,
  - Damage to infrastructure, i.e. aquaculture facilities, ports, fishing vessels, etc.
  - Landslides,
  - Coral bleaching,

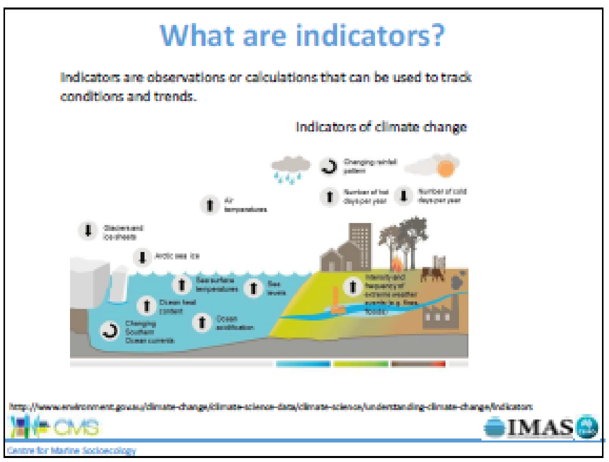
- Increasing frequency of harmful algal blooms and diseases increasing the susceptibility of fish to pathogens.

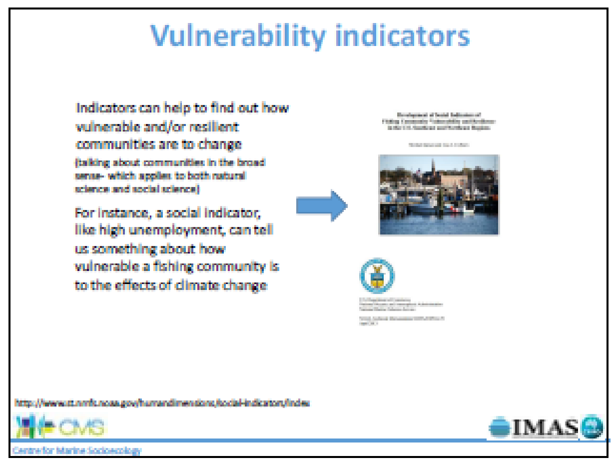
- **Actions taken by APEC economies present**
- Need to identify and prevent threats, and benefit from opportunities.
- Some APEC economies have already developed and are currently implementing climate change adaptation plans to strengthen adaptive capacity of fisheries and aquaculture sectors to climate challenges and maximize opportunities.
- Closer collaboration with fishers and resource managers to develop adaptation plans.
- Some challenges for APEC economies are technical capacity issues, lack of realistic policies, human resources capacity, technology know/how transfer.

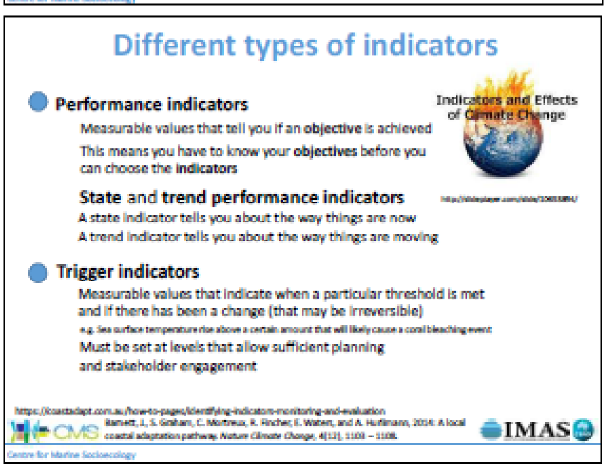
Session 3: Indicators, data gathering methods, and expert elicitation

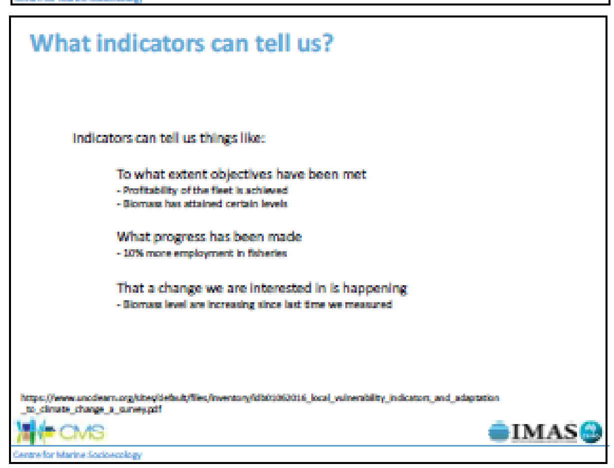
Ingrid Van Putten
Commonwealth Scientific and Industrial Research Organisation (CSIRO)











What indicators can not tell us

Indicators only provide an indication that something has happened – they are not proof

Indicators cannot tell us:

- Why an action/adaptation has made a difference
  - Biomass has increased and this may be due to the way we managed the fishery but we can't be sure
- Why and how change occurs
  - Why water temperatures are exceeding certain levels
- How communication about indicator levels and implications should be undertaken

https://www.uncclearn.org/sites/default/files/inventory/idb03062016_local_vulnerability_indicators_and_adaptation_to_climate_change_a_survey.pdf

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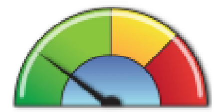
Selecting good indicators

Good indicators need to be:

- **easily understood** and
- **meaningful** to those who use the information

Indicators need to be able to:

- Monitor progress (trend) and performance (state)
- Address problems before they become critical (trigger)



https://www.climate-eval.org/sites/default/files/studies/Good-Practice-Study.pdf
http://www.betterevaluation.org/sites/default/files/IA_PM%26E_toolkit_module_2_objectives%26indicators_for_publication.pdf

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Good practice for selecting indicators

SMART indicators

Specific	Measurable	Achievable & attributable	Relevant & realistic	Time-bound
Does the indicator clearly capture the essence of what you want to achieve (your objective)	Does the indicator (unambiguously) show progress towards the desired result	Does the indicator let you track and account for interventions	Does the indicator contribute to measuring overall performance and success that is achievable in a practical manner	Does the indicator allow progress to be tracked in a cost effective way

http://www.mymanagementguide.com/project-kpi-library-improve-performance-analysis/
https://coastadapt.com.au/how-to-pages/identifying-indicators-monitoring-and-evaluation
Allen et al 2011, Harding et al 2008, Leagravet et al 2015

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For example IndiSeas socio economic indicators in support of ecosystem-based fisheries management

- Wellbeing and resilience of fisher communities
- Effectiveness and efficiency of fisheries management
- Quality of governance
- Contribution of fisheries to broader society

4 overarching objectives

Objective	Descriptive measure	Indicator
Economic contribution to society	Landed value in relation to GDP	Total landed value of marine fisheries as % of GDP
	Fisheries GDP compared to GDP	Fisheries GDP as % of GDP
	Fisheries Exports	Value of fish export value as % of total export value.
Socio-economic contribution to society	Employment	Number of fishermen (direct + indirect) as % of economically active population (EAP)
Contribution to food security	Fish as a proportion of total protein consumed	Fish protein intake as % of total animal protein intake.
Total protein intake	Total protein consumed	Per capita consumption per year

CMS http://www.indiseas.org/more-information/ecological-indicators IMAS

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Climate change vulnerability indicators

	Criteria that a vulnerability indicator should meet	Function that a vulnerability indicator should serve
1	Understandable	Set priorities
2	Policy-relevant	Provide a background for action
3	Based on available data	Raise awareness
4	Captures root cause of vulnerability	Analyse trends
5	Reproducible	Empower people
6	Representative data	Relevant for evaluation
7	Statistically sound	Specify targets
8	Cost-effective and easy to collect	Compare situations and trends

CMS Source: Adapted from Birkmann (2006) Table 4 available at http://archive.unu.edu/unupress/sample-chapters/1135-MeasuringVulnerabilityToNaturalHazards.pdf IMAS

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Data collection methods for vulnerability assessments (how to get the values for the indicators)

Data collection approaches in vulnerability assessments

- Top down and bottom up

Importance of engaging stakeholders

Social science methods to gather data from and about people

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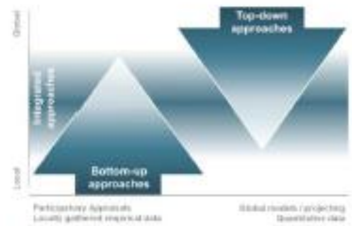
Two approaches to vulnerability assessments

Indicator or modeling based approach – often focused on impacts



Stakeholder approach - often focused on adaptation

http://unfccc.int/resource/cd_roms/na1/v_and_a/index.htm

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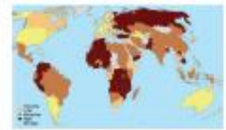
Top down approach

Top-down are usually **scenario-driven** assessments that apply global or regional climate **projections** to assess potential physical and natural impacts on for instance marine systems

Top-down analysis emphasises understanding the **plausible impacts**

They often attempt to represent different sources of uncertainty

For example Allison et al 2009



Allison et al 2009 Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries, 10, 173–196
https://www.climatechangeinaustralia.gov.au/en/climate-campus/modelling-and-projections/using-projections/approaches-climate-change-impact-assessment/
http://www.adaptationcommunity.net/?wpfb_dl=64

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Bottom up approach

Bottom up approaches are typically smaller and more localised, such as households or communities.

Vulnerabilities to climate change are sometimes considered in context with non-climate factors.

The emphasis is more on current and short-term time scales

Can use indicators, but often (also) use qualitative data

Local knowledge is often integrated through participatory processes.

https://www.climatechangeinaustralia.gov.au/en/climate-campus/modelling-and-projections/using-projections/approaches-climate-change-impact-assessment/
http://www.adaptationcommunity.net/?wpfb_dl=64

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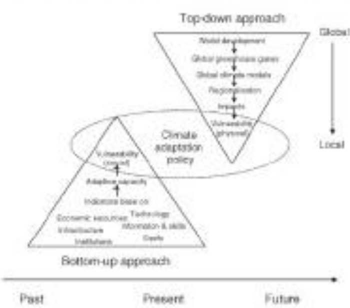
Top down versus bottom up approach



Source: Dessai, S. and Hulme, M. (2004). Does climate adaptation policy need probabilities. Climate policy: 4. 2-22.

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Qualitative versus quantitative methods

for bottom up approach

What are qualitative methods	What are quantitative methods
Focus groups, in-depth interviews, content analysis (review of documents)	Surveys, structured interviews, reviews of documents for numeric information
Unstructured or semi-structured response options	Fixed response options
Text based	Number based
More in-depth information on a small sample	Less in depth but more breadth and larger sample size
More subjective- point of view of the person experiencing	More objective- observed effects that are interpreted by researcher
Highly dependent on the skills of the researcher	Highly dependent on the measurement device or instrument used to collect data
Less generalizable	More generalizable

https://www.osu.gov/cdcynergy/soc2web/Content/phase05/phase05_step03_deeper_qualitative_and_quantitative.htm

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Qualitative versus quantitative methods

for bottom up approach

What to use qualitative methods for	What to use quantitative methods for
Primarily inductive – used to formulate theories or hypotheses	Primarily deductive – used to test pre-specified concepts & hypotheses
Develop an initial understanding about an issue or a problem	Recommend a final course of action
Look for a range of ideas and feelings about something	Project results to a larger population
Understand different perspectives between people	Identify evidence regarding cause and effect relationships
Uncover underlying motivations that influence decision making	Describe characteristics of relevant groups and people
Explain findings from quantitative studies	

https://lmucial.wordpress.com/2011/11/25/qualitative-research-isnt-as-scientific-as-quantitative-methods/

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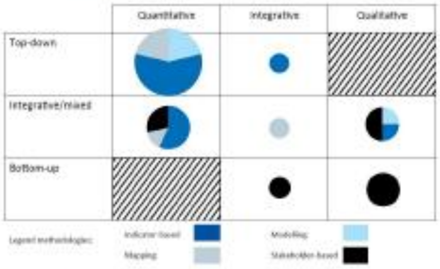
Methods applied in fisheries and aquaculture

Types of vulnerability assessment methodologies applied to fisheries and aquaculture



Notes:
Total number of published studies identified (based on Bartley, De Young and Brugère, 2013): 24 from 1995 to 2012.
The size of the pies is proportional to the number of studies found using these methodologies, whereas sections of the pie indicate the nature of the methods used.

Bartley, W., De Young, C & Brugère, C. 2013. Vulnerability assessment methodologies: an annotated bibliography for climate change and the fisheries and aquaculture sector. FAO Fisheries and Aquaculture Circular No. 1083. Rome, FAO. 45 pp.

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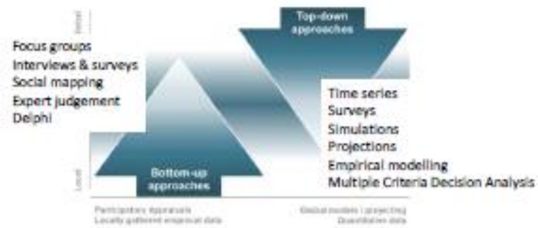
Top down data collection methods



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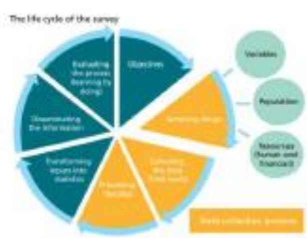
Interviews and surveys

Closed-ended questions can give quantitative information. Open ended questions can give qualitative information

Closed-ended questions may limit the feedback that can be gained from a respondent.

Conducting interviews can give more in-depth information but can be expensive



http://www.fao.org/3/a-i4879e.pdf
http://www.mngconnect.com/projects/userfiles/file/focusgroupbrief.pdf

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Information collection should ideally be based on a consultative approach - 'knowledge co-production'

When knowledge is co-produced it provides a better understanding of the multiple drivers, interdependencies and complexities of the climate challenge

- Participatory research
- Interactive research
- Civic science
- Trans-disciplinary research
- Joint knowledge production

Applied at different scales (from case studies to global assessment)

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Consultative approach focus groups and workshops

Focus groups and workshops are consultative in nature and widely used to collect (mainly) qualitative data

Focus groups provide insights into how people think and provide a deeper understanding of the phenomena being studied

In its simplest form, it consists of personal interviews with individuals or small groups, as well as observation and participation in local activities and community life.

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Consultative approaches based on 'Action learning' principle

Action learning is an approach to solving real problems that involves taking action and reflecting upon the results, which helps improve the problem-solving process, as well as the solutions developed by the team.

The action learning process includes:

1. a real problem that is important, critical, and usually complex,
2. a diverse problem-solving team or "set",
3. a process that promotes curiosity, inquiry, and reflection,
4. a requirement that talk be converted into action and, ultimately, a solution, and
5. a commitment to learning.

https://en.wikipedia.org/wiki/Action_learning

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Action learning - Cognitive mapping

Cognitive mapping (sometimes called a mental **map** or mental model) is a type of mental representation which helps acquire, code, store, recall, and decode information about a problem (or explain phenomena in their environment)

For example: the interaction between SST increases and coral bleaching

cmcs.soc.surrey.ac.uk

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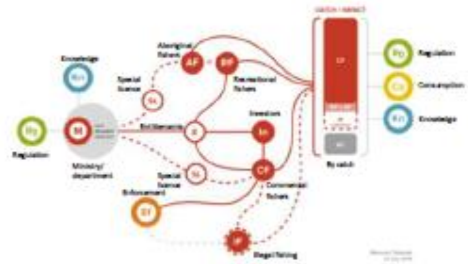
Action learning - governance system mapping



The map displays current knowledge of institutions and organisations that affect the resource and it reveals formal and informal practices and linkages

CMS Dutra et al (in prep) Governance Mapping: a tool for assessing the adaptive capacity of marine resource governance to environmental change IMAS
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Action learning - Social mapping

Social mapping is a visual method of showing the relative location of households and the distribution of different people (such as male, female, adult, child, landed, landless, literate, and illiterate) together with the **social** structure, groups and organisations of an area.

It helps understand the context within which adaptation has to take place

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Action learning
Participatory rural appraisal (PRA)

The approach aims to incorporate the knowledge and opinions of rural people in the planning and management of development projects and programmes

To ensure that people are not excluded from participation, these techniques avoid writing wherever possible, relying instead on the tools of oral communication and visual communication such as pictures, symbols, physical objects and group memory.

https://en.wikipedia.org/wiki/Participatory_rural_appraisal

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Action learning
Participatory GIS (PGIS)

PGIS combines a range of geo-spatial information management tools and methods such as sketch maps, participatory 3D modelling(P3DM), aerial photography, satellite imagery, and Global Positioning System (GPS) data to represent peoples' spatial knowledge.

Virtual or physical two- or three-dimensional maps can be used as interactive vehicles for spatial learning, discussion, information exchange, analysis, decision making and advocacy

http://www.tweedforum.org/research/borderlands_community_mapping_guide_.pdf

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Vulnerability assessment

To do a vulnerability assessment you need indicators to tell you your vulnerability state or trends (which means you have to collect data)

You need to identify the objectives you want to meet before you decide on the indicators you need to collect

Vulnerability can be viewed from adaptation perspective (bottom up) or from the impacts point of view (top-down)

Gather data from stakeholders –

- Think of the scale you need the data at
- Think of the type of data you need (qualitative – quantitative)
- Think of how you will get it (i.e. survey, focus group – participator GIS etc)

http://www.tweedforum.org/research/borderlands_community_mapping_guide_.pdf

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What is expert elicitation?

Expert elicitation is essentially a scientific consensus methodology.

Many methods/techniques exist that elicit information from experts

For example:

Focus groups

Delphi techniques

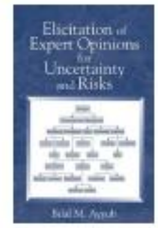
Can be used for many different types of study

For example

Disease prediction

Ecological risk assessment

Public policy assessment



https://en.wikipedia.org/wiki/Expert_elicitation

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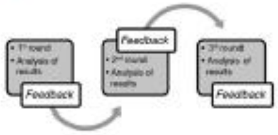
Delphi method is an expert elicitation technique

Delphi method is designed to predict the likelihood of future events (*forecasting technique*)

The Delphi method is based on the principle that forecasts (or decisions) from a structured group of individuals (experts) are more accurate than those from unstructured groups



http://www.businessdictionary.com/definition/Delphi-technique.html
http://www.investopedia.com/terms/d/delphi-method.asp

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Why use expert elicitation?

Expert elicitation generally quantifies uncertainty

Expert elicitation allows for *parametrization* of an "educated guess"

We will focus on the use of expert elicitation for estimating probability, risk and uncertainty in vulnerability assessments

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Uncertainty and risk analysis

The reason we use expert elicitation is that we want to:

- use **probability** to measure **uncertainty,**
- in order to reduce **uncertainty** to mitigate **risk,**
- or make adaptation policies robust to uncertainty

Probability = the relative possibility an even will occur (likelihood)

Uncertainty = the estimated amount by which a value may differ from the true value

Risk = the possibility (degree or probability) of a loss / danger / hazard

http://acceleratedevelopment.ca/blog/uncertainty-and-risk-in-software-development-3-of-3/

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Key stages in expert elicitation of risk

1. Scoping and planning

2. Assessment preparation

3. Elicitation

4. Analysis

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

A.H. Perera et al. (eds.), Expert Knowledge and Its Application in Landscape Ecology, 11 DOI 10.1007/978-1-4614-1034-8_2, © Springer Science + Business Media, LLC 2012 Chapter 2 Marissa F. McBride and Mark A. Burgman What Is Expert Knowledge, How Is Such Knowledge Gathered, and How Do We Use It to Address Questions in Landscape Ecology?

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Elicitation session

Motivation of experts (the issue/problem is important)

Probability assessment training (make sure they all understand same things)

Encoding judgements (doing the scoring) ★

Gather rationale/reasons for judgements (find out why they scored in certain ways)

Verify probability judgments (ensure that you've understood correctly what they said)

Adapted from: Match decision methods to requirements and resources, D.Guggenheim, School of Aerospace Engineering, Georgia Institute of Technology

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Example – US climate vulnerability assessment

Assumption that vulnerability of fish stocks to climate change is a function of **exposure and sensitivity**

12 different sensitivity attributes

SENSITIVITY ATTRIBUTES 1
Habitat Specificity 1
Prey Specificity 3
Sensitivity to Ocean Acidification 4
Complexity in Reproductive Strategy 6
Sensitivity to Temperature 10
Early Life History Survival and Settlement Requirements 12
Stock Size/Status 14
Other Stressors 16
Population Growth Rate 17
Dispersal of Early Life Stages 19
★ Adult Mobility 21
Spawning Cycle 22

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

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Climate vulnerability assessment - exposure

Step 1

Experts received climate model ensemble maps of ocean surface temperature, ocean surface salinity, air temperature, and pH combined with on species distribution

Experts use the spatial species distribution and the exposure maps to estimate *exposure* in the Northeast U.S. Shelf ecosystem

Exposure to climate change

	Exposure	Approximate Probabilities	$\lvert E_S \rvert$	Exposure Score
Mean	Very High	>95.4%	>2	4
	High	86.6-95.4%	1.5-2	3
	Moderate	38.3-86.6%	0.5-1.5	2
	Low	<38.3%	<0.5	1
			$\lvert \log ES \rvert$	
Variance	Very High	>95.4%	>1.78	4
	High	86.6-95.4%	1.54-1.78	3
	Moderate	38.3-86.6%	1.15-1.54	2
	Low	<38.3%	<1.15	1

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

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Exposure – lobster results

Species	Functional Group	Attribute	Attribute Category	Low	Moderate	High	Very High
American Lobster	Benthic Invertebrate	Air Temperature (Proxy for Nearshore Ocean Temp)	Exposure Factor	5	4	10	1
American Lobster	Benthic Invertebrate	Currents	Exposure Factor	3	11	6	0
American Lobster	Benthic Invertebrate	Mean Precipitation	Exposure Factor	16	4	0	0
American Lobster	Benthic Invertebrate	Mean Sea Surface Salinity	Exposure Factor	13	5	2	0
American Lobster	Benthic Invertebrate	Mean Sea Surface Temperature	Exposure Factor	0	0	1	19
American Lobster	Benthic Invertebrate	Ocean Acidification	Exposure Factor	0	0	0	20
American Lobster	Benthic Invertebrate	Sea Level Rise	Exposure Factor	14	6	0	0
American Lobster	Benthic Invertebrate	Variability in Air Temperature	Exposure Factor	20	0	0	0
American Lobster	Benthic Invertebrate	Variability in Ocean Acidification	Exposure Factor	20	0	0	0
American Lobster	Benthic Invertebrate	Variability in Precipitation	Exposure Factor	15	5	0	0
American Lobster	Benthic Invertebrate	Variability in Sea Surface Salinity	Exposure Factor	16	4	0	0
American Lobster	Benthic Invertebrate	Variability in Sea Surface Temperature	Exposure Factor	20	0	0	0

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756

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Climate vulnerability assessment - sensitivity

Step 2

Experts the score all 12 *sensitivity* attributes for species for each species group using information on species distribution and the exposure maps

Adult Mobility

Relationship to climate change: Site-dependent species that are unable to move to better habitat when a location becomes unfavourable are less able to adapt to environmental change than highly mobile species.

Everyone gets 5 tallies 𝍸

			Expert very certain	Expert less certain
Low	**Non-site dependent**	The stock is highly mobile and non-site dependent		
Moderate	**Site dependent but highly mobile**	The stock has site-dependent adults capable of moving from one site to another if necessary	𝍸	III
High	**Site dependent with limited mobility**	The stock has site-dependent adults that are restricted in their movement by environmental or behavioral barriers		II
Very High	**Non-mobile**	The stock has sessile adults.		

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Sensitivity – lobster results

Species	Functional Group	Attribute	Attribute Category	Low	Moderate	High	Very High
American Lobster	Benthic Invertebrate	Adult Mobility	Sensitivity Attribute	4	15	6	0
American Lobster	Benthic Invertebrate	Complexity in Reproductive Strategy	Sensitivity Attribute	16	8	1	0
American Lobster	Benthic Invertebrate	Dispersal of Early Life Stages	Sensitivity Attribute	5	18	2	0
American Lobster	Benthic Invertebrate	Early Life History Survival and Settlement Requirements	Sensitivity Attribute	2	11	12	0
American Lobster	Benthic Invertebrate	Habitat Specificity	Sensitivity Attribute	12	12	1	0
American Lobster	Benthic Invertebrate	Other Stressors	Sensitivity Attribute	1	10	13	1
American Lobster	Benthic Invertebrate	Population Growth Rate	Sensitivity Attribute	0	4	9	12
American Lobster	Benthic Invertebrate	Prey Specificity	Sensitivity Attribute	22	3	0	0
American Lobster	Benthic Invertebrate	Sensitivity to Ocean Acidification	Sensitivity Attribute	10	7	3	5
American Lobster	Benthic Invertebrate	Sensitivity to Temperature	Sensitivity Attribute	3	12	9	1
American Lobster	Benthic Invertebrate	Spawning Cycle	Sensitivity Attribute	2	7	12	4
American Lobster	Benthic Invertebrate	Stock Size/Status	Sensitivity Attribute	5	10	8	2

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756

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Data quality

Step 3 Everyone gets 4 tallies IIII

Experts score the directional effect of climate change for each species

Regional species impacts are either negative, neutral, or positive (negative = -1, neutral = 0, positive = 1)

Step 4

Each expert notes their opinion of data quality for each sensitivity attribute or exposure factor for each species.

Data Quality Score	Description
3	**Adequate Data.** The score is based on data which have been observed, modeled or empirically measured for the species in question and comes from a reputable source.
2	**Limited Data.** The score is based on data which has a higher degree of uncertainty. The data used to score the attribute may be based on related or similar species, come from outside the study area or the reliability of the source may be limited.
1	**Expert Judgement.** The attribute score reflects the expert judgement of the reviewer and is based on their general knowledge of the species, or related species, and their relative role on the ecosystem.
0	**No Data.** No information to base an attribute score on. Very little is known about the species or related species and there is no basis for forming an expert opinion.

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756

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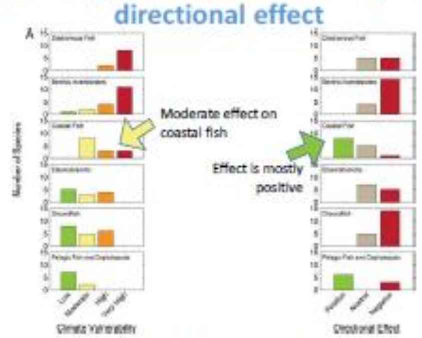
Species group level vulnerability and directional effect



Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756

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Logic rule for climate exposure & sensitivity

A certain number of individual scores over a certain threshold are used to determine the overall climate exposure and biological sensitivity

Overall Sensitivity or Exposure Score	Numeric Score	Logic Rule
Very High	4	3 or more attributes or factors mean ≥ 3.5
High	3	2 or more attributes or factors mean ≥ 3.0
Moderate	2	2 or more attributes or factors mean ≥ 2.5
Low	1	All other scores

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756

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Overall climate vulnerability score

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756

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Expert elicitation to assess climate vulnerability is good approach

A lot of work will go into developing the exposure maps that experts will need to use to assess sensitivity

Significant amount of research will go into finding the scientific evidence to underpin sensitivity attributes

Need to think carefully about how to frame the questions for each attribute to make sure no bias is created

Need to make sure the experts are well informed

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There are different sorts of experts

Proficiency scale for expertise

"Expert" expert (contributory expertise)
Fully developed and internalized skills and knowledge, including an ability to contribute new knowledge or to teach

Informal expert (Interactional expertise)
Knowledge gained from learning the language of specialist groups, without necessarily obtaining practical competence.

Learning by doing expert (Primary source knowledge)
Knowledge gained from the primary literature, including basic technical competence.

Popular(ist) expert (popular understanding)
Knowledge from the media, with little detail and less complexity.

Specific (local) knowledge expert
Formulaic, rule-based knowledge, typically simple, context specific, and local.

Collins, HM, Evans R (2007) Rethinking expertise. University of Chicago Press, Chicago
Hoffman RR (1998) How can expertise be defined? Implications of research from cognitive psychology. In: Williams R, Faulkner W, Fleck J (eds) Exploring expertise. Macmillan, New York. pp 81–100

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Uncertainty related to experts

Expert knowledge is not perfect and uncertainty is derived from multiple sources.

Incertitude (sometimes termed "epistemic uncertainty")

arises from incomplete knowledge and can be reduced by additional research and data collection.

Natural variation (sometimes termed "aleatory uncertainty"),

results from inherent natural randomness, such as fluctuations in rainfall and temperature. It can be better understood but not reduced by additional study or measurement improvements (Burgman 2005)

Linguistic uncertainty

arises from imprecision in language, and results from ambiguous, vague, underspecified, and context-dependent terms.

Ask the Experts

Hoffman RR (1998) How can expertise be defined? Implications of research from cognitive psychology. In: Williams R, Faulkner W, Fleck J (eds) Exploring expertise. Macmillan, New York, pp 81–100

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Expert judgment is susceptible to cognitive and motivational bias

100% EXPERT 100%

Availability

When an expert judges the probability of an event, the events that are easier to recall are judged more probable and vice versa.

Representativeness

When an expert is assessing the probability that A belongs to some class of B he or she tends to judge on the level of similarity between A and B.

Anchoring and adjustments

People who are asked to estimate a quantity start with an initial estimate ("anchor") and then adjust up or down. So if asked for repeated judgements for the same kind of problem you will get the same kind of estimate.

A. Babuscia, K.-M. Cheung, An approach to perform expert elicitation for engineering design risk analysis: methodology and experimental results, Journal of the Royal Statistical Society: Series A (Statistics in Society) 177(2) (2014) 475-497.

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Expert judgment is susceptible to cognitive and motivational bias

Hindsight bias

People will estimate a probability higher if it has actually already occurred

Awareness of underlying conditional probabilities

People do not take into account the underlying probabilities of events (i.e. the estimate of some crimes are estimated much higher than they actually are).

Law of small numbers

People generally forget that larger samples are less likely to deviate from the mean than smaller samples

Coherence

People forget about coherence in probability assessment (which is adherence to the basic probability laws).

The sum of a disjoint set of events that includes all possible events in the sample space must sum to 1.

The probability of an intersection of independent events is the product of the respective probabilities.

A. Babuscia, K.-M. Cheung, An approach to perform expert elicitation for engineering design risk analysis: methodology and experimental results, Journal of the Royal Statistical Society: Series A (Statistics in Society) 177(2) (2014) 475-497.

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Strengths and limitations of expert elicitation

Strengths

It has the potential to make use of all available knowledge including knowledge that cannot be easily formalised otherwise

It can easily include views of sceptics and reveals the level of expert disagreement on certain estimates.

Weaknesses

The fraction of experts holding a given view is not proportional to the probability of that view being correct

One may safely average estimates of model parameters, but if the expert's models were incommensurable, one may not average models (Keith, 1996).

If differences in expert opinion are irresolvable, weighing and combining the individual estimates of distributions is only valid if weighted with competence of the experts regarding making the estimate

There is no good way to measure competence.

The results are sensitive to the selection of the experts whose estimates are gathered.

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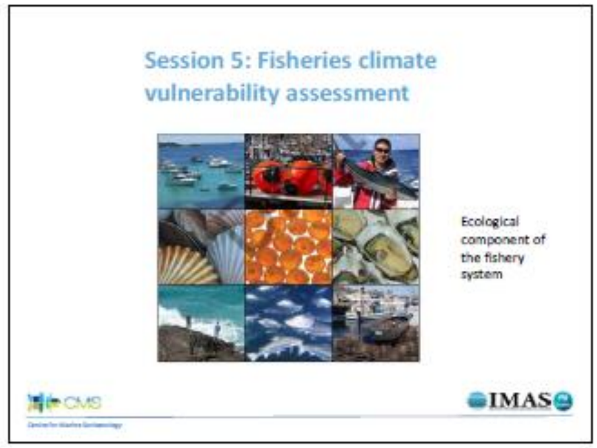
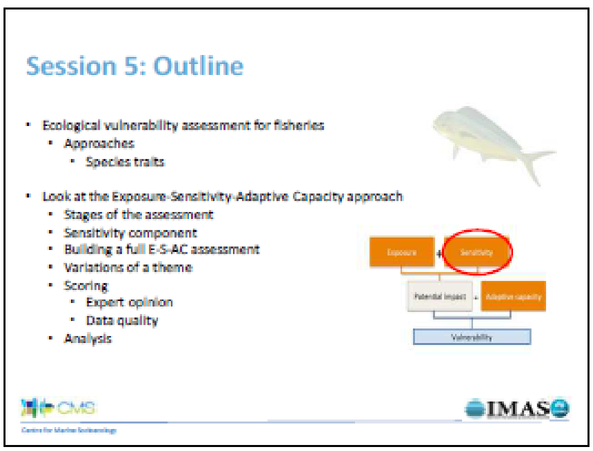
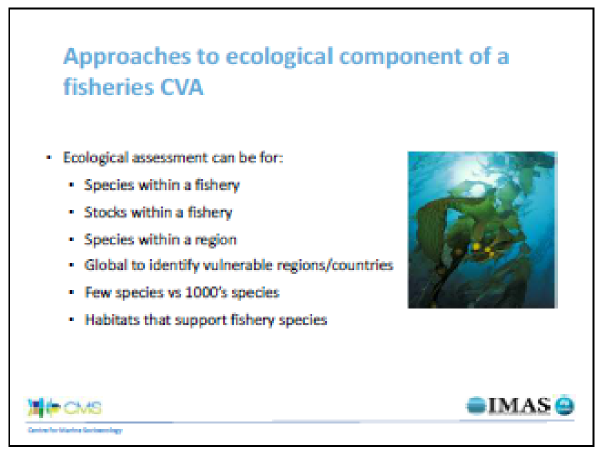
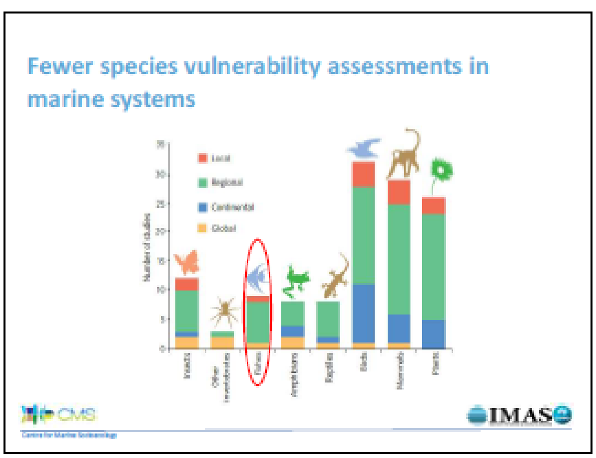
Session 4: Fisheries vulnerability assessment

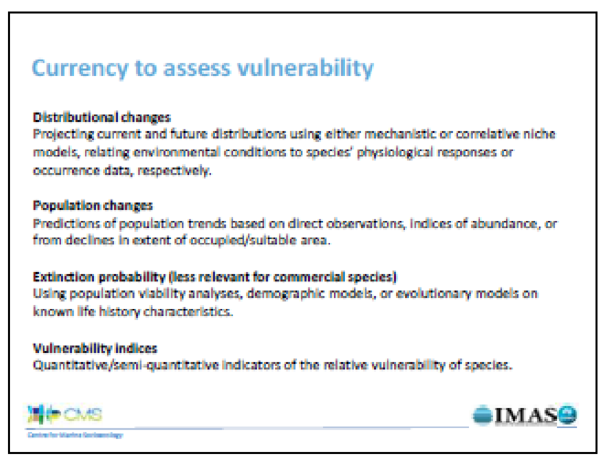
Gretta Pecl
Institute for Marine and Antarctic Studies – University of Tasmania









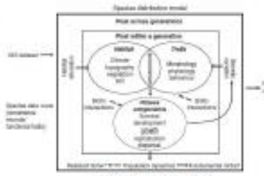


Species' vulnerability assessment approaches

Correlative
Projecting future distributions based on niche models, etc. Relate environmental conditions to species' occurrence data.

Mechanistic
Laboratory and field observations, detailed and data intensive models. Relate environmental conditions to species' physiological data.

Trait-based
Use biological characteristics or life-history traits as predictors of risk



Kearney & Porter, 2009

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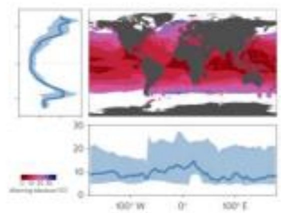
Vulnerability based on physiology traits



- Integrates physiological-based metrics of sensitivity with future climatic exposure.
- Upper thermal limits of fishes
- Estimated species-specific physiological sensitivity using the warming tolerance
- Authors recognize that a singular focus on physiological risk is not sufficient to inform robust management strategies

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Comparison between species vulnerability approaches

Approach	Aim	Advantage	Disadvantage
Correlative	To represent the realized niche.	• Applicable to a wide range of taxa at various spatial scales. • Quick and cheap.	• Climatic, algorithm, and biotic uncertainties. • Not good for poorly known species.
Mechanistic	To represent the fundamental niche.	• Provides a better approximation of the climatic space in which an organism can exist, compared with the correlative approaches. • Can consider evolutionary changes and physiological responses.	• Require detailed data that lack for most species. • Uncertainty due to poor knowledge of model parameters (e.g. population abundance) and to combining data collected at different spatial resolutions. • Do not account for non-climatic threats to dispersal or for biotic interactions.
Trait-based vulnerability assessment approach	Biological characteristics as predictors of extinction risk due to Climate Change.	assessment for multiple species. • Do not require extensive knowledge of modelling techniques. • Can work with data poor	are often unknown. • Traits are weighted equally. • Not possible to compare vulnerability between taxonomic groups if using different traits for each group. • Uncertainty associated with the choice of traits, parameterisation of thresholds of associated vulnerability, and from gaps of knowledge of individual species' characteristics.

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Using of species vulnerability approaches

- Each of the different approaches has **strengths and weaknesses**, depending on the information available and the spatial and temporal scales of application
- Trait-based approaches are less resource-intensive and therefore more widely used
- Application in fisheries & aquaculture:
  - Becoming common to use trait-based studies of many species to identify greatest **relative risk**
  - Then apply more data intensive detailed studies of a few species- estimate **specific risk**
  - High value/important species – direct to data intensive single species methods

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Life history traits influence vulnerability to climate change

- Many published studies have shown that life-history traits are more important than taxonomy and distribution in determining species vulnerability to climate change (Foden et al 2013, Pacifici et al 2015)
- Traits that commonly make a species vulnerable to *climate change include:*
  - Limited dispersal capacity
  - Lower reproductive rates
  - Habitat specificity
  - Diet specificity
  - Restricted distribution
  - Narrow physiological tolerance

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Traits linked to 'invasion success ' vs 'extinction risk' are very different

Species Traits	Invasion	Extinction
Reproductive rate	- high	- low
Population size	- high	- low
Population fluctuation	- low	- high
Generation time	- short	- long
Genetic diversity	- high	- low
Dispersal potential	- high	- low
Habitat requirements	- generalist	- specialist
Environmental tolerance	- broad	- narrow
Environmental cue for phenology	- independent	- dependent
Interspecific interactions	- independent	- dependent

Bates, Pecl et al 2015

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Traits explain a significant % of variation in climate-driven changes in distribution

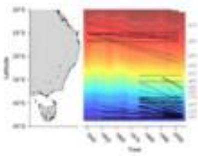
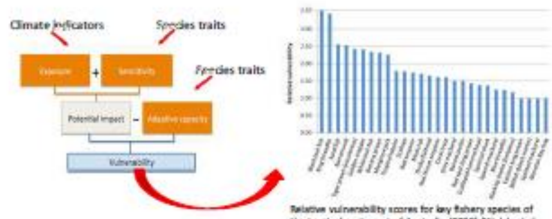


Figure: Poleward range boundary shifts of Coastal marine fishes & invertebrates in eastern Australia (black lines), & latitudinal changes in mean annual temperature isotherms (colours)

Assessing relative vulnerability in the Exposure-Sensitivity-Adaptive Capacity Framework



Relative vulnerability scores for key fishery species of the tropical east coast of Australia (2030) (Welch et al 2014).

Stages of fisheries climate vulnerability assessment

(regardless of framework applied)

Johnson et al 2016

Hare et al 2016

Stages in common

- Scoping and planning
  - Objectives
  - Spatial scale
  - Species
- Selecting framework & method/s
- Selecting indicators
- Data gathering
- Scoring
- Analyses
- Dissemination/communication/distribution

- Here, using E-S-AC framework
- But stages would apply to many other methods
- And can use multiple methods, e.g. data rich detailed ethnographic approach embedded in an E-S-AC framework

Objectives

- What actions or decisions do you want made at the end?
  - Who will make these decisions?
  - Who needs to be consulted at the start?
  - Who needs to be engaged in the process?
- What are the specific goals of the assessment?
  - Establish relative vulnerability of:
    - Species within a fishery?
    - Stocks within a fishery?
    - Species within a region?
    - Region with most vulnerable species?
- What resources (time, $, data) do you have to work with?

Selecting spatial scale

- Larger-scale can provide rapid comparative results for policy decisions and, in some cases, may be operationalized more quickly than in-depth assessments at smaller scales (Whitney et al 2017)
  - But do not incorporate local, traditional, cultural knowledge
  - May be inappropriate for use at smaller scales
- As concerns about climate impacts have increased, the need for information at scales that are relevant to stakeholders and managers has been increasingly recognized

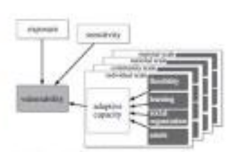


Figure 2. Conceptual framework for understanding components of social vulnerability to climate change. Exposure, sensitivity and the four components of adaptive capacity operate at local, regional, national and regional scales to varying degrees, depending on conditions. Adaptive capacity includes aspects of governance, education, health and wealth as aspects of the four components. Based on Cinner et al. (2009).

Selecting species

- What comes out of the assessment depends on what goes in at the start
- Even though can be 'rapid approach', often still cant include everything
- How select species to include?
- Could have many other types of criteria
  - Employment?
- Need to be clear on basis for decisions
- WHO gets to be involved in decisions is important

Criterion used to prioritise species for assessment (Welch et al 2014, Pecl et al 2014)

Criterion	Guiding definitions
Social/cultural importance	Species historically targeted due to popularity as a sportfish, edible qualities, large size, or other historical significance
Economic importance	Dollar value mostly as a commercial target species or through high recreational effort and/or tourism attraction
Catch	Volume of catch
Ecological importance	Considers trophic level and interactions

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Exposure-Sensitivity-Adaptive Capacity Framework

- Start with the sensitivity component – south east Australia (Pecl et al 2011, Pecl et al 2014)
  - Selection of traits
  - Scoring – allocating to a sensitivity category
  - Ranking of species – from most sensitive to least sensitive
- Building on the sensitivity component – full E-S-AC framework – northern & eastern Australia (Welch et al 2014)
  - Exposure
  - Adaptive capacity
  - Putting the components together
- Improvements
  - Assessing data quality
- Variations
  - Scoring components with expert opinion
  - Alternative method for ranking

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The Exposure-Sensitivity-Adaptive Capacity Framework

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Trait-based approach for assessing relative species sensitivity within regions

Pecl et al 2011 (report), Pecl et al 2014 (paper)

- Conducted for South East Australia, but repeated in northern Australia and West Australia (total of approximately 120 species)
- Built on Ecological Risk Assessment for fisheries approach
- Extended/adapted and applied by NOAA and Canada
- Adapted/adopted in Brazil, India and South Africa

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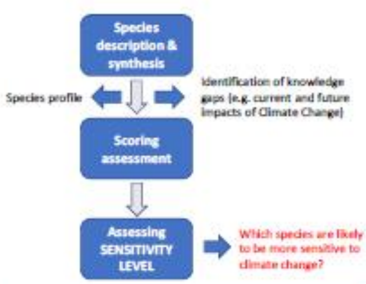
Components of the sensitivity assessment approach



Pecl et al 2014

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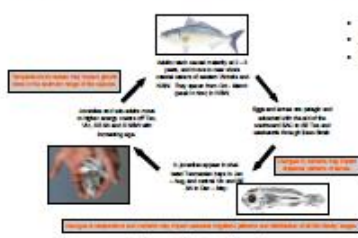
Assembled detailed life-history information on each species – "species profiles"

- Literature review
- Authored by species experts
- Consultation with other experts



Life cycle of Australian salmon

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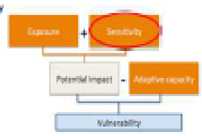
Trait-based approach for assessing species sensitivity

- Estimate sensitivity of species to climate change drivers based on traits that influence:
  - ABUNDANCE - measures of potential for biological productivity
    - Egg production?
    - Age at maturity?
  - DISTRIBUTION – measures of capacity to shift
    - Capacity for larval dispersal?
    - Thermal tolerance?
  - PHENOLOGY – measures of potential impact on timing of life cycle events
    - Temperature as a cue for spawning or moulting?
- Broken up the sensitivity attributes into three categories that reflected fishery managers interests



Pecl et al., 2014

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Estimate sensitivity of species to climate drivers based on ABUNDANCE

Sensitivity attribute		Risk category (sensitivity and capacity to respond to change)		
		High sensitivity (3), low capacity to respond (higher risk)	Medium (2)	Low sensitivity (1), high capacity to respond (lower risk)
Abundance	Fecundity – egg production	<100 eggs per year	100–20,000 eggs per year	>20,000 eggs per year
	Recruitment period – successful recruitment event that sustains the abundance of the fishery.	Highly episodic recruitment event	Occasional and variable recruitment period	Consistent recruitment events every 1–2 years
	Average age at maturity	>10 years	2–10 years	≤2 years
	Generalist vs. specialist – food and habitat	Reliance on both habitat and prey	Reliance on either habitat or prey	Reliance on neither habitat or prey

Pecl et al 2014

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Estimate sensitivity of species to climate drivers based on PHENOLOGY

Sensitivity attribute		Risk category (sensitivity and capacity to respond to change)		
		High sensitivity (3), low capacity to respond (higher risk)	Medium (2)	Low sensitivity (1), high capacity to respond (lower risk)
Phenology	Environmental variable as a phenological cue for spawning or breeding – cues include salinity, temperature, currents, & freshwater flows.	Strong correlation of spawning to environmental variable	Weak correlation of spawning to environmental variable	No apparent correlation of spawning to environmental variable
	Environmental variable as a phenological cue for settlement or metamorphosis	Strong correlation to environmental variable	Weak correlation to environmental variable	No apparent correlation to environmental variable
	Temporal mismatches of life-cycle events – duration of spawning, breeding or moulting season.	Brief duration; <2 months	Wide duration; 2–4 months	Continuous duration; >4 months
	Migration (seasonal and spawning)	Migration is common for the whole population	Migration is common for some of the population	No migration

Pecl et al 2014

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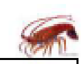
Estimate sensitivity of species to climate drivers based on DISTRIBUTION



e.g. southern rock lobster

Sensitivity attribute		Risk category (sensitivity and capacity to respond to change)		
		High sensitivity (3), low capacity to respond (higher risk)	Medium (2)	Low sensitivity (1), high capacity to respond (lower risk)
Distribution	Capacity for larval dispersal or larval duration – hatching to settlement (benthic species), hatching to yolk sac re-adsorption (pelagic species).	<2 weeks or no larval stage	2–8 weeks	>2 months ★
	Capacity for adult/juvenile movement – lifetime range post-larval stage.	<10 km ★	10–1000 km	>1000 km
	Physiological tolerance – latitudinal coverage of adult species as a proxy of environmental tolerance.	<10° latitude ★	10–20° latitude	>20° latitude
	Spatial availability of unoccupied habitat for most critical life stage – ability to shift distributional range.	No unoccupied habitat; 0 – 2° latitude or longitude ★	Limited unoccupied habitat; 2–6° latitude or longitude	Substantial unoccupied habitat; >6° latitude or longitude

(3+3+3+1)/4 = **2.5** (scores for each attribute added and totals ranked)

Pecl et al 2014

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Relative sensitivity rankings – South East Australia

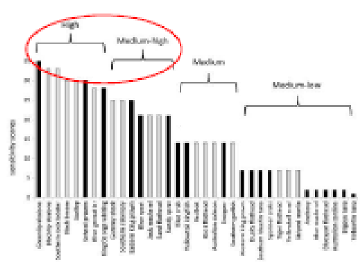

Fig. 2 Overall ranking of wild capture fishery species sensitivity based on an average of all attributes (distribution, abundance and phenology). Black columns = species which are predicted to undergo a range extension; grey columns = species which are predicted to undergo a range contraction

Pecl et al 2014

- Overall sensitivity ranking combines Distribution, Abundance and Phenology
- Can present Distribution only for example if potential for changes in distribution of particular interest

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How was this assessment used?

Abalone (H)

Southern rock lobster (H)

Blue grenadier (H)

Snapper (M)

- Used to select species for development of targeted impact research & adaptation strategies
- Sensitivity - High or medium risk to climate change impacts
  - Rock lobster and abalone - potential ecological indicators for rocky reefs
  - Snapper - important component of coastal fish assemblages
  - Blue grenadier - highest risk commonwealth species
- Species likely to exhibit different responses
  - Declines in abundance
  - Shift in resource distribution at small (between communities) and large (between jurisdictions) spatial scales
  - Shifts in temporal patterns (timing of spawning/moulting)
- Species with different industry and sectoral features
- Fisheries with different management arrangements

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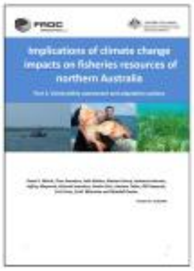
Building on the sensitivity assessment

- The full E-S-AC framework (for ecological vulnerability)
- Adding in EXPOSURE and ADAPTIVE CAPACITY



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Exposure

Exposure indicators and their criteria. Indicators based on changes in the respective variables projected for 2030. High (A1FI) and low (A1B) emission scenarios are similar for 2030 (Welch et al 2014, East Coast Australia)

Projections for 2030 (A1B & A1FI)	Low = 1	Medium = 2	High = 3
SST increase 0.4 to 0.6 °C	Adult spends <50% of time in surface (<25 m) waters	Adult spends 50-80% of time in surface (<25 m) waters	Adult spends 80-100% of time in surface (<25 m) waters
Rainfall -10 to 0%	Spends no time in estuarine or freshwater habitats during any life history phase	Spends <50% of time in estuarine or freshwater habitats; no critical (larvae, juvenile, spawning) life history phase in these habitats	Spends >50% of time or has critical (larvae, juvenile, spawning) part of life cycle in estuarine or freshwater habitats
pH decline 0.1 unit	Open ocean or deep water species	Continental shelf species	Inshore or estuarine species
Salinity decline 0.1 psu	Open ocean or deep water species	Continental shelf species	Inshore or estuarine species
Habitat changes (loss of productivity, structure or function) [illegible]	Species with wide habitat preferences	Species dependent on pelagic or mangrove/estuarine habitats	Species dependent on seagrass or coral reef habitats
Altered large-scale currents: Stronger EAC; weaker Leeuwin current	Live young/egg bearers or no dependence on large-scale wind/current for larval dispersal/settlement	Proximate dispersal/settlement of young not entirely dependent on large-scale wind/current dispersal	Dispersal/settlement of young 100% dependent on large-scale wind/currents
More intense cyclones/storms but possibly fewer	Deep water or highly mobile species	Shallow water (< 25 m) and moderately mobile species	Shallow water (< 25 m) or low mobility species
Reduction in riverflow/nutrient supply	Spends no time in estuarine or freshwater habitats during any life history phase	Spends <50% of time in estuarine or freshwater habitats; no critical (larvae, juvenile, spawning) life history phase in these habitats	Spends >50% of time or has critical (larvae, juvenile, spawning) part of life cycle in estuarine or freshwater habitats

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Exposure

- Changes in exposure values averaged over large spatial area
- There is a basis for inclusion of each factor – an impact pathway, e.g. SST impacts growth, metabolic costs
- You might not have access to all exposure factors you know are important, eg changes in bottom temperature

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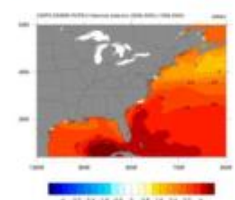
Exposure



Hare et al 2016 (NOAA, U.S. assessment)

- Instead of average over geographical region, use maps of predicted change in exposure over a certain period (maps for Hare et al 2016 were obtained from NOAA's Climate Change Web Portal)
- These maps were compared with species distributions to determine climate exposure
- You can use ensemble modelling of Global Climate Models (GCMs) to calculate an estimate of uncertainty in exposure
- BUT you might have access to a high resolution downscaled model that may better represent your area – trade-off

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Adaptive capacity

- Ecological system – difference between indicators for 'sensitivity' vs 'adaptive capacity' not clear cut
- Often not included in ecological vulnerability assessments (eg Hare et al 2016)
- In natural systems, ecological adaptive capacity is an indicator of evolutionary adaptive potential suggesting that a species or ecosystem has the existing natural ability to persist over time and through change (Smit and Wandel 2006)
- In contrast, the adaptive capacity of social systems refers to the ability of human actors and communities to respond to change and maintain human wellbeing over time (Smit and Wandel 2006)
- Sometimes use integrated social-ecological indicators

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Adaptive Capacity

Adaptive capacity indicators and their criteria. NB. Adaptive capacity has the inverse effect compared to Exposure and Sensitivity. Low Sensitivity is a positive trait while low Adaptive Capacity is a negative trait.

		Low = 1	Medium = 2	High = 3
Adaptive Capacity	Stock status	Overfished or on the verge of overfishing	Undefined	Sustainably fished
Adaptive Capacity – Ecological	Replenishment potential	Late maturing (>6 years), slow growth or few young	Matures at 3-6 years, moderate growth or moderate numbers of young	Early maturing, fast growth or many young
Adaptive Capacity – Ecological	Suitable alternate habitat availability	Low availability of habitat outside range or currently near northern edge of range	Some availability of habitat outside range or currently near middle of range	High availability of habitat outside range and currently near middle of range
Adaptive Capacity – Ecological	Species mobility	Low mobility; can travel <2 km/day	Moderately mobile; can travel 2-10 km/day	Highly mobile; can travel >10 km/day
Adaptive Capacity – Ecological	Non-fishing pressures on stock	Multiple chronic pressures (eg. poor water quality, disease, incidental catch)	Some acute pressures (eg. cyclones, storms, floods)	No or minimal other pressures

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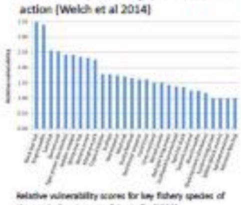
Putting the E-S-AC components together

- Calculate Sensitivity score
- Calculate Exposure score
- Sensitivity x Exposure = Potential impact
- Adaptive capacity
  - Calculated as average of AC indicators
  - Scores were then standardised to 1.00 with the highest average AC score given 1.00 and all other scores expressed as a proportion
  - Inverse is then taken to derive the AC index That is, AC index = 1 - Standardised AC.
- Vulnerability = (Potential impact x AC index) + 1.

The result?

Used to assist managers and other fishery end-users in prioritising species for future action (Welch et al 2014)



Relative vulnerability scores for key fishery species of the tropical east coast of Australia (2030).

Relative vulnerability vs level of fishery importance. High vulnerability and high fishery importance species are the highest priority (top right of the graph).

Variations on the Australian method

(Pecl et al 2011, 2014, Welch et al 2014, Johnson et al 2016)

- Looked only at EXPOSURE and SENSITIVITY
- More detailed, more robust assessment
- NOAA - 82 federally managed fish and invertebrate species assessed using an expert panel for both sensitivity and exposure

Data quality score

Data Quality Score	Description
3	**Adequate Data:** The score is based on data which have been observed, modeled or empirically measured for the species in question and comes from a reputable source.
2	**Limited Data:** The score is based on data which has a higher degree of uncertainty. The data used to score the attribute may be based on related or similar species, come from outside the study area, or the reliability of the source may be limited.
1	**Expert Judgment:** The attribute score reflects the expert judgment of the reviewer and is based on their general knowledge of the species, or other related species, and their relative role in the ecosystem.
0	**No Data:** No information to base an attribute score on. Very little is known about the species or related species and there is no basis for forming an expert opinion.

Hare et al 2016

Data quality score

Data Quality Score	Description
3	**Adequate Data:** The score is based on data which have been observed, modeled or empirically measured for the species in question and comes from a reputable source.
2	**Limite[d Data]** ... higher degree of uncert... y be based on related or simila... r the reliability of the source may b[e limited]
1	**Exper[t Judgment]** ... pert judgment of the review... the species, or other relate... em.
0	**No Da[ta]** ... n. Very little is known about ... basis for forming an expert opinion.

Except, nothing in this ranking about how recent data is.

We suggest adding information on how recent data is to quality score

eg 1960's vs 2010 for example

Hare et al 2016

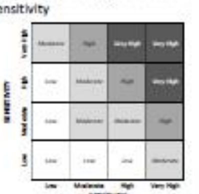
Alternative method for scoring and ranking

- Rather than averaging all fields within 'sensitivity' or 'exposure' use a logistic model

Logic rules for determining each species' sensitivity and exposure component scores (Hare et al 2016)

Component Score	Scoring Criteria
Very High	3 or more mean attribute or factor scores ≥ 3.5
High	2 or more mean attribute or factor scores ≥ 3.0
Moderate	2 or more mean attribute or factor scores ≥ 2.5
Low	Less than 2 or more mean attribute or factor scores ≥ 2.5

- Matrix for combining 'exposure' and 'sensitivity' and arriving at final species designation (Hare et al 2016)
- Instead of multiplying Exposure x Sensitivity



Weaknesses of general E-S-AC approach

- Ecosystem & indirect affects not well accounted for (eg increased predation)
- Relationships very simplified (eg 'generalist' or 'specialist')
- Precise sensitivity thresholds with each trait unknown
- Traits are weighted equally (but you could weight them)
- Choice of traits
- Needs expert review!
- Not made with all potential species in mind

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Strengths of E-S-AC approach

- Many quantitative approaches use only one (eg Temp) or two exposure elements, this method can consider many
- Integrates, synthesises and summarises known information
- Highlights data and knowledge gaps
- Transparent
- Repeatable
- Can work with data poor and expert opinion
- Rapid assessment
- Prioritise

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CMS — UNIVERSITY of TASMANIA — IMAS — CSIRO

Case study exercise -Coral reef system?

Relevant to PNG, Malaysia, Indonesia, Thailand

- Scoping and planning
  - Objectives – who will use assessment and what do they want to know?
  - Spatial scale – local, regional, country?
  - Who needs to be involved and have a say?
  - Species to include?
- Selecting framework & method/s (Here, use E-S-AC)
- Selecting indicators – Exposure, Sensitivity, Adaptive Capacity
  - What are key impacts/impact pathways?
- Data gathering – is data available? Do we use experts? How many experts do we have?
- Scoring
  - Do we have three Low, Medium, High categories?
  - Or Low, Moderate, High, Very High?
  - One score per attribute or many experts scoring?
- Analyses
  - Average scores?
  - Logistic model?
- Dissemination/communication/distribution

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Hare et al 2016 (NOAA U.S. Fishery Assessment)

Example sensitivity attributes

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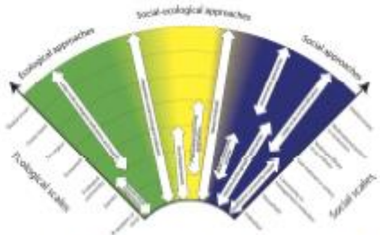
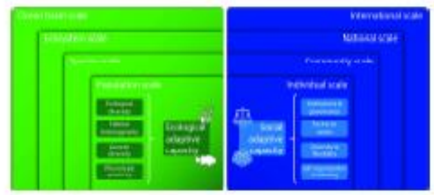
Approaches for assessing adaptive capacity



Comparison of 11 approaches for assessing adaptive capacity at different spatial scales and with varying attention to social and ecological systems (Whitney et al 2017).

Adaptive capacity and spatial scale



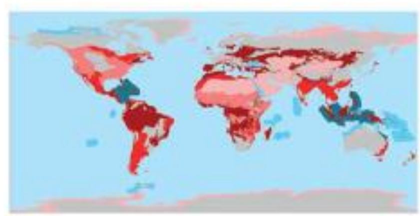
Example measures of adaptive capacity in ecological or social systems across spatial scales. Measures are examples only and are not meant to be prescriptive or specific to a given scale as shown here.

Advantages of including fishers knowledge in assessment

Observation	Attributed cause	Knowledge of observation
Destruction of habitats in recent years (mangroves/seagrass inshore, coral reef shoals offshore). Will decrease tiger prawn/mud crab/red emperor recruitment potentially for many years	Cyclones	Habitat damage is known and documented; impacts have not been established
In recent years water temperatures inshore have been too high for large Spanish mackerel	Higher SST	Not known and not yet established
Mackerel, grunters and red snapper are spawning earlier than they used to	Higher SST	Not documented
Baitfish in the southern Great Barrier Reef are less abundant than they used to be	Unknown	Not documented
A lack of longtail tuna coming inshore in recent years	Unknown	Known. Not documented
This year juvenile billfish appeared in Bowling Green Bay in August; earlier than usual and the most in 7 years	Unknown	Known. Not documented

Welch et al 2014

Marine species vulnerable to climate change



- Ecoregional global concentrations of marine climate change vulnerable species
- Integration of other published studies

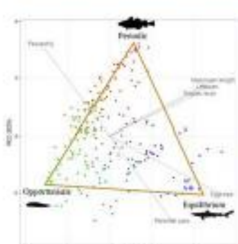
Marine
- Low
- Medium
- High

Pacifici et al., 2015

Full sensitivity attribute list from Pecl et al 2011, Pecl et al 2014

Sensitivity attribute		Sensitivity category (sensitivity and capacity to respond to change): High sensitivity (3), low capacity to respond	Medium (2)	Low sensitivity (1), high capacity to respond
Abundance	Fecundity - egg production	<100 eggs per year	100 - 20,000 eggs per year	>20,000 eggs per year
	Recruitment period - successful recruitment event that sustains the abundance of the fishery	Highly episodic recruitment event	Occasional and variable recruitment period	Consistent recruitment events every 1-2 years
	Average age at maturity	>10 years	2-10 years	≤2 years
	Generalist vs. Specialist - food and habitat	Reliance on both habitat and prey	Reliance on either habitat or prey	Reliance on neither habitat or prey
Distribution	Capacity for larval dispersal or larval duration - hatching to settlement (benthic species), hatching to yolk sac re-absorption (pelagic species)	<2 weeks or no larval stage	2 - 8 weeks	>2 months
	Capacity for adult/juvenile movement - lifetime range post larval stage	<10 km	10 - 1000 km	>1000 km
	Physiological tolerance - latitudinal coverage of adult species as a proxy of environmental tolerance	<10° latitude	10 - 20° latitude	>20° latitude
	Spatial availability of unoccupied habitat for most critical life stage - ability to shift distributional range	No unoccupied habitat 0 - 2° latitude or longitude	Limited unoccupied habitat; 2 - 6° latitude or longitude	Substantial unoccupied habitat; >6° latitude or longitude
Phenology	Environmental variable as a phenological cue for spawning or breeding - cues include salinity, temperature, currents and freshwater flows	Strong correlation of spawning to environmental variable	Weak correlation of spawning to environmental variable	No apparent correlation of spawning to environmental variable
	Environmental variable as a phenological cue for settlement or metamorphosis	Strong correlation to environmental variable	Weak correlation to environmental variable	No apparent correlation to environmental variable
	Temporal mismatches of life cycle events - duration of spawning, breeding or moulting season	Brief duration <2 months	Wide duration 2 - 4 months	Continuous duration >4 months
	Migration (seasonal or spawning)	Migration is common for the whole population	Migration is common for some of the population	No migration

Can also reduce multiple traits to a single metric



- Use of 'archetype analysis' to reduce multiple traits down to a single metric suitable for use as an indicator of sensitivity to climate change
- The first and second principal components (PC1 and PC2) from a principal component analysis (PCA) are used as axes
- Each species used in the study is represented by a dot
- The three extreme points (archetypes) that encompass the trait-space are represented by crosses, corresponding to equilibrium, opportunistic and periodic strategies, respectively

Pecuchet et al. (2017) From traits to life-history strategies: Deconstructing fish community composition across European seas. Global Ecology and Biogeography. https://doi.org/10.1111/geb.12587

Session 5: Practical session

Gretta Pecl[1] and Ingrid Van Putten[2]
[1]Institute for Marine and Antarctic Studies – University of Tasmania, [2]Commonwealth Scientific and Industrial Research Organisation (CSIRO)

The participants selected sensitivity and exposure indicators for two species of a coral reef ecosystem: for a shark, and for an octopus. Sensitivity scores were assigned based on the available information of the species using an Excel spreadsheet format. Exposure scores were assigned based on climatic variations of the region of study. Adaptive capacity indicators were also considered; however, it was stressed that these can often be difficult to include in vulnerability assessments because there is no clear cut between sensitivity and adaptive capacity indicators.

An exercise was also performed where the participants assigned data quality scores based on the source of the information using an Excel spreadsheet format. Uncertainty through the experts' tallies approach and the use of the logistic model approach were explained, considering the benefit of using the logistic model approach rather than the average approach.

Considering a list of species assessed in previous studies, a matrix of sensitivity vs exposure was elaborated to sort out the species with relatively highest vulnerability to the impacts of climate change.

Assessing risk & vulnerability to climate change in marine fisheries and aquaculture

Workshop material prepared and presented by Associate Professor Gretta Pecl and Dr Ingrid van Putten, for IMARPE & APEC, Peru October 2017

Gretta.Pecl@utas.edu.au
Ingrid.Vanputten@csiro.au

THIS IS AN EXAMPLE SPREADSHEET
for calculating climate change EXPOSURE, SENSITIVITY and ADAPTIVE CAPACITY of species

PLEASE DO NOT DISTRIBUTE

Hypothetical example derived & adapted from the methodology of Johnson et al 2016

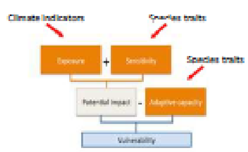
"Assessing and reducing vulnerability to climate change: Moving from theory to practical decision-support" Marine Policy 74 (2016) 220–229

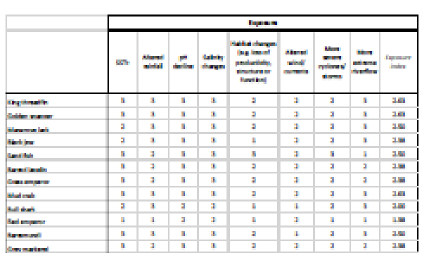
Please note I have changed some attributes and categories from the original source

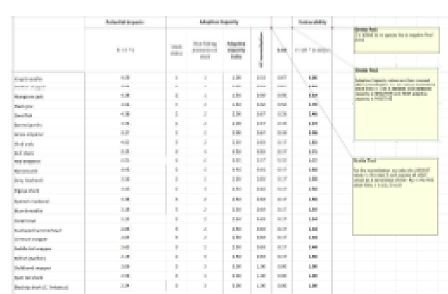
To apply this method in your own region, you would need to determine your own attributes and categories for each of EXPOSURE, SENSITIVITY and ADAPTIVE CAPACITY, based on careful examination of your particular system. The attributes and categories used here may not be appropriate

Please also note there other methods for combining EXPOSURE, SENSITIVITY and ADAPTIVE CAPACITY

Populating these boxes in the Exposure-Sensitivity-Adaptive Capacity Framework



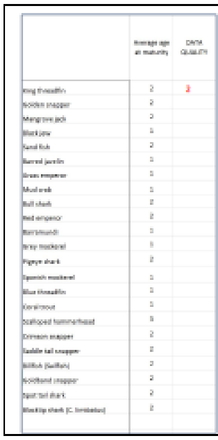


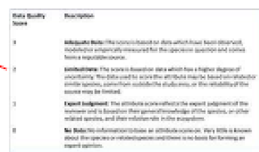


Most of what else we have been discussing, are variations on this spreadsheet

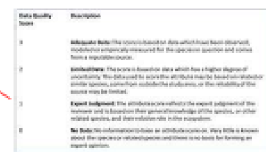
Variation 1- Adding a data quality score

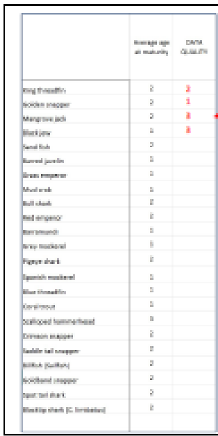
Data Quality Score	Description
3	**Adequate Data:** The score is based on data which have been observed, modeled or empirically measured for the species in question and comes from a reputable source.
2	**Limited Data:** The score is based on data which has a higher degree of uncertainty. The data used to score the attribute may be based on related or similar species, come from outside the study area, or the reliability of the source may be limited.
1	**Expert Judgment:** The attribute score reflects the expert judgment of the reviewer and is based on their general knowledge of the species, or other related species, and their relative role in the ecosystem.
0	**No Data:** No information to base an attribute score on. Very little is known about the species or related species and there is no basis for forming an expert opinion.





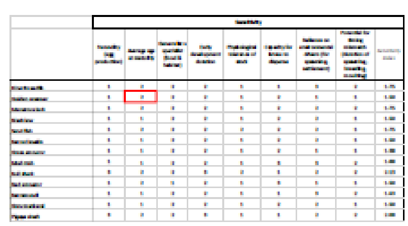
So maybe we have data on age at maturity for this species, but from a different region





You have good quality data on this species in this region

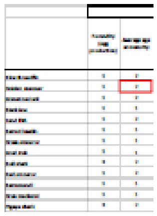
Variation 2- Including uncertainty in expert scoring



In this version, each piece of the assessment only has one score

e.g. we have ONE expert assessment of age at maturity

Variation 2- including uncertainty in expert scoring

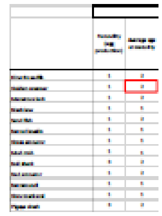


	LOW	MEDIUM	HIGH
Expert 1			
Expert 2			

But what if we have multiple experts we can ask??

Maybe more opinions are better than one.

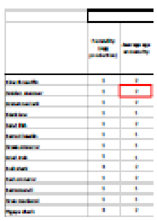
Variation 2- including uncertainty in expert scoring



	LOW	MEDIUM	HIGH
Expert 1	I	III	I
Expert 2			

Expert 1- 'reasonably sure' it's medium category (3-10 years age at maturity), but there's a chance that they mature earlier or later

Variation 2- including uncertainty in expert scoring

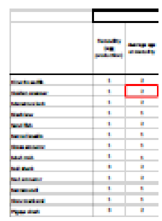


	LOW	MEDIUM	HIGH
Expert 1	I	III	I
Expert 2		III	I

Expert 1- 'reasonably sure' it's medium category (3-10 years age at maturity), but there's a chance that they mature earlier or later

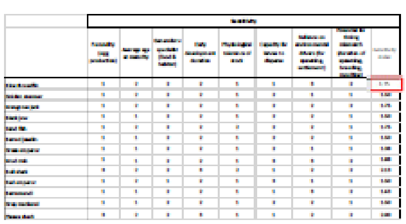
Expert 2- more confident it's medium category (3-10 years age at maturity), but there's a chance that they mature later

Variation 2- including uncertainty in expert scoring



	LOW	MEDIUM	HIGH
Expert 1	I	III	I
Expert 2		III	I
totals	1	7	2
SENSITIVITY SCORE		MEDIUM	

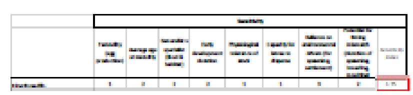
Variation 3- alternative methods of scoring and ranking



Average of all values for sensitivity for threadfin

Averaging all fields within each of 'sensitivity', 'exposure' and 'adaptive capacity

Variation 3- alternative methods of scoring and ranking



Average of all values for sensitivity for threadfin

Component Score	Scoring Criteria
Very High	3 or more mean attribute or factor scores ≥3
High	3 or more mean attribute or factor scores ≥2.5
Moderate	3 or more mean attribute or factor scores ≥2
Low	Less than 3 or more mean attribute or factor scores ≥2

Instead of averaging, could use 'logistic model'

Variation 3- alternative methods of scoring and ranking

Average of all values for sensitivity for threadfin

Component Score	Scoring Criteria
Very High	3 or more mean attribute or factor scores ≥ 3
High	3 or more mean attribute or factor scores ≥ 3.0
Moderate	3 or more mean attribute or factor scores ≥ 2
Low	Less than 3 or more mean attribute or factor scores ≥ 2

You would need to make your own rules depending on number of sensitivity categories and indicators etc

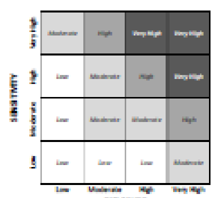
Instead of averaging, could use 'logistic model'

Variation 3- alternative methods of scoring and ranking

Component Score	Scoring Criteria
Very High	3 or more mean attribute or factor scores ≥ 3
High	3 or more mean attribute or factor scores ≥ 3.0
Moderate	3 or more mean attribute or factor scores ≥ 2
Low	Less than 3 or more mean attribute or factor scores ≥ 2

Instead of averaging, could use 'logistic model'

- Matrix for combining 'exposure' and 'sensitivity' and arriving at final species designation (Hare et al 2016)
- Instead of multiplying Exposure x Sensitivity



Conclusions of the second day

Jorge E. Ramos
Institute for Marine and Antarctic Studies-University of Tasmania

Asia-Pacific
Economic Cooperation

APEC "International Workshop on ecological risk assessment of impacts of climate change on fisheries and Aquaculture resources"

Conclusions
Day 2, 26th October 2017

Jorge E. Ramos (jeramos@utas.edu.au)

- **Vulnerability indicators**
  - To do a vulnerability assessment you need indicators (e.g. observations or calculations) that can be used to track conditions and trends
  - Indicators can help to find out how vulnerable and/or resilient systems are to change, e.g. climate change
  - Two types of indicators:
    - Performance indicators – tell you if an objective is achieved
    - Trigger indicators – indicate when a particular threshold is met and if there has been a change
  - Considerations to select indicators:
    - Specific
    - Measurable
    - Achievable and attributable
    - Relevant and realistic
    - Time-bound

- Data collection approaches in vulnerability assessments
  - Top-down. Modelling based approach, often focused on impacts
  - Bottom-up. Stakeholder approach, often focused on adaptation
  - Each with qualitative and quantitative methods.

- **Expert elicitation**
- Expert elicitation is a scientific consensus methodology to get the information you want from the experts
- There are many methods/techniques that elicit information from experts, e.g. focus group, Delphi techniques
- Expert elicitation allows using probability to measure uncertainty, to reduce uncertainty to mitigate risk, or to make adaptation policies robust to uncertainty
- Types of experts: "Expert" expert, informal expert, learning by doing expert, popular(ist) expert, specific (local) knowledge expert
- There is uncertainty related to experts due to incomplete knowledge, inherent natural randomness, linguistic uncertainty
- Expert judgement is susceptible to cognitive and motivational bias

- **Fisheries Climate Vulnerability Assessment**
- Can be used at different levels, e.g. for species within a fishery, stocks within a fishery, species within a region or country
- Different approaches of CVA:
  - Correlative
  - Mechanistic
  - Trait-based. Less resource-intensive and therefore more widely used
- Traits that commonly make species vulnerable to climate change:
  - Limited dispersal capacity
  - Lower reproductive rates
  - Habitat specificity
  - Diet specificity
  - Restricted distribution
  - Narrow physiological tolerance
  - The more specialized the more vulnerable!

- Assessing relative vulnerability in the **Exposure, Sensitivity, and Adaptive Capacity (E-S-AC)** framework.
- **Exposure** - Stimuli that have an impact on species or systems, e.g. climatic conditions
  - Exposure indicators can include:
    - SST
    - Rainfall
    - pH decline
    - Salinity decline
    - Habitat changes
    - Altered large-scale currents
    - More intense cyclones/storms
    - Reduction in riverflow/nutrient supply
    - Bottom indicators for benthic species
- **Sensitivity** - Degree to which a system is affected by the climate stimuli
  - Can be based on traits that influence abundance, distribution, phenology

- **Adaptive capacity**
  - In natural systems - natural ability of species or ecosystems to persist over time and through change
  - In social systems - ability of human actors and communities to respond to change and maintain human wellbeing over time
  - Often not included in ecological vulnerability assessments because there is not a clear cut between indicators for sensitivity vs adaptive capacity
  - Some adaptive capacity indicators are:
    - Stock status
    - Replenishment potential
    - Suitable alternate habitat availability
    - Species mobility
    - Non-fishing pressures on stock

  With Exposure, Sensitivity and Adaptive Capacity you can estimate vulnerability

- **Vulnerability** - Degree to which a system is susceptible to damage (the detrimental part of sensitivity)

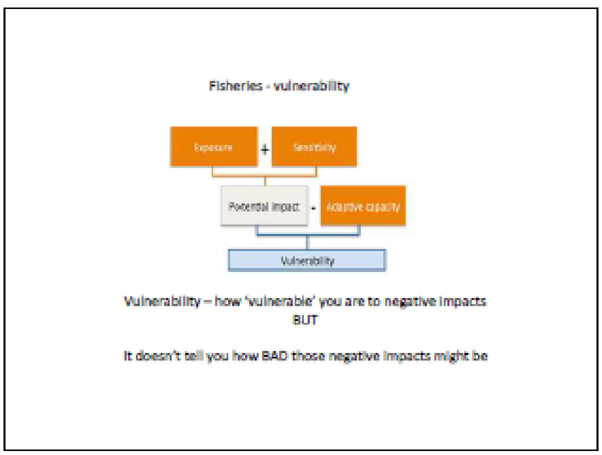
- Weaknesses of E-S-AC approach:
  - Precise sensitivity thresholds with each trait unknown
  - Traits are weighted equally (but you could weight them)
  - Choice of traits
  - Needs expert review!
  - Not made with all potential species in mind

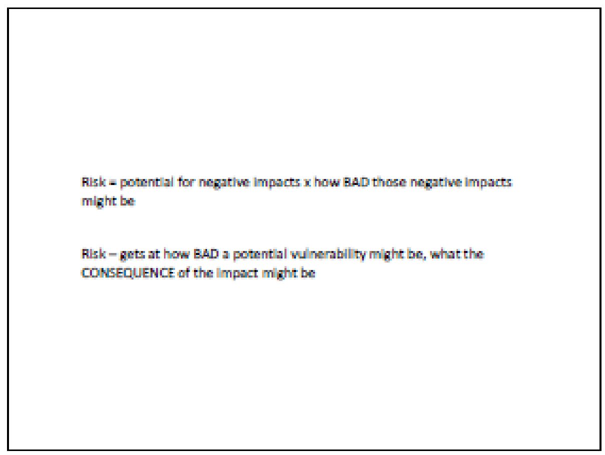
- Strengths of E-S-AC approach:
  - Integrates, synthesises and summarises known information
  - Highlights data and knowledge gaps
  - Transparent and repeatable
  - Rapid assessment
  - Prioritise

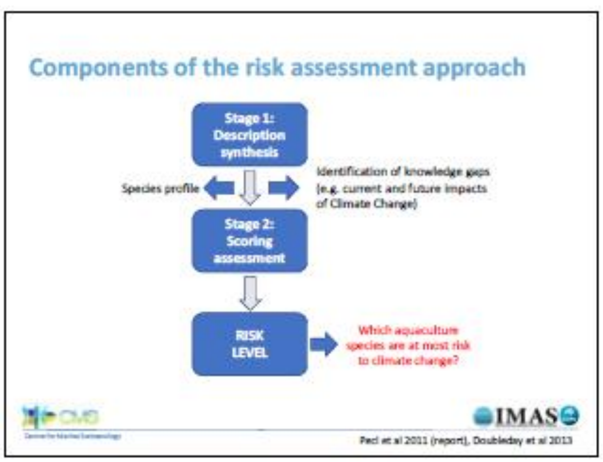
Requires lots of participation and communication!

Session 6: Aquaculture risk assessment

Gretta Pecl
Institute for Marine and Antarctic Studies – University of Tasmania







Risk assessment process

- The risk assessment is based on an examination of all stages and methods of the farming process, encompassing all basic farming and life-history stages. What are all of the discrete steps involved in farming process?
- Essential to have a strong knowledge on the main aquaculture traits of species.
- Source of information: scientists, experts from aquaculture industry, stakeholders, etc.

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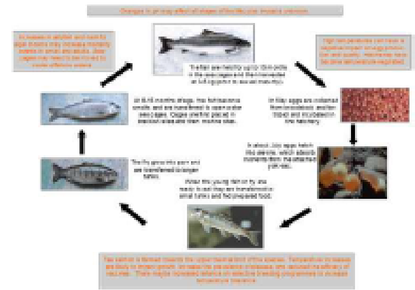
Breaking the farming system down into components and methods (or 'attributes')



Atlantic salmon aquaculture 'Life Cycle'

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Farming attributes

1. **Broodstock availability & conditioning** – degree of environmental control
2. **Spawning & fertilisation** – degree of difficulty and environmental control
3. **Larval rearing** – degree of complexity and environmental control
4. **Juvenile rearing (to stage stocked into growout system)** – degree of complexity and environmental control
5. **Growout: connectivity to natural environment** – degree of environmental control
6. **Growout: availability of alternative farm sites & systems** – capacity to relocate farm site or use of alternative farming system
7. **Growout: feed** – wild verses manufactured sources; frequency of manual feeding
8. **Growout: farm operations** – level of exposure to the natural environment and environmental extremes
9. **Growout: diseases and pests** – management and susceptibility

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Sensitivity categories for each farming attribute

Attribute	Sensitivity category (level of sensitivity)		
	Low sensitivity (1)	Medium sensitivity (2)	High sensitivity (3)
1. Broodstock availability & conditioning – degree of environmental control	[illegible]	[illegible]	Breed in the wild

E.g. oysters where farmer gets babies from mother oysters kept in a lab

vs

Where farmer collects oysters from wild and hope to make the mothers spawn

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Sensitivity categories for each farming attribute

Attribute	Sensitivity category (level of sensitivity)		
	Low sensitivity (1)	Medium sensitivity (2)	High sensitivity (3)
1. Broodstock availability & conditioning – degree of environmental control	[illegible]	[illegible]	Breed in the wild
2. Spawning & fertilisation – degree of difficulty and environmental control	[illegible]	[illegible]	Occurs naturally in the wild
3. Larval rearing – degree of complexity and environmental control	[illegible]	[illegible]	Occurs naturally in the wild
4. Juvenile rearing (to stage stocked into growout system) – degree of complexity and environmental control	[illegible]	[illegible]	Occurs naturally in the wild

e.g. Atlantic salmon, juveniles are reared in a laboratory facility

e.g. juveniles reared in wild (eg sea cages)

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Sensitivity categories for each farming attribute

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	Low sensitivity (1)	Medium sensitivity (2)	High sensitivity (3)
1. Broodstock availability & conditioning – degree of environmental control	[illegible]	[illegible]	Breed in the wild
2. Spawning & fertilisation – degree of difficulty and environmental control	[illegible]	[illegible]	Occurs naturally in the wild
3. Larval rearing – degree of complexity and environmental control	[illegible]	[illegible]	Occurs naturally in the wild
4. Juvenile rearing (to stage stocked into growout system) – degree of complexity and environmental control	[illegible]	[illegible]	Occurs naturally in the wild
5. Growout: connectivity to natural environment – degree of environmental control	[illegible]	[illegible]	[illegible]
6. Growout: availability of alternative farm sites & systems – capacity to relocate farm site or use of alternative farming system	[illegible]	[illegible]	[illegible]
7. Growout: feed – wild verses manufactured sources; frequency of manual feeding	Manufactured feeds used	[illegible]	Natural productivity
8. Growout: farm operations – level of exposure to the natural environment and environmental extremes	[illegible]	[illegible]	[illegible]
9. Growout: diseases and pests – management and susceptibility	[illegible]	[illegible]	[illegible]

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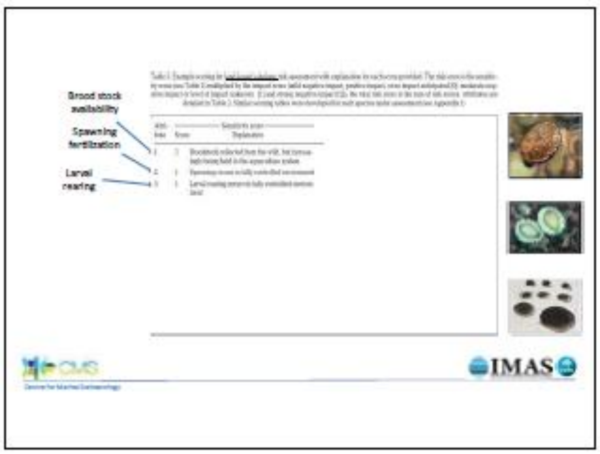
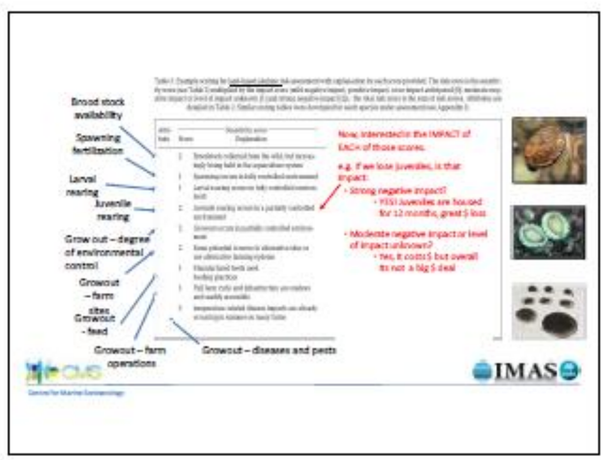
Brood stock availability

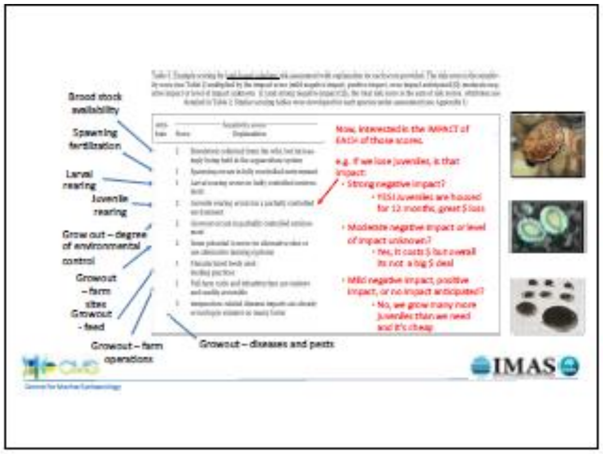

Brood stock availability
Spawning fertilization


Brood stock availability
Spawning fertilization
Larval rearing


Brood stock availability
Spawning fertilization
Larval rearing
Juvenile rearing


Brood stock availability
Spawning fertilization
Larval rearing
Juvenile rearing
Grow out – degree of environmental control
Growout – farm sites
Growout - feed
Growout – farm operations
Growout – diseases and pests
Now interested in the IMPACT of EACH of those scores.
e.g. If we lose juveniles, is that impact:
• Strong negative impact?
• YES! Juveniles are housed for 12 months, great $ loss


Brood stock availability
Spawning fertilization
Larval rearing
Juvenile rearing
Grow out – degree of environmental control
Growout – farm sites
Growout - feed
Growout – farm operations
Growout – diseases and pests
Now interested in the IMPACT of EACH of those scores.
e.g. If we lose juveniles, is that impact:
• Strong negative impact?
• YES! Juveniles are housed for 12 months, great $ loss
• Moderate negative impact or level of impact unknown?
• Yes, it costs $ but overall its not a big $ deal


Brood stock availability
Spawning fertilization
Larval rearing
Juvenile rearing
Grow out – degree of environmental control
Growout – farm sites
Growout – feed
Growout – farm operations
Growout – diseases and pests
Now, interested in the IMPACT of EACH of those scores.
e.g. If we lose juveniles, is that impact:
• Strong negative impact?
• YES! Juveniles are housed for 12 months, great $ loss
• Moderate negative impact or level of impact unknown?
• Yes, it costs $ but overall its not a big $ deal
• Mild negative impact, positive impact, or no impact anticipated?
• No, we grow many more juveniles than we need and it's cheap
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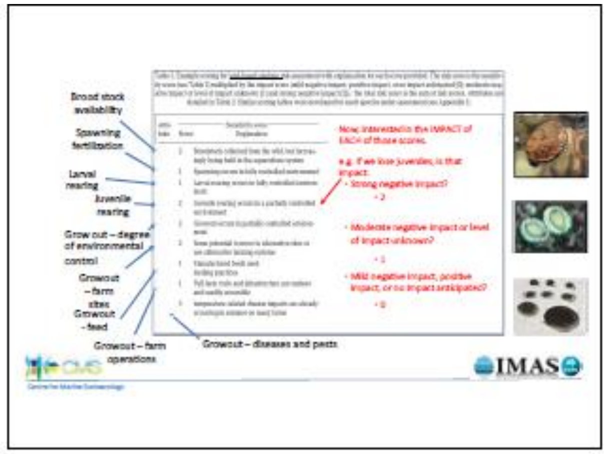
Brood stock availability
Spawning fertilization
Larval rearing
Juvenile rearing
Grow out – degree of environmental control
Growout – farm sites
Growout – feed
Growout – farm operations
Growout – diseases and pests
Now, interested in the IMPACT of EACH of those scores.
e.g. If we lose juveniles, is that impact:
• Strong negative impact?
• 2
• Moderate negative impact or level of impact unknown?
• 1
• Mild negative impact, positive impact, or no impact anticipated?
• 0
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Brood stock availability
Spawning fertilization
Larval rearing
Juvenile rearing
Grow out – degree of environmental control
Growout – farm sites
Growout – feed
Growout – farm operations
Growout – diseases and pests
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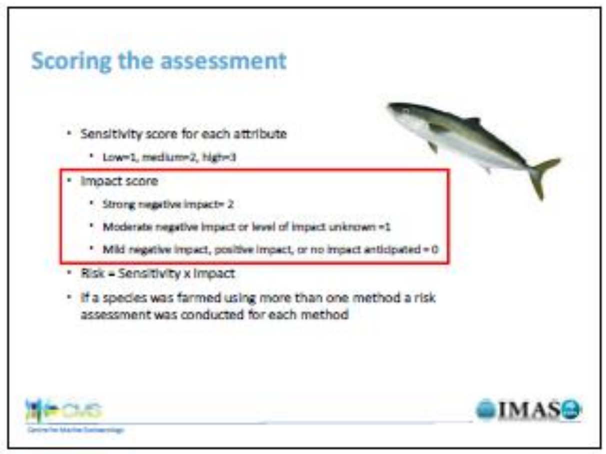
Scoring the assessment
• Sensitivity score for each attribute
• Low=1, medium=2, high=3
• Impact score
• Strong negative impact= 2
• Moderate negative impact or level of impact unknown =1
• Mild negative impact, positive impact, or no impact anticipated = 0
• Risk = Sensitivity x impact
• If a species was farmed using more than one method a risk assessment was conducted for each method
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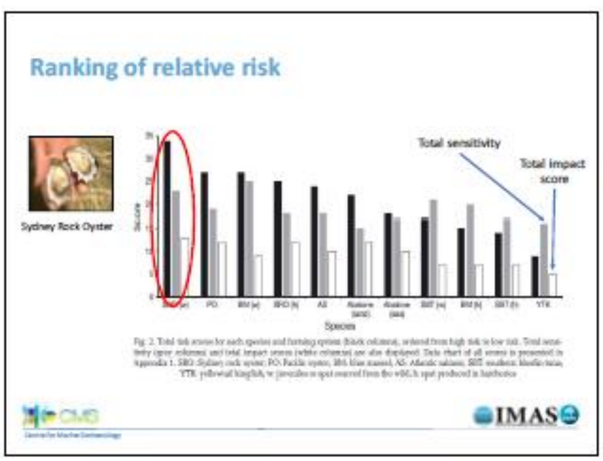
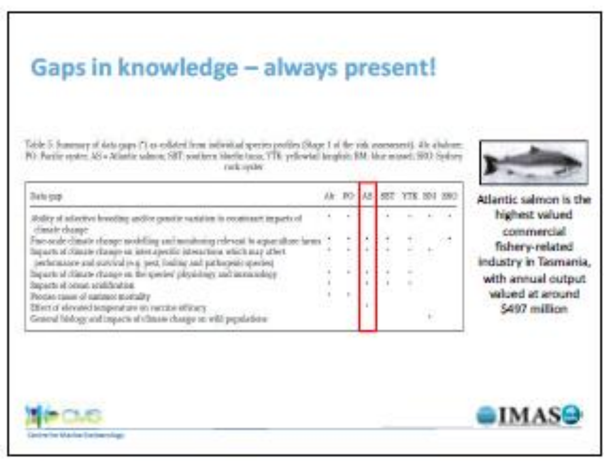

Ranking of relative risk
Sydney Rock Oyster
Total sensitivity
Total impact score
Score
Species
PO
AS
YTK
IMAS


Gaps in knowledge – always present!
Atlantic salmon is the highest valued commercial fishery-related industry in Tasmania, with annual output valued at around $497 million
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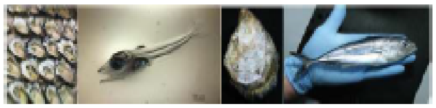
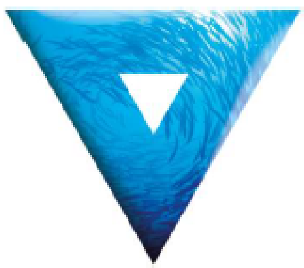
How would you adapt this approach?

- Go through all the stages of your aquaculture system and make sure you are considering each stage of the process
- Are there any stages of the aquaculture farming process that the current list of 'attributes' or farming stages, doesn't adequately consider?
- If not, add a new attribute or stage to the assessment
- How would you score sensitivity and impact of those new components?



Farming attributes

1. **Broodstock availability & conditioning** – degree of environmental control
2. **Spawning & fertilisation** – degree of difficulty and environmental control
3. **Larval rearing** – degree of complexity and environmental control
4. **Juvenile rearing (to stage stocked into growout system)** – degree of complexity and environmental control
5. **Growout: connectivity to natural environment** – degree of environmental control
6. **Growout: availability of alternative farm sites & systems** – capacity to relocate farm site or use of alternative farming system
7. **Growout: feed** – wild verses manufactured sources; frequency of manual feeding
8. **Growout: farm operations** – level of exposure to the natural environment and environmental extremes
9. **Growout: diseases and pests** – management and susceptibility



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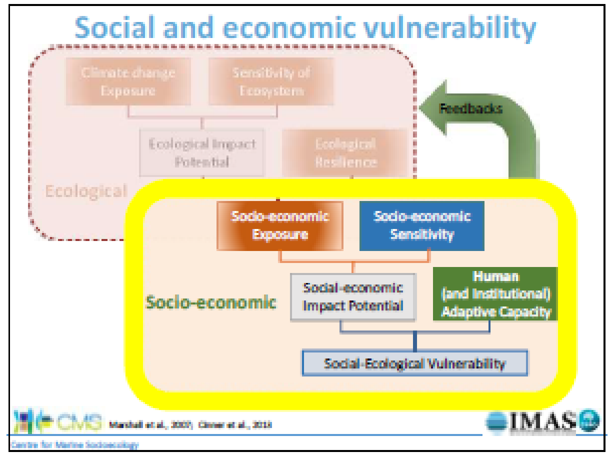
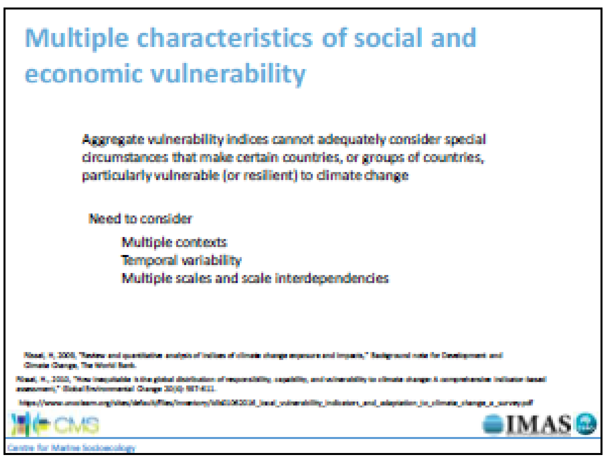
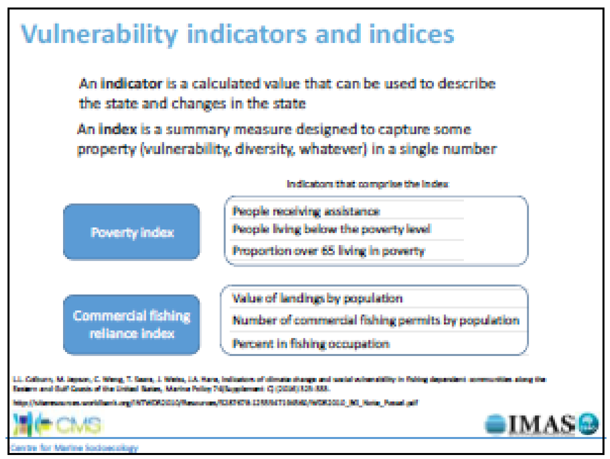
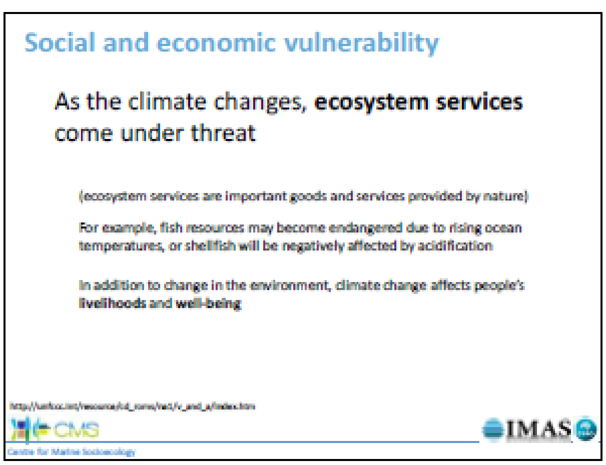
Session 7: Social and economic vulnerability assessment

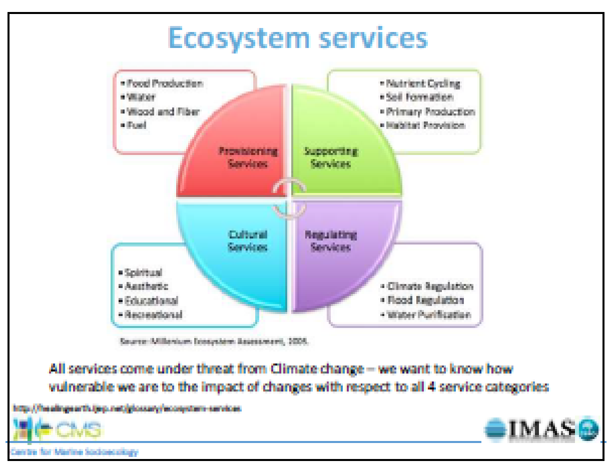
Ingrid Van Putten
Commonwealth Scientific and Industrial Research Organisation (CSIRO)



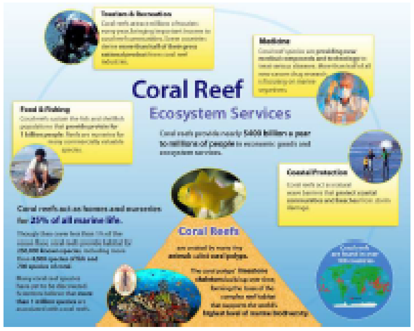








Ecosystem services values



https://primmecorals.weebly.com/coral-reefs---threats.html

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Socio-economic vulnerability analysis

As the climate changes, **ecosystem services** come under threat. These threats can affect people's **livelihoods** and **well-being.**

We want to know how vulnerable people are to changes in ecosystem services

Sustainable Livelihoods Frameworks (SLFs) provide a structured way to assess people's vulnerability with a focus on poverty

https://www.shareweb.ch/site/Poverty-Wellbeing/resources/Documents/
L.D. Bhatta, B.E.H. van Oort, N.E. Stork, H. Baral, Ecosystem services and livelihoods in a changing climate: Understanding local adaptations in the Upper Koshi, Nepal, International Journal of Biodiversity Science, Ecosystem Services & Management 11(2) (2015) 145-155.

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What are livelihoods

Livelihoods is the assets, capabilities, and activities that we have available to us to make a living.

The livelihoods strategies we implement do not only generate income but include many other elements, like social assets

Livelihoods are sustainable when they can cope with, and recover from, stresses and shocks and maintain or enhance their capabilities and assets both now and in the future, while not undermining the natural resource base

https://www.shareweb.ch/site/Poverty-Wellbeing/resources/Documents/
L.D. Bhatta, B.E.H. van Oort, N.E. Stork, H. Baral, Ecosystem services and livelihoods in a changing climate: Understanding local adaptations in the Upper Koshi, Nepal, International Journal of Biodiversity Science, Ecosystem Services & Management 11(2) (2015) 145-155.

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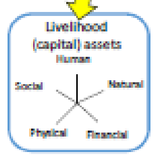
Sustainable Livelihoods Framework

Often used as indicators in assessing adaptive capacity



Natural capital: the natural resource stocks that people can draw on for their livelihoods, e.g. the ocean and fish

Human capital: the skills, knowledge, and the ability to work and to be in good health

Social capital: the social resources that people draw on to make a living, e.g. relationships or membership of groups or organisations.

Physical capital: the basic infrastructure that people need to make a living, e.g. boats, communication systems, and fuel

Financial capital: savings, in whichever form, e.g. access to financial services, and regular inflows of money

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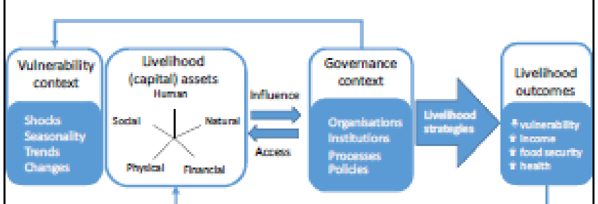
Sustainable Livelihoods Framework

Analytical approach
There are many different analytical approaches!!!



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Just reminder that there are many different ways to do vulnerability analysis

Vulnerability analysis is not a single or standard measurement system
Many methodologies have been applied
Conducted at different levels

- Household
- Individual
- Community
- Within a livelihood zone
- Administrative zone
- National or global level

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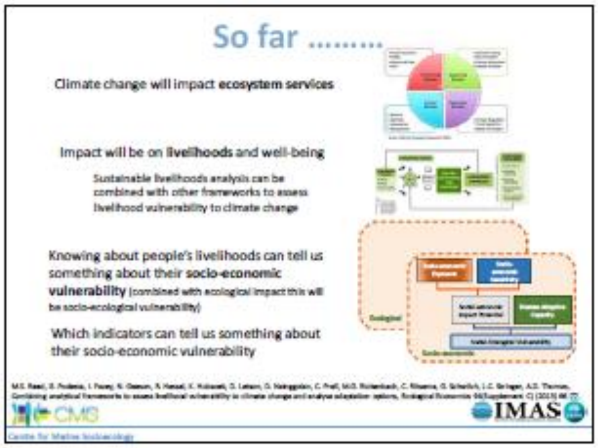
So far ....
Climate change will impact ecosystem services
Impact will be on livelihoods and well-being
Sustainable livelihoods analysis can be combined with other frameworks to assess livelihood vulnerability to climate change
Knowing about people's livelihoods can tell us something about their socio-economic vulnerability (combined with ecological impact this will be socio-ecological vulnerability)
Which indicators can tell us something about their socio-economic vulnerability
Ecological
Socio-economic
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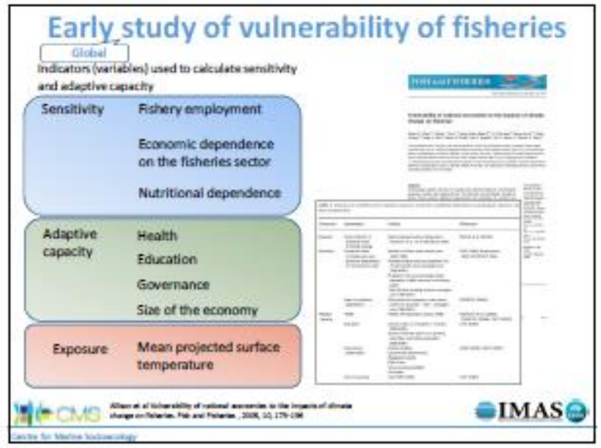
Early study of vulnerability of fisheries
Global
Indicators (variables) used to calculate sensitivity and adaptive capacity
Sensitivity
Fishery employment
Economic dependence on the fisheries sector
Nutritional dependence
Adaptive capacity
Health
Education
Governance
Size of the economy
Exposure
Mean projected surface temperature
Allison et al Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries , 2009, 10, 173–196
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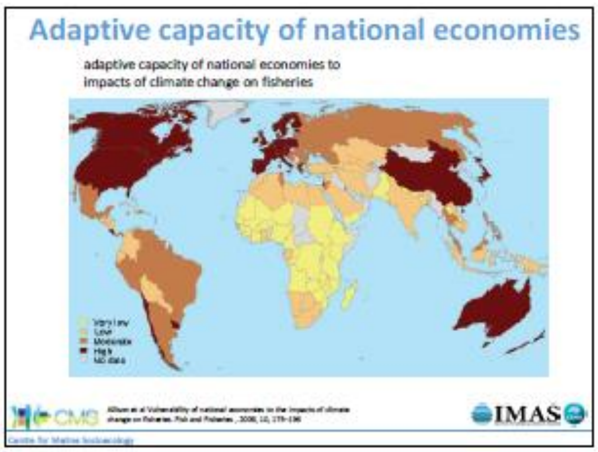
Adaptive capacity of national economies
adaptive capacity of national economies to impacts of climate change on fisheries
Very low
Low
Moderate
High
NO data
Allison et al Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries , 2009, 10, 173–196
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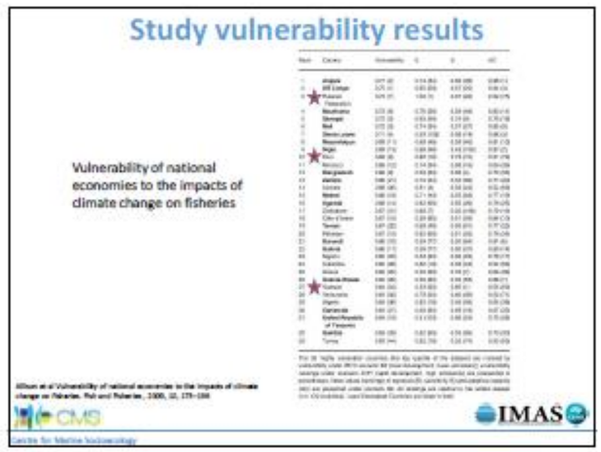
Study vulnerability results
Vulnerability of national economies to the impacts of climate change on fisheries
Allison et al Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries , 2009, 10, 173–196
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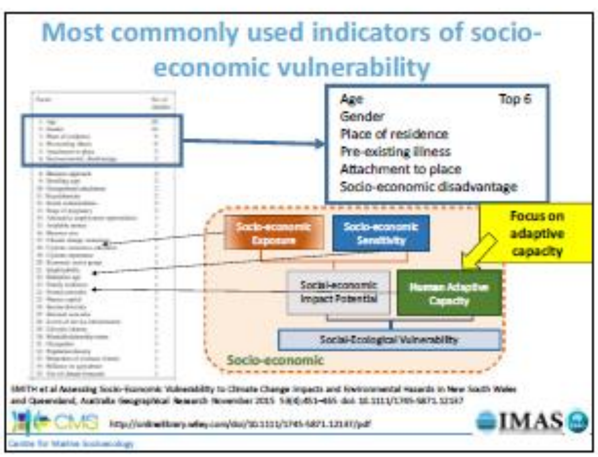
Most commonly used indicators of socio-economic vulnerability
Age
Top 6
Gender
Place of residence
Pre-existing illness
Attachment to place
Socio-economic disadvantage
Socio-economic Exposure
Socio-economic Sensitivity
Focus on adaptive capacity
Social-economic Impact Potential
Human Adaptive Capacity
Social-Ecological Vulnerability
Socio-economic
SMITH et al Assessing Socio-Economic Vulnerability to Climate Change Impacts and Environmental Hazards in New South Wales and Queensland, Australia Geographical Research November 2015 54(4):451–465 doi: 10.1111/1745-5871.12147
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http://onlinelibrary.wiley.com/doi/10.1111/1745-5871.12147/pdf
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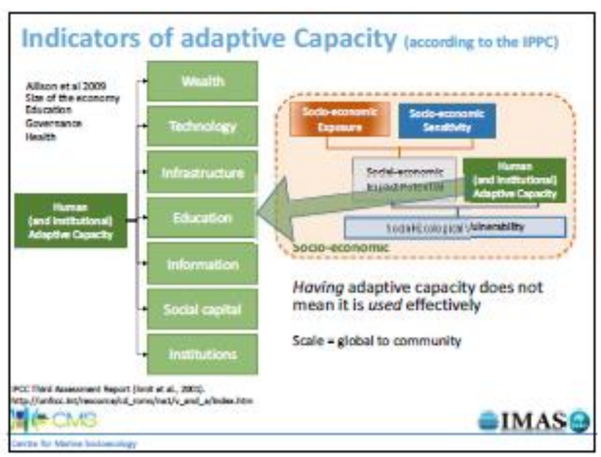
Indicators of adaptive Capacity (according to the IPPC)
Allison et al 2009
Size of the economy
Education
Governance
Health
Wealth
Technology
Infrastructure
Education
Information
Social capital
Institutions
Human (and Institutional) Adaptive Capacity
Socio-economic Exposure
Socio-economic Sensitivity
Social-economic Impact Potential
Human (and Institutional) Adaptive Capacity
Social-Ecological Vulnerability
Socio-economic
Having adaptive capacity does not mean it is used effectively
Scale = global to community
IPCC Third Assessment Report (Smit et al., 2001).
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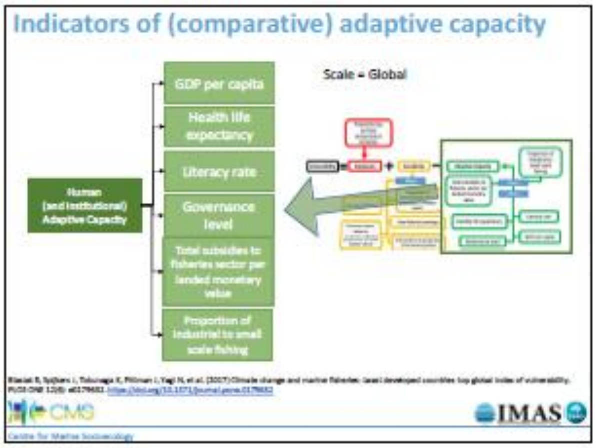
Indicators of (comparative) adaptive capacity
Scale = Global
Human (and Institutional) Adaptive Capacity
GDP per capita
Health life expectancy
Literacy rate
Governance level
Total subsidies to fisheries sector per landed monetary value
Proportion of industrial to small scale fishing
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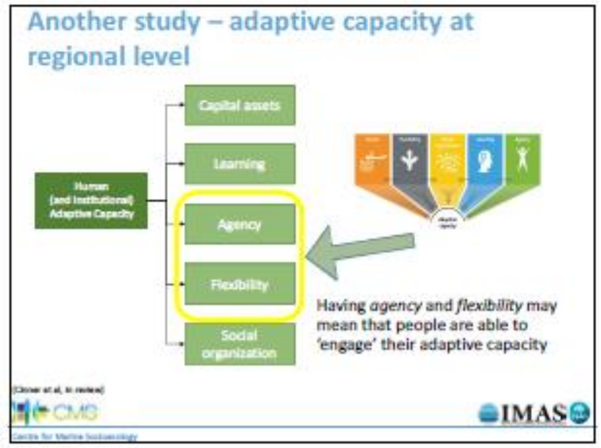
Another study – adaptive capacity at regional level
Human (and Institutional) Adaptive Capacity
Capital assets
Learning
Agency
Flexibility
Social organization
Having agency and flexibility may mean that people are able to 'engage' their adaptive capacity
(Cinner et al, in review)
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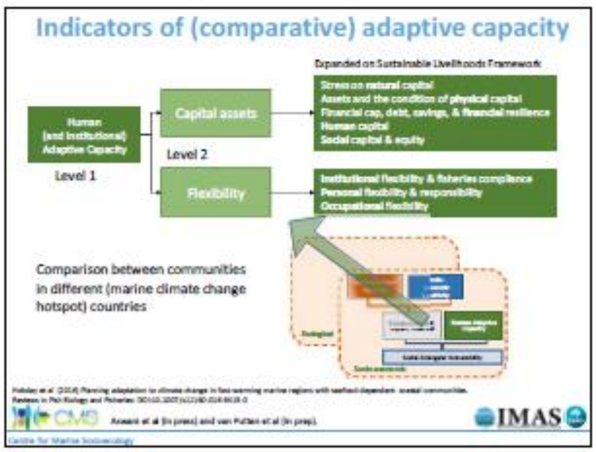
Indicators of (comparative) adaptive capacity
Expanded on Sustainable Livelihoods Framework
Human (and Institutional) Adaptive Capacity
Level 1
Level 2
Capital assets
Flexibility
Stress on natural capital
Assets and the condition of physical capital
Financial cap, debt, savings, & financial resilience
Human capital
Social capital & equity
Institutional flexibility & fisheries compliance
Personal flexibility & responsibility
Occupational flexibility
Comparison between communities in different (marine climate change hotspot) countries
Aswani et al (in press) and van Putten et al (in prep).
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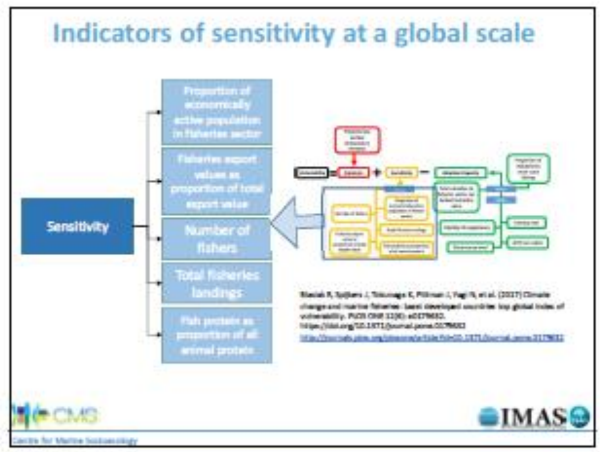
Indicators of sensitivity at a global scale
Sensitivity
Proportion of economically active population in fisheries sector
Fisheries export values as proportion of total export value
Number of fishers
Total fisheries landings
Fish protein as proportion of all animal protein
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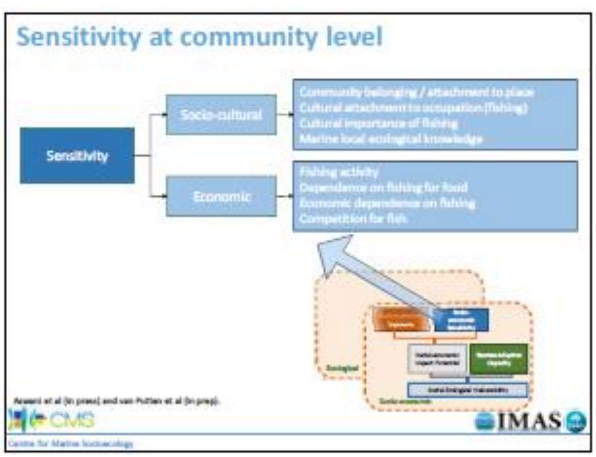
Sensitivity at community level
Sensitivity
Socio-cultural
Economic
Community belonging / attachment to place
Cultural attachment to occupation (fishing)
Cultural importance of fishing
Marine local ecological knowledge
Fishing activity
Dependence on fishing for food
Economic dependence on fishing
Competition for fish
Aswani et al (in press) and van Putten et al (in prep).
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Psychology matters in both sensitivity and adaptive capacity
Perception of risk
The ability to cope with change (mental health)
Level of interest in change
Attachment to place
IUCN
A Framework for Social Adaptation to Climate Change
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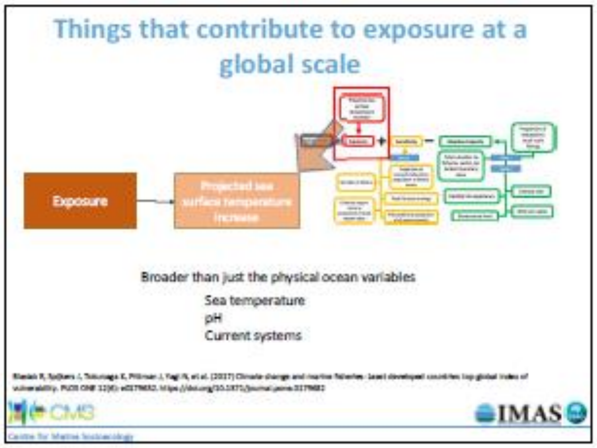
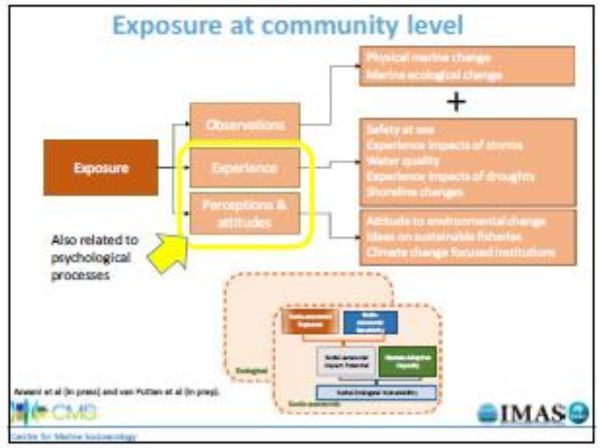
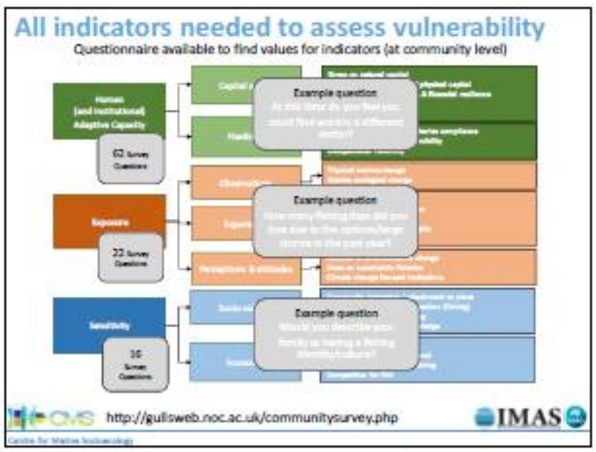

Things that contribute to exposure at a global scale
Exposure
Projected sea surface temperature increase
Broader than just the physical ocean variables
Sea temperature
pH
Current systems
IMAS


Exposure at community level
Exposure
Observations
Experience
Perceptions & attitudes
Physical marine change
Marine ecological change
+
Safety at sea
Experience impacts of storms
Water quality
Experience impacts of droughts
Shoreline changes
Attitude to environmental change
Ideas on sustainable fisheries
Climate change focused institutions
Also related to psychological processes
Aswani et al (in press) and van Putten et al (in prep).
IMAS


All indicators needed to assess vulnerability
Questionnaire available to find values for indicators (at community level)
Human (and institutional) Adaptive Capacity
62 Survey Questions
Exposure
22 Survey Questions
Sensitivity
16 Survey Questions
Example question
Example question
Example question
http://gullsweb.noc.ac.uk/communitysurvey.php
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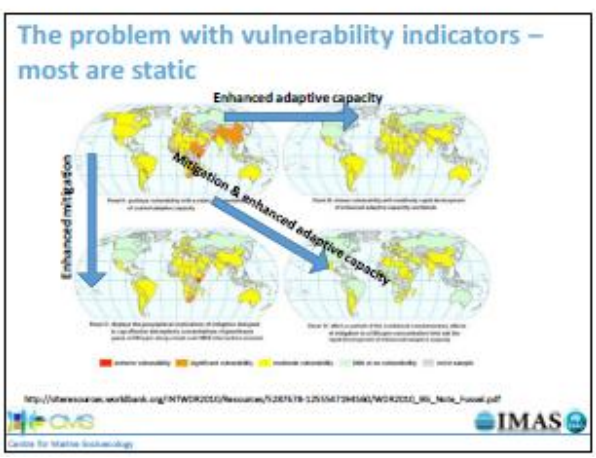
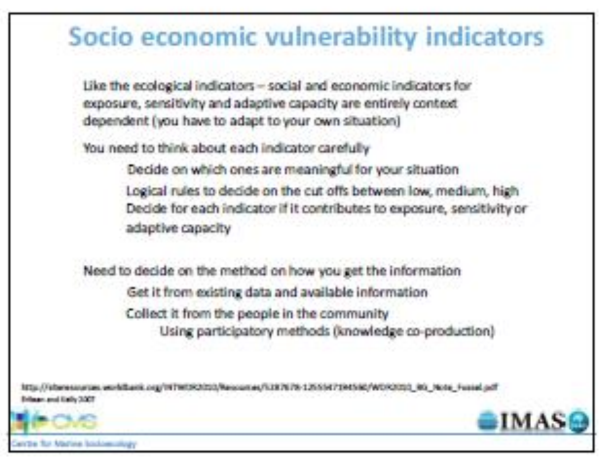
The problem with vulnerability indicators – they need weighting
Weighting different indicators plays a critical role in quantifying vulnerability to natural disasters.
The individual measures need to be weighted according to their relative importance.
Weighting can be done through statistical or participatory approaches
Differential weighting has been criticized for being too subjective but equal weighting is just as subjective
High correlation between indicators might introduce implicit weighting in an equal weighting scheme
Huang 2018 Comprehensive Geographic Information Systems. Elsevier
IMAS


The problem with vulnerability indicators – most are static
Enhanced adaptive capacity
Enhanced mitigation
Mitigation & enhanced adaptive capacity
IMAS


Socio economic vulnerability indicators
Like the ecological indicators – social and economic indicators for exposure, sensitivity and adaptive capacity are entirely context dependent (you have to adapt to your own situation)
You need to think about each indicator carefully
Decide on which ones are meaningful for your situation
Logical rules to decide on the cut offs between low, medium, high
Decide for each indicator if it contributes to exposure, sensitivity or adaptive capacity
Need to decide on the method on how you get the information
Get it from existing data and available information
Collect it from the people in the community
Using participatory methods (knowledge co-production)
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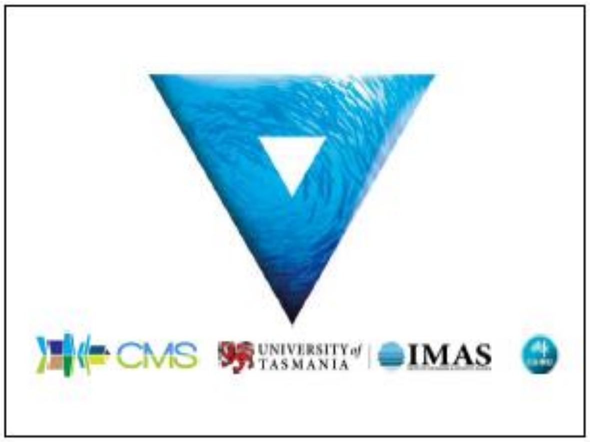
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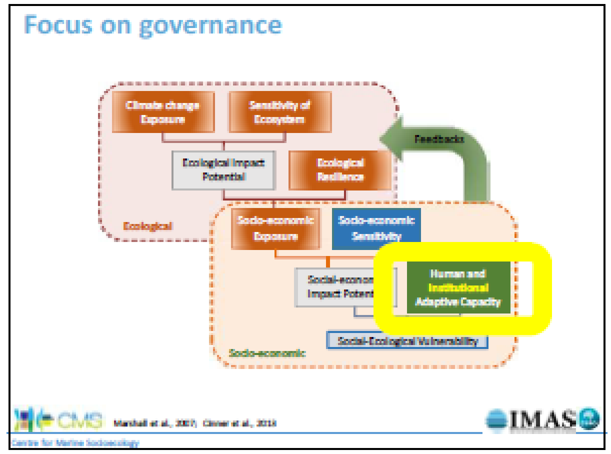
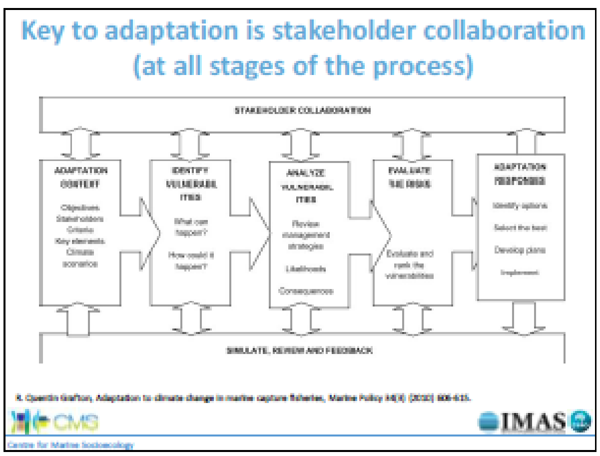
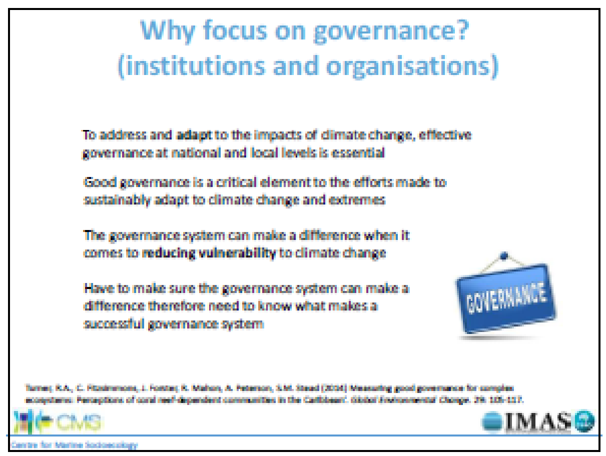
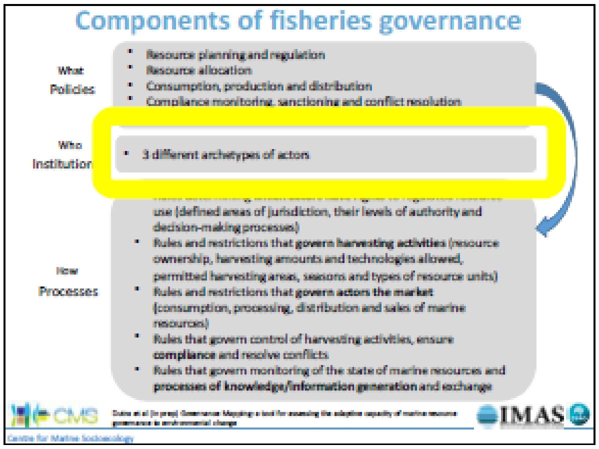
Session 8: Governance and supply chain assessment

Ingrid Van Putten
Commonwealth Scientific and Industrial Research Organisation (CSIRO)








Components of fisheries governance
What
Policies
Resource planning and regulation
Resource allocation
Consumption, production and distribution
Compliance monitoring, sanctioning and conflict resolution
Who
Institution
3 different archetypes of actors
use (defined areas of jurisdiction, their levels of authority and decision-making processes)
Rules and restrictions that govern harvesting activities (resource ownership, harvesting amounts and technologies allowed, permitted harvesting areas, seasons and types of resource units)
How
Processes
Rules and restrictions that govern actors the market (consumption, processing, distribution and sales of marine resources)
Rules that govern control of harvesting activities, ensure compliance and resolve conflicts
Rules that govern monitoring of the state of marine resources and processes of knowledge/information generation and exchange
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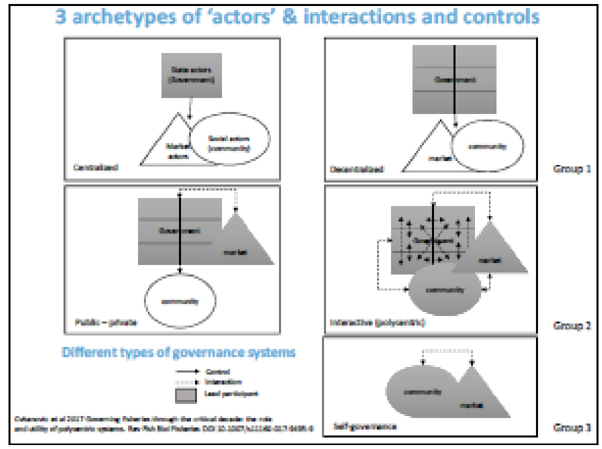
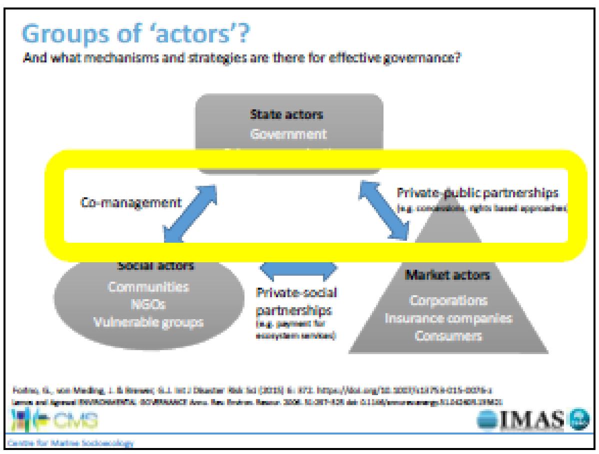

3 archetypes of 'actors' & interactions and controls
Centralised
Decentralised
Group 1
Government
market
community
Public – private
Interactive (polycentric)
Group 2
Different types of governance systems
Control
Interaction
Lead participant
Self-governance
Group 3


Groups of 'actors'?
And what mechanisms and strategies are there for effective governance?
State actors
Government
Co-management
Private-public partnerships
Social actors
Communities
NGOs
Vulnerable groups
Private-social partnerships
Market actors
Corporations
Insurance companies
Consumers
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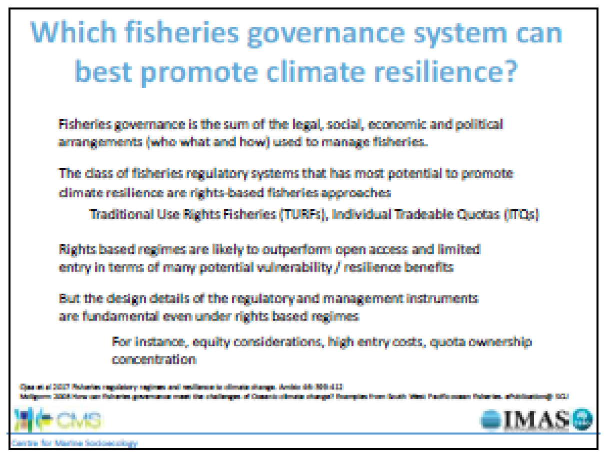
Which fisheries governance system can best promote climate resilience?
Fisheries governance is the sum of the legal, social, economic and political arrangements (who what and how) used to manage fisheries.
The class of fisheries regulatory systems that has most potential to promote climate resilience are rights-based fisheries approaches
Traditional Use Rights Fisheries (TURFs), Individual Tradeable Quotas (ITQs)
Rights based regimes are likely to outperform open access and limited entry in terms of many potential vulnerability / resilience benefits
But the design details of the regulatory and management instruments are fundamental even under rights based regimes
For instance, equity considerations, high entry costs, quota ownership concentration
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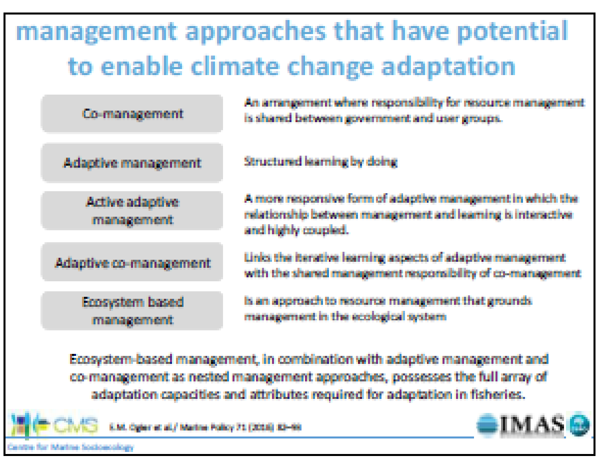
management approaches that have potential to enable climate change adaptation
Co-management
An arrangement where responsibility for resource management is shared between government and user groups.
Adaptive management
Structured learning by doing
Active adaptive management
A more responsive form of adaptive management in which the relationship between management and learning is interactive and highly coupled.
Adaptive co-management
Links the iterative learning aspects of adaptive management with the shared management responsibility of co-management
Ecosystem based management
Is an approach to resource management that grounds management in the ecological system
Ecosystem-based management, in combination with adaptive management and co-management as nested management approaches, possesses the full array of adaptation capacities and attributes required for adaptation in fisheries.
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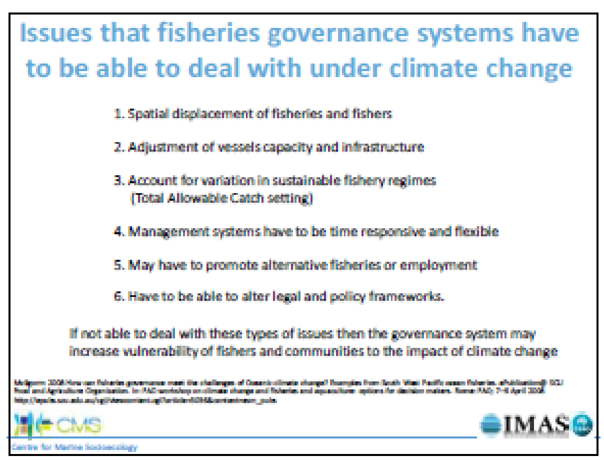
Issues that fisheries governance systems have to be able to deal with under climate change
1. Spatial displacement of fisheries and fishers
2. Adjustment of vessels capacity and infrastructure
3. Account for variation in sustainable fishery regimes (Total Allowable Catch setting)
4. Management systems have to be time responsive and flexible
5. May have to promote alternative fisheries or employment
6. Have to be able to alter legal and policy frameworks.
If not able to deal with these types of issues then the governance system may increase vulnerability of fishers and communities to the impact of climate change
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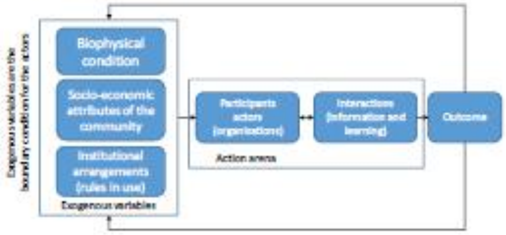
Formal approach to assess governance systems
(or the capacity to adapt)

The Institutional Analysis and Development (IAD) framework adjusted for governance analysis



http://www.nature.com/nclimate/journal/v6/n4/fig_tab/nclimate2966_F1.html?foxtrotcallback=true

Critical governance capacities

Good governance of fisheries, which is critical to building their adaptive capacity and social-ecological resilience, is very important in the context of climate change, and it involves

1. Learning orientation
2. Capacity to cope with complexity and uncertainty
3. Long term focus
4. Ecosystem focus.
5. Integration of multiple sectors and scales.
6. Monitoring and review capability, and
7. Enhanced stakeholder engagement and empowerment.

E.M. Ogier et al./ Marine Policy 71 (2016) 82–93

Generic indicators to assess governance systems
Within the action arena

- Resources
- Fair governance
- Learning capacity

— With subgroups

- Room for autonomous change
- Variety
- Leadership
- Institutional linkages
- Effective decision making

Depending on how well you do for each of these indicators will impact overall community vulnerability

See Ostrom et al (1994) Rules, games, & common pool resources. The University of Michigan Press, Ann Arbor

Indicators that support climate adaptation

M. Howes, Indicators of governance and the 'ability to achieve', in review

Checklist to guide reform and assess progress towards a climate-ready marine future

If the alignment of policy and management is not compatible with responses, then preconditioning changes must first occur

Future proofing activities can be widely initiated after pre-conditioning. These activities are generally implemented by single agencies guided by the higher order policies.

Transformational opportunities where the benefits of action result in even greater feedback and reinforcement of the benefits are particularly important, and will require sustained effort to achieve.

Creighton et al in press *Adapting Management of Marine Environments to a Changing Climate: A Checklist to Guide Reform and Assess Progress*

Resources for governance analysis

Governance (fisheries) will need adaptive capacity to address climate change.

Indicators available that can tell you if the system has that adaptive capacity

Preferably adaptation should be anticipatory rather than reactive.

Surveys (for experts) are available from 'IndiSeas' to assess the effectiveness and efficiency of management, and quality of governance

http://www.indiseas.org/more-information/human-dimension-indicators

Group discussion

Which organisational stakeholders (public- private- civil) are key to adaptation planning in your country?

What are the main institutional and/or organisational constraints to adapting to climate change in the marine environment (i.e. compliance or resources)?

What actions or institutional changes would you propose to overcome these constraints

Climate effects on supply chains

Fishing relies on supply chains for delivery of seafood to consumers – global product

Climate impacts will not stop at the fishers but will impact all the people who receive, trade, transport, process, and consume the fish

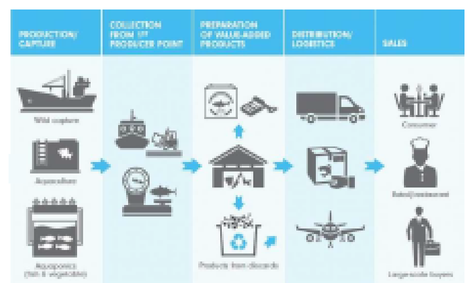
Vulnerability assessments have to ensure the knock on effects of climate on the fishing sector are also considered

This is why **supply chains** have to be analysed in conjunction with the harvest sector

What is a (fisheries) supply chain?

The people, businesses, and organisations involved in getting fish from the people who catch the fish to the consumer

Many ways to depict a (fisheries) supply chain



Manta consulting Inc 2013

Examples of climate impact pathways

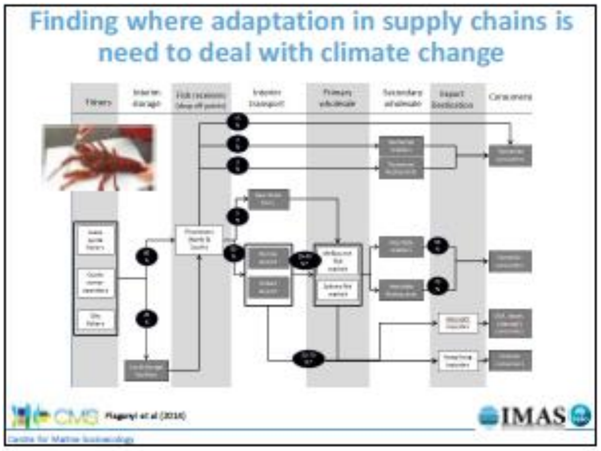
Inputs & services	Production	Trade and transport	Processing	Marketing
Danger to boat crew and fishers	Lower growth rates	Trade routes become impassable	Post harvest losses	Supply scarcity & price increases
Exposure of gear to extreme weather and winds	Water temperature	Untimely & irregular transport	Increased variability in supply	
	Less predictable seasonality		Processing infrastructure affected by unpredictable weather	

Adaptation in fisheries supply chains to deal with climate impact

Need to consider adaptation in critical nodes in supply chain to cope with climate change

Some supply chains are more vulnerable than others to climate shocks

Diversify supply chains to build resilience ($)


Finding where adaptation in supply chains is need to deal with climate change
Plagányi et al (2014)
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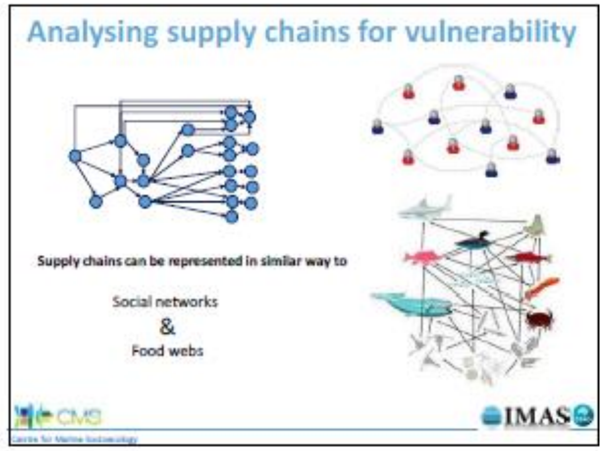
Analysing supply chains for vulnerability
Supply chains can be represented in similar way to
Social networks
&
Food webs
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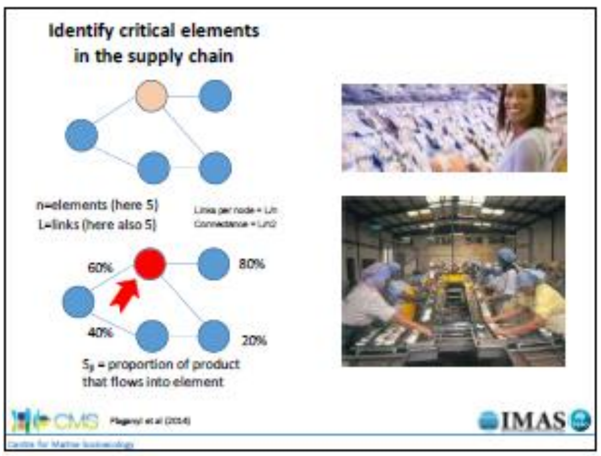
Identify critical elements in the supply chain
n=elements (here 5)
L=links (here also 5)
60%
80%
40%
20%
S_{ij} = proportion of product that flows into element
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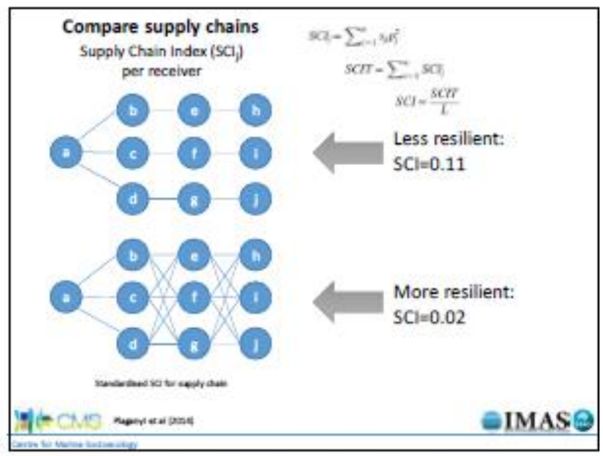
Compare supply chains
Supply Chain Index (SCI_j) per receiver
Less resilient:
SCI=0.11
More resilient:
SCI=0.02
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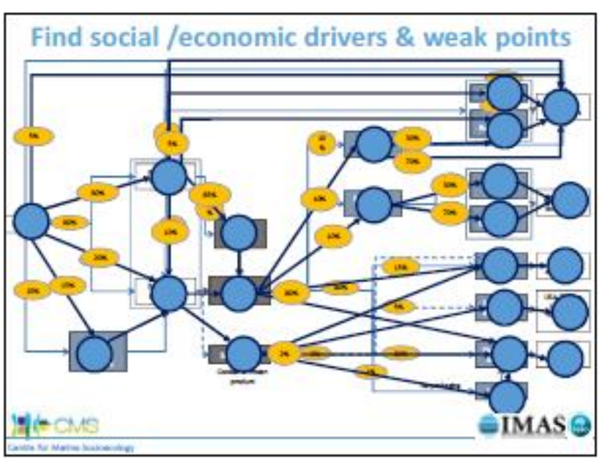
Find social /economic drivers & weak points
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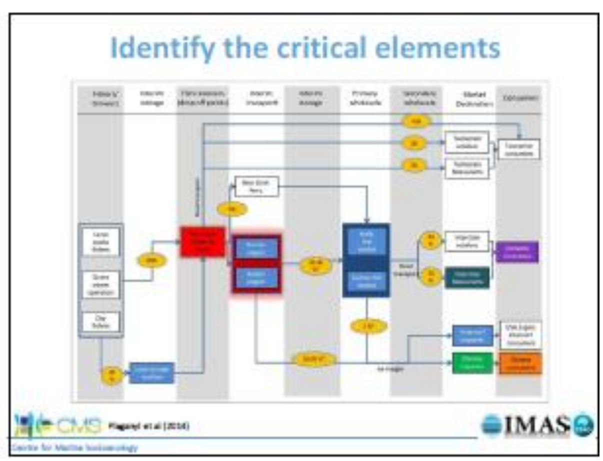
Identify the critical elements
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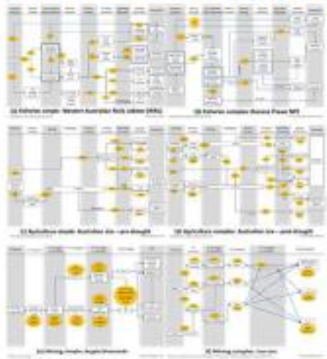
Compare different supply chains



Lim-Camacho et al (2017)

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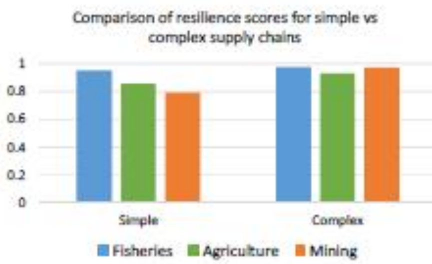
Complex supply chains more resilient

But not economically "optimal"



Lim-Camacho et al (2017)

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Group discussion

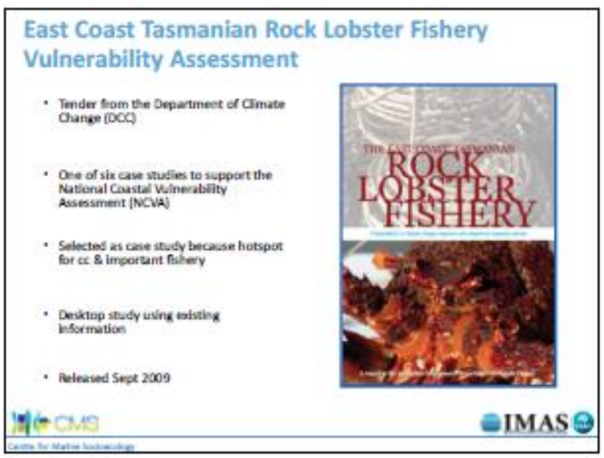
How do small scale fishery supply chains differ from large scale industrial fisheries?

Is vulnerability assessment for SSF supply chains useful?

How to deal with informal trade

Session 9: Communicating vulnerability assessments

Gretta Pecl[1] and Ingrid Van Putten[2]
[1]Institute for Marine and Antarctic Studies – University of Tasmania, [2]Commonwealth Scientific and Industrial Research Organisation (CSIRO)



Learning 2: Consider engagement as your number 1 priority (or pretty close to it)

- 80% of fishers thought climate change was not real
- Getting them engaged:
  - ASK how they want to be involved
  - Give stakeholders a clear role to play and a something to contribute – *from the start*
- Keeping them engaged:
  - Feedback (when & how THEY want it)
  - Highlight short-term wins as well as those further into the future
  - Avoid despair if you can – present 'packageable solutions'

Learning 3: Present adaptation/vulnerability assessment as an opportunity

- Adaptation is about IMPROVING what you do – create the vision
  - Give a concrete example at the start
  - Highlight that they ALREADY 'do' adaptation
- Consider what is of importance to that sector/group
  - Fishers – succession, fuel prices, *Centrostephanus*
  - Manager – comprehensive assessment

Key rock lobster lessons learned....

- Don't underestimate the time interdisciplinary and participatory research takes to do properly
- Consider engagement as your number one priority
- Present adaptation and vulnerability assessment as opportunities – what's in it for them?

Communicating climate change and vulnerability

The key points or findings need to be delivered very early and it needs to be concise but acknowledge what is not known or missing

https://www.forbes.com/sites/marshallshepherd/2016/11/22/9-tips-for-communicating-science-to-people-who-are-not-scientists/

Why is climate change so challenging to communicate?

Six psychological challenges posed by climate change to the human moral judgement system

Abstract and complex

Climate change is tough to understand

The blamelessness of unintentional action

Nobody is intentionally heating the atmosphere on purpose – so we are blameless

Guilty bias

We're all somewhat to blame for climate change. To avoid feeling guilt, shame, and regret

Uncertainty breeds wishful thinking:

The lack of definitive prognoses results in unreasonable optimism

Moral tribalism:

The politicization of climate change fosters ideological polarization which puts us off

Long time horizons and far away places

Climate victims are seen as Other, and we don't deal with the Other very well.

http://grist.org/article/why-climate-change-doesnt-spark-moral-outrage-and-how-it-could/

Communication strategies

Table 2 | Six psychological strategies that communicators can use to bolster the recognition of climate change as a moral imperative.

Use existing moral values
Frame climate change using more broadly held values that appeal to untapped demographics

Burdens versus benefits
Focus messaging on the costs, not benefits, that we may impose on future generations

Emotional carrots, not sticks
Motivate action through appeals to hope, pride and gratitude rather than guilt, shame and anxiety

Be wary of extrinsic motivators
Pushing action on climate change as 'good business' may backfire

Expand group identity
Increase identification with and empathy for future generations and people living in other places

Highlight positive social norms
Leverage human susceptibility to social influence and approval

http://grist.org/article/why-climate-change-doesnt-spark-moral-outrage-and-how-it-could/

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Basic principles

https://coast.noaa.gov/data/digitalcoast/pdf/psychology-climate-change-communication.pdf

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9 Tips For Communicating Science To People Who Are Not Scientists

1. Know your audience
2. Don't use jargon.
3. Get to the point.
4. Use analogies and metaphors
   weather is your mood, climate is your personality
   if you don't like the weather wait a few hours, if you don't like the climate move
5. Three points.
   keep message memorable, meaningful and miniature.
6. You are the expert.
   (a) Be confident because you are the expert, (b) Don't speculate or stretch if you don't know (say so), and (c) Reflect on what you want (or do not want) on the record days, months or years later and use that as a filter
7. Use social media.
8. "Popularizing" is ok.
9. Relate.
   The science communicator must keep this in mind and find ways to relate the message to the core values of the person or audience. For some that may be economics, faith, defense or curiosity.

https://www.forbes.com/sites/marshallshepherd/2016/11/22/9-tips-for-communicating-science-to-people-who-are-not-scientists/#5512fcd166ae

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Session 10: Group discussions

Gretta Pecl[1] and Ingrid Van Putten[2]
[1]Institute for Marine and Antarctic Studies – University of Tasmania, [2]Commonwealth Scientific and Industrial Research Organisation (CSIRO)

During the group discussion the APEC representatives acknowledged that climatic changes have been detected across APEC economies. Some climatic changes have greater impact on some economies that on others, but in general the most significant oceanic changes observed across the APEC economies were oceanic warming, ocean acidification, sea level rise, changes in upwelling systems, and frequency and intensity of extreme events.

There was a wide range of ecological impacts of Climate Change detected across APEC economies. However, the most common and significant were changes in distribution and abundance of species, changes in phenology, changes in species assemblages, changes in the habitat, and changes in the structure and function of ecosystems.

Impacts not only extend to the marine resources, but also to human populations that depend on such resources. Populations from all APEC economies have already been affected by climate change at different levels; some socio-economic impacts of Climate Change detected across APEC economies were changes in fisheries and aquaculture catch, damage of fisheries and aquaculture infrastructure, reduced income / unemployment, health, people in conditions of poverty are the most affected, and impacts on women are underestimated.

There was a consensus that Climate Vulnerability Assessments for Fisheries and Aquaculture are valuable tools than can be successfully applied to manage risks, minimise losses and maximise opportunities.

Implementation of the Exposure-Sensitivity-Adaptive capacity framework has several benefits; for instance, this approach is repeatable, adaptable, reliable, and can inform where to invest for research and adaptation.

The two components of the vulnerability assessment, i.e. ecological and social-economic, will allow a better understanding of the vulnerabilities of the systems of interest.

Conclusions of the third day

Jorge E. Ramos
Institute for Marine and Antarctic Studies-University of Tasmania

Asia-Pacific Economic Cooperation

APEC "International Workshop on ecological risk assessment of impacts of climate change on fisheries and Aquaculture resources"

Conclusions
Day 3, 27th October 2017

Jorge E. Ramos (jeramos@utas.edu.au)

- **Aquaculture climate vulnerability assessment**
  - Based on an examination of all stages and methods of the farming process, encompassing all basic farming and life-history stages
  - Source of information: scientists, experts from aquaculture industry, stakeholders, etc
  - Nine farming attributes that consider the degree of environmental control linked to broodstock availability and conditioning, spawning and fertilisation, larval and juvenile rearing, availability of alternative farm sites and systems, source of the food, diseases and pests

Risk = Sensitivity x Impact

- **Social and economic vulnerability**
- Climate change affects people's livelihoods and well-being through changes in ecosystem services
- Social and economic vulnerability assessments are used to know how vulnerable people are to climate change
- Needs to consider:
  - Multiple contexts
  - Temporal variability
  - Multiple scales and scale interdependencies
- **Vulnerability indicators and indices**
  - **Indicator:** a calculated value that can be used to describe the state and changes in the state
  - **Index:** a summary measure designed to capture some property (vulnerability, diversity, whatever) in a single number

- Sustainable Livelihoods Frameworks provide a structured way to assess people's vulnerability with a focus on poverty
- Vulnerability analysis can be conducted at different levels, e.g. household, individual, community, within a livelihood zone, administrative zone, national or global level
- Indicators of socio-economic vulnerability vary according to the level the analysis is conducted
- Problems with vulnerability indicators
  - Need to be weighted according to their relative importance
  - Differential weighting and equal weighting can be subjective
  - High correlation between indicators might introduce implicit weighting in an equal weighting scheme
  - Need to be adapted to each situation

- **Governance**
- To address and **adapt** to the impacts of climate change, effective governance at national and local levels is essential
- Stakeholder collaboration is key to adaptation
- Governance describes 1) who makes decisions, 2) what are their Powers and responsibilities, and 3) how are powers and responsibilities exercised
- Management approaches that have potential to enable climate change adaptation:
  - Co-management
  - Adaptive management
  - Active adaptive management
  - Adaptive co-management
  - Ecosystem based management
- Issues that fisheries governance systems have to be able to deal with under climate change:
  - Spatial displacement of fisheries and fishers
  - Adjustment of vessels capacity and infrastructure

  - Account for variation in sustainable fishery regimes (Total Allowable Catch setting)
  - Management systems have to be time responsive and flexible
  - May have to promote alternative fisheries or employment
  - Have to be able to alter legal and policy frameworks
- **Critical governance capacities**
  - Learning orientation
  - Capacity to cope with complexity and uncertainty
  - Long term focus
  - Ecosystem focus
  - Integration of multiple sectors and scales.
  - Monitoring and review capability
  - Enhanced stakeholder engagement and empowerment

- **Supply chains**
- People, businesses, and organisations involved in getting fish from the people who catch the fish to the consumer
- Climate impacts will not stop at the fishers but will impact all the people who receive, trade, transport, process, and consume the fish
- Some supply chains are more vulnerable than others to climate shocks; therefore it is key to identify critical elements in the supply chain
- Complex supply chains are more resilient but not economically optimal

- **Communicating Climate Change and Vulnerability**
- **Communication strategies:**
  - Use existing moral values
  - Burdens vs benefits
  - Motivate action through appeals of hope, pride and gratitude
  - Be wary of extrinsic motivators
  - Expand group identity
  - Highlight positive social norms
- **Communicating science to Not-scientists:**
  - Know your audience
  - Don't use jargon
  - Get to the point
  - Use analogies and metaphors
  - Keep message memorable, meaningful and miniature
  - You are the expert, be confident, don't speculate
  - Use social media
  - "Popularizing" is ok
  - Relate to the core values of the audience

Conclusions and final remarks

APEC representatives acknowledged that climatic changes have been detected across APEC economies. Some climatic changes have greater impact on some economies that on others, but in general the most significant oceanic changes observed across the APEC economies were:

- Oceanic warming
- Ocean acidification
- Sea level rise
- Changes in upwelling systems
- Frequency and intensity of extreme events

There was a wide range of ecological impacts of Climate Change detected across APEC economies. However, the most common and significant were:

- Changes in distribution and abundance of species
- Changes in phenology
- Changes in species assemblages
- Changes in the habitat
- Changes in the structure and function of ecosystems

Impacts not only extend to the marine resources, but also to human populations that depend on such resources. Populations from all APEC economies have already been affected by climate change at different levels; some socio-economic impacts of Climate Change detected across APEC economies were:

- Changes in fisheries and aquaculture catch
- Damage of fisheries and aquaculture infrastructure

- Reduced income / unemployment
- Health
- People in conditions of poverty are the most affected
- Impacts on women are underestimated

There was a consensus that Climate Vulnerability Assessments for Fisheries and Aquaculture are valuable tools than can be successfully applied to manage risks, minimise losses and maximise opportunities.

Implementation of the Exposure-Sensitivity-Adaptive capacity framework has several benefits; for instance, this approach is repeatable, adaptable, reliable, and can inform where to invest for research and adaptation.

The two components of the vulnerability assessment, i.e. ecological and social-economic, will allow a better understanding of the vulnerabilities of the systems of interest.

The **recommendations** that APEC economies representatives provided were:

1. Climate Vulnerability Assessments must be adapted and applied to the particular situations of each economy/region.
2. Implementation of Climate Vulnerability Assessments at different levels (e.g. species, industries, areas) will allow a better understanding of the risks of the systems of interest.
3. It is key to include socio-economic vulnerability assessments, as livelihoods in several economies are already being threatened by Climate Change.
4. It is necessary to encourage the closer and permanent collaboration between ecologists, economists and sociologists, and other human dimension experts.
5. It is crucial to involve actively the local communities and other stakeholders, in particular policy makers, for co-planning.
6. Climate Change must be communicated better at the policy level to facilitate its perception and implementation.

Closure remarks

Ladies and gentlemen, good afternoon. Time has passed so fast over the last few days at the APEC workshop. I know these days have been very productive; I´ve been speaking with some participants and the information that has been delivered and discussed have proved to be of great interest to all.

Climate change has a series of consequences with increasingly greater impacts that we have been able to detect over the last few years. For instance, oceanic warming has resulted in changes in species distributions and also in changes of the type of habitat. However, we seen that some resources can be resilient to such changes. We don´t fully understand the processes behind those changes nor how some marine resources can be resilient to them. Still, the capacity of those resources to resist or thrive under such conditions provides us with a window of opportunities. Therefore, we must be ready for the opportunities to come and this is why we are already working on this endeavour.

The changes in fish catch and aquaculture can not only affect the economy but also the livelihoods of people that depend on those resources. Peru has about 3000 kilometres of coast, an extended coastline that is inhabited by large human populations. Climatic changes and impacts on marine resources will affect the livelihoods of those people; hence we must be ready.

Considering the vulnerability of coastal communities and of marine resources we must actively address these changes, do the required research and improve the communication between scientists and stakeholders, including policy makers. Interactions amongst these actors must be closer, in real time, and with no limitation in terms of availability of information. This may allow policy makers to have a better understanding of the climate change reality.

I can only congratulate you for the work you have done and thank you for your effort and good will. I am confident that this effort will be fruitful for all the participant economies.

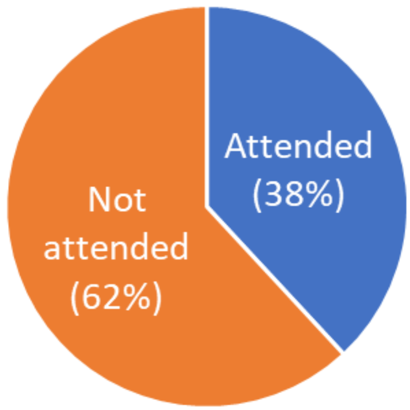
Once again, our must sincere appreciations and congratulations to you all. Thanks to the Ministry of Foreign Affairs of Peru for their hospitality. Have a safe and happy return to your countries, and I officially declare the closure of this APEC workshop.

Thank you.

Vice Admiral (r) Javier Gaviola Tejada
President of the Board of Directors of the Peruvian Marine Research Institute, IMARPE

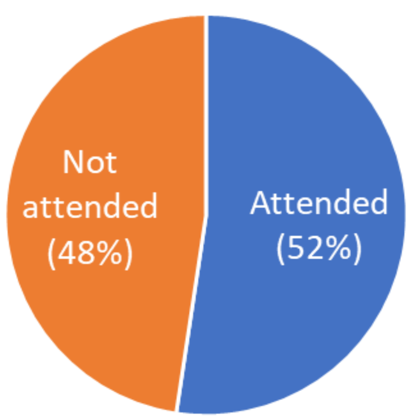
Indicators of monitoring and evaluation of the workshop

- **Indicator of selection, announcement and confirmation of participants:** A total of 21 APEC economies were invited of which 8 APEC economies attended the workshop.



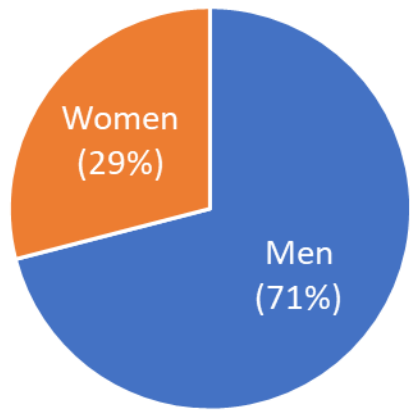
Ratio of number of confirmed economies attending the workshop over the number of invited economies.

- **Indicator of organization of the main event:** a total of 21 APEC economies representatives were invited to the workshop of which 11 APEC economies representatives attended. Malaysia, Papua New Guinea, Russia, Thailand, and Viet Nam were represented by one participant each. Chile, Indonesia, and Peru were represented by two participants each.



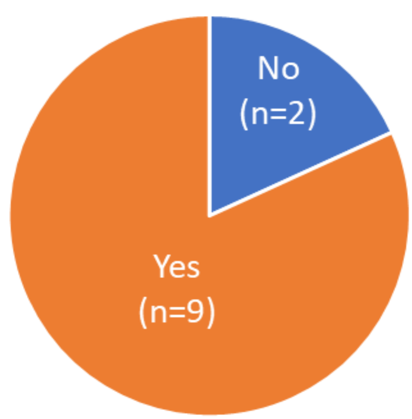
Ratio between the number of participants attending over the number of invited participants.

- **Indicator of gender:** 29% of women attending the workshop was comprised by 3 APEC economies representatives and 6 invited guests from Peru. The 71% of men attending the workshop was comprised by 8 APEC economies representatives and 14 invited guests from Peru. Two women were the expert speakers that led the workshop.

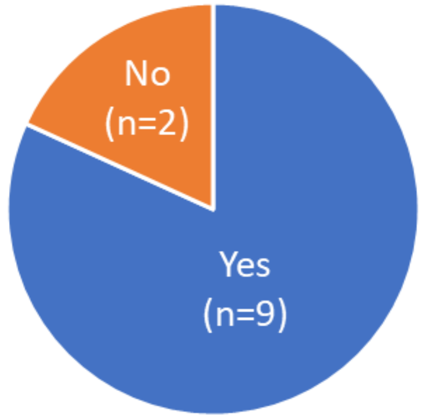


Percentage of women attending the workshop.

- **Indicators of outcomes:** The two APEC economies representatives that indicated that they would not specifically apply the ecological risk assessment of the impacts of climate change on their own fisheries and aquaculture resources suggested that they would advise others to conduct assessments under their guidance, or they would be part of a network of people conducting regional climate vulnerability assessments.



Number of APEC economies representatives who plan to replicate the workshop.



Number of APEC economies who plan to apply the ecological risk assessment of the impacts of climate change on their own fisheries and aquaculture resources.

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Appendix

I. Pictures

Opening ceremony. At the front table from left to right: Dimitri Gutiérrez (Project Overseer), Raúl Salazar Cosío (Minister of Foreign Affairs of Peru and APEC Senior Officer of Peru), Javier Gaviola Tejada (President of the Board of Directors of the Peruvian Marine Research Institute)

Official photo of the "APEC International Workshop on Ecological risk assessment of impacts of climate change on fisheries and aquaculture resources". 1. Min. Raúl Salazar, APEC Senior Officer of Peru; 2. Vice Admiral (r) Javier Gaviola, President of IMARPE; 3. Ingrid Van Putten; 4. Gretta Pecl; 5. Dimitri Gutiérrez; 6. Jorge Tam; 7. Javier Verastegui; 8. Melissa Montes; 9. Jorge E. Ramos; 10. Carlos Yván Romero; 11. Hendri Kurniawan; 12; Ana Alegre; 13. Elisa Goya; 14. Luis Escudero; 15. Christian Paredes; 16. Mónica Catrilao; 17. Jesús Rujel; 18. Tajuddin Idris; 19. Hans Jara; 20. Victor Aramayo; 21. Boonsong Sricharoendham; 22. Jhon Dionicio; 23. Abdul Razak Bin Abdul Rahman; 24. Nguyen Dang Kien; 25. Marco Ruiz; 26. Nicole Maturana; 27. Paul Kandu; 28. Vitaliy Samonov; 29. Juan Carlos Ernesto Fernández Johnston; 30. María Antonieta Paliza Huerta; 31. Frida Rodríguez; 32. Carlos Paulino; 33. Daniel Flores Castillo

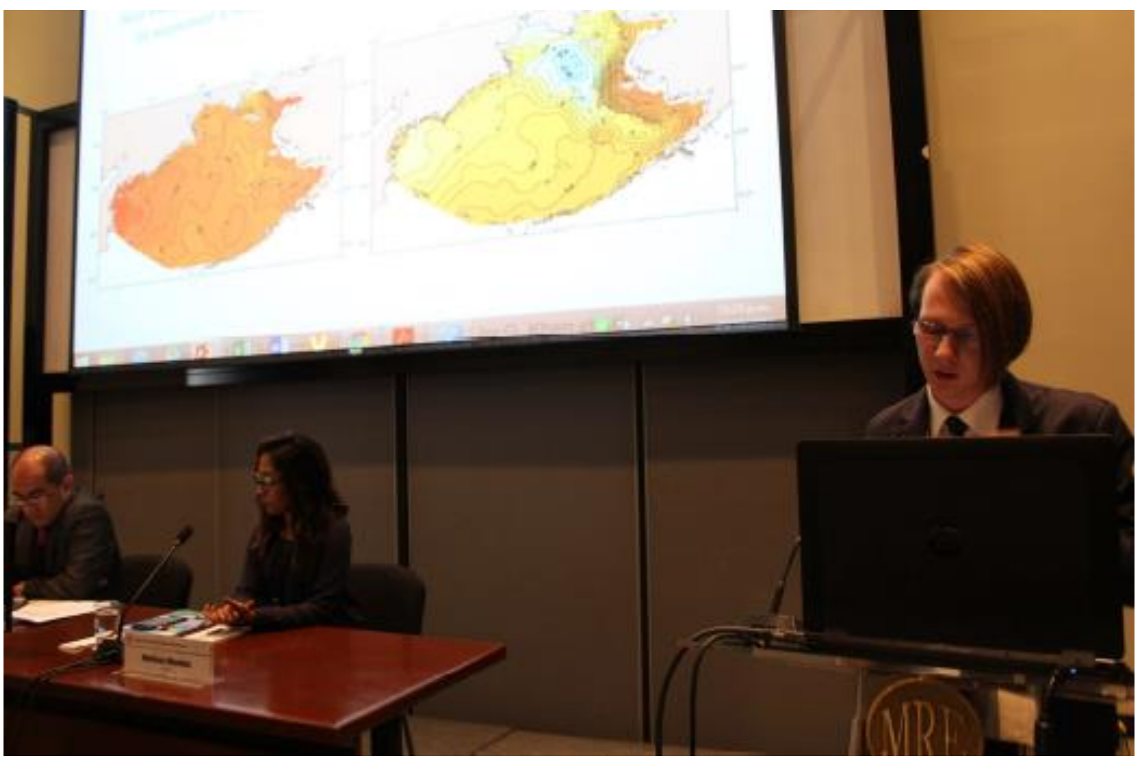
Dimitri Gutiérrez presenting an overview of the workshop

Tajuddin Idris presenting “The impacts of climate change on aquaculture in Indonesia”

Abdul Razak Bin Abdul Rahman presenting "The effects of climate change in fisheries and aquaculture resources in Malaysia"

Paul Kandu presenting "Impacts of climate variations on local fisheries and aquaculture resources in Papua New Guinea"

Jorge Tam presenting “Current knowledge of impacts of climate variations on local fisheries and aquaculture resources in Peru”



Vitalii Samonov presenting “Climate change and fish resources in the western Bering Sea”

Boonsong Sricharoendham presenting “The Effect of Climate Change on Fisheries and Aquaculture Resources in Thailand”

Nguyen Dang Kien presenting “The effect of climate change in fisheries and aquaculture resources in Viet Nam”

Gretta Pecl presenting "Climate Vulnerability Assessments"

Ingrid Van Putten presenting "Socio-Economic Vulnerability Assessments"

Christian Paredes during the questions session

Tajuddin Idris during the questions session

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