# Oceanographic Information as a Co-Benefit of Marine Renewable Energy Projects

## A case study of Japan's Ocean Current Power Project

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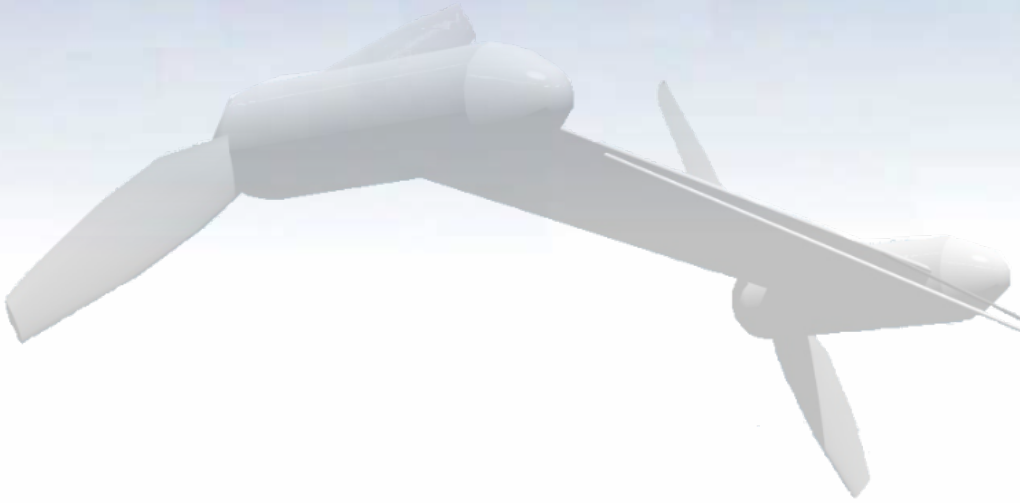

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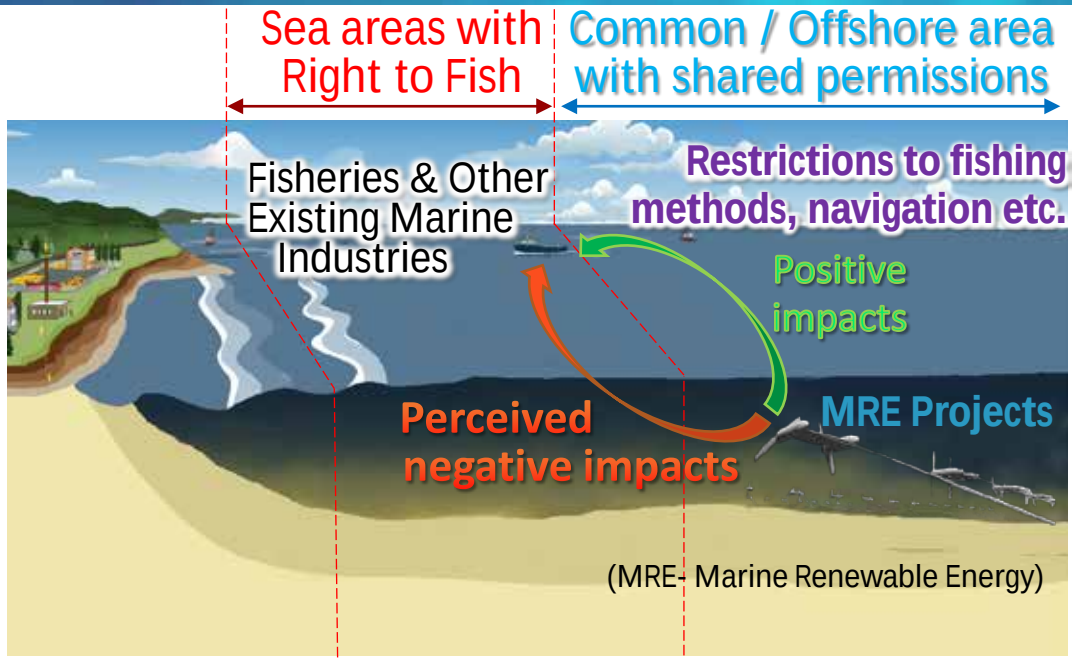
# Introduction

Research Background & Problem Identification

Research Hypothesis and Objectives

# Problem - Japan's MRE Projects & Acceptability

- Most MRE Projects will be deployed in the 'Common offshore sea areas'
  [Headquarters for Ocean Policy, (2013)]
- Existing regulations & industrial practices has to be adjusted in the 'offshore sea areas' [Sakaguchi (2015)]
- Fisheries are concerned about the potential **negative impacts**




- But not enough evidences on negative impacts to the fisheries
- The practical way to improve their acceptability is to create **positive impacts** out of these MRE projects

*Policy makers & project developers should search for ways to **create positive impacts** among local stakeholders to reduce the conflicting interests and to enhance the social acceptability of the power project.*

# Strategies to Create Positive Local Impacts

**Strategies used in previous projects or proposed in Literature**

- **Monetary compensation** ✓✓
- **Non Monetary incentives**
  - **Cheap/Free Electricity** ✓✓
  - **Co-location with Existing industries (Fisheries, Tourism etc. )** ✓✓
  - **Sharing Real time Oceanographic Information** ✓✓✓✓
- **Investment opportunities** ✓✓
- **Industry Amalgamation** ✓✓✓
- **Collaborative Decision Making** ✓

Source : RIOE(2013), IEA Wind (2013), Jobert et al., (2007),


- Incentives to stakeholders
- Sharing of co-benefits
- High stakeholder engagement
- Cost !∝ No. of beneficiaries

*à Essential for planning marine activities*

*à If the information can be **obtained** without having additional developments*

*à If the information can be **shared** among all relevant stakeholders*

*à Cost of **sharing** information is negligible due to existing ICT infrastructure*

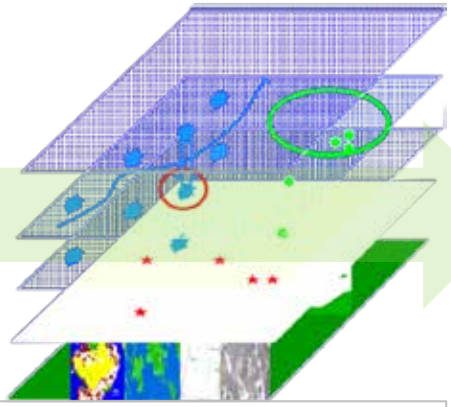
*Proposed 'Oceanographic information sharing' option satisfy all prerequisites but has not been analyzed empirically for MRE projects*

# Concept of the Proposed Information Sharing System

**Information Sources**

- Satellite Observation
- Ocean Monitoring platforms (GOOS, FINO, Argo & other buoys etc.)
- Dedicated monitoring Systems (VMS, AIS, Monitoring vessels etc.)
- User Specific ocean monitoring
- Offshore Power Plants

**Oceanographic Information**



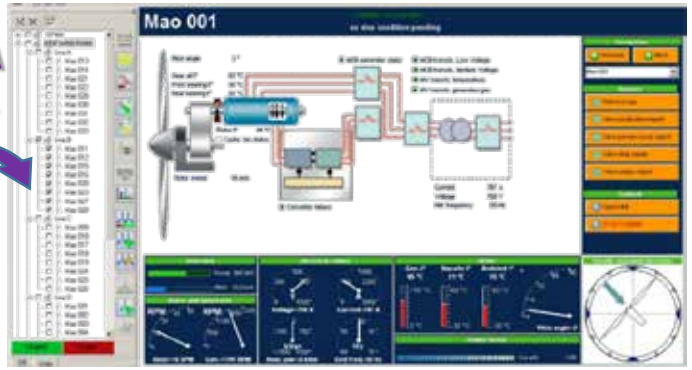
Data Processing & management layer

**Stakeholders**

- Fishery
- Shipping Authorities
- Env. Monitoring orgs.
- Researchers
- Tourism
- Coast Guard

co-benefit


Intended benefit




*SCADA system for power plant management*

*Source: DEIF wind power technology*

Source: IHI Corp, "**Power Generation Using Kuroshio Current**"

**Hypothesis - Stakeholders' information requirements can be fulfilled by the power plant's Condition Monitoring System (CMS)**

# Research Objective

Analyze the possibility of creating positive impacts among multiple stakeholders by an oceanographic information sharing scheme (taking Japanese Ocean Current Power project as a case study)

# Research Questions (R.Q.)

1. What oceanographic parameters are required by stakeholders?
2. What oceanographic parameters can be generated by the plant's CMS?
3. What is the expected incremental costs and benefits to the stakeholders?

Potential Demand

Potential Supply

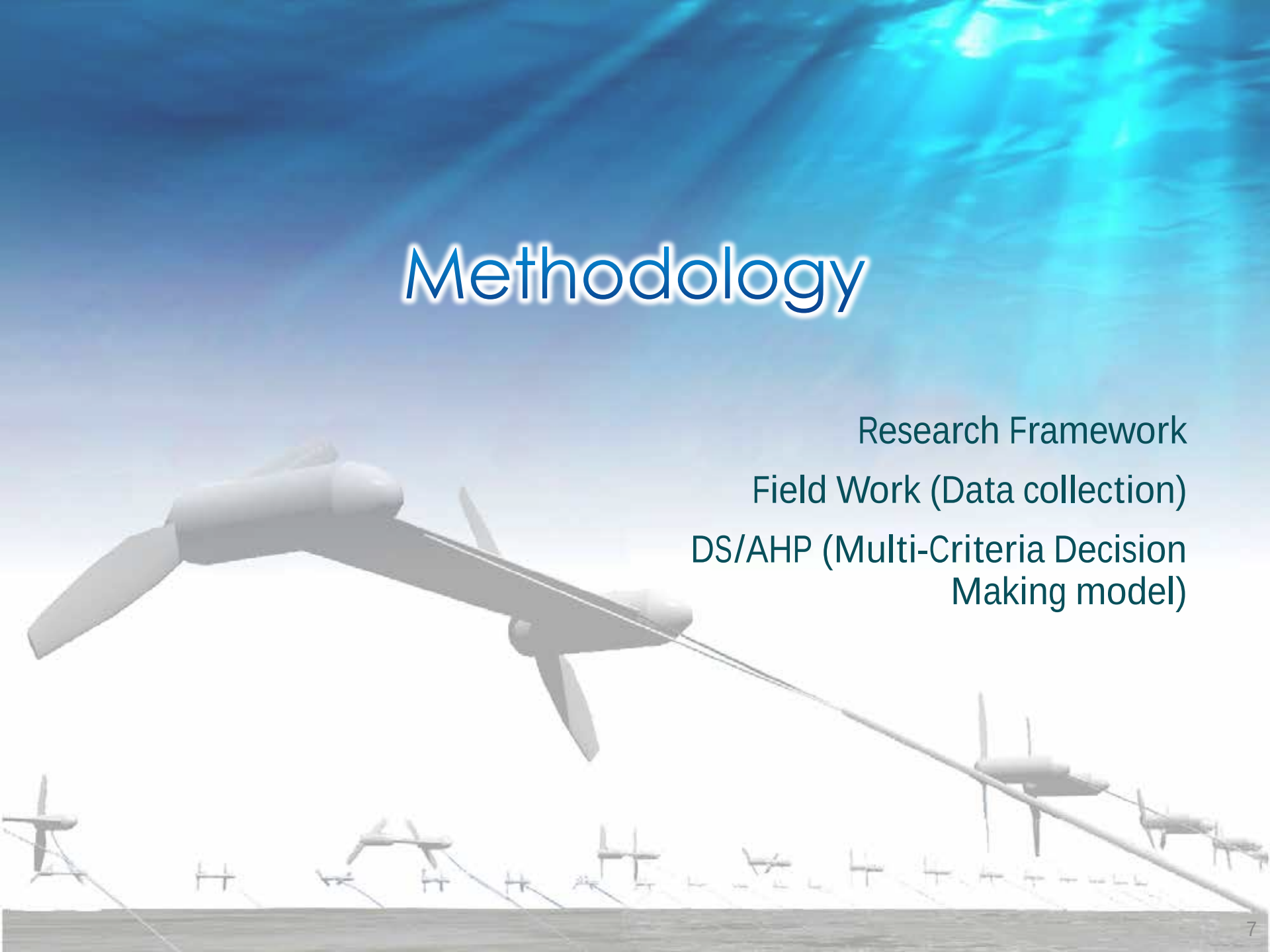
Feasibility

# Methodology

Research Framework

Field Work (Data collection)

DS/AHP (Multi-Criteria Decision Making model)



# Case study - Japan's Ocean Current Power (OCP) Project

- OCP Project à A demonstration research of an '*Underwater Floating Type Ocean Current Turbine System*' to generate electricity from the Kuroshio ocean current.

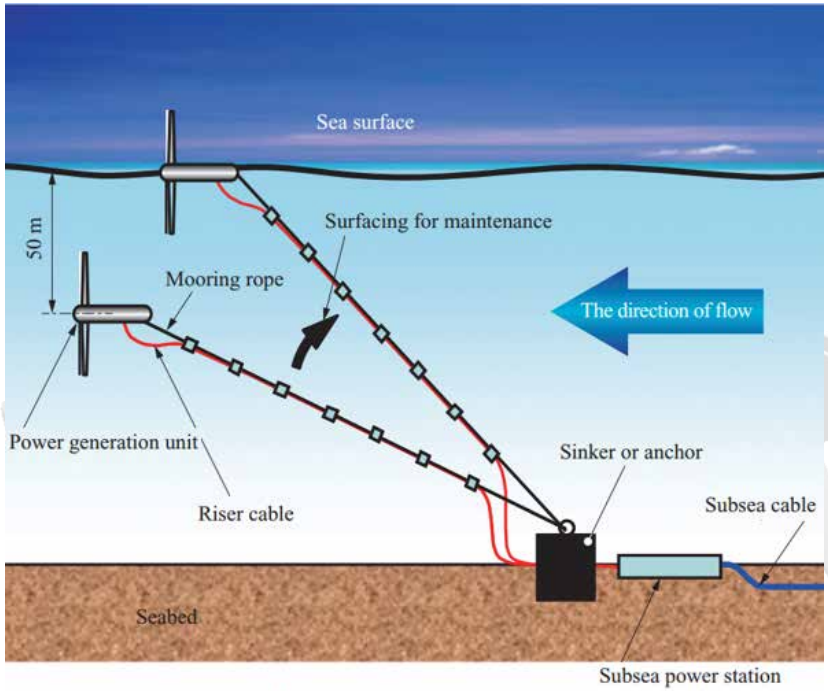
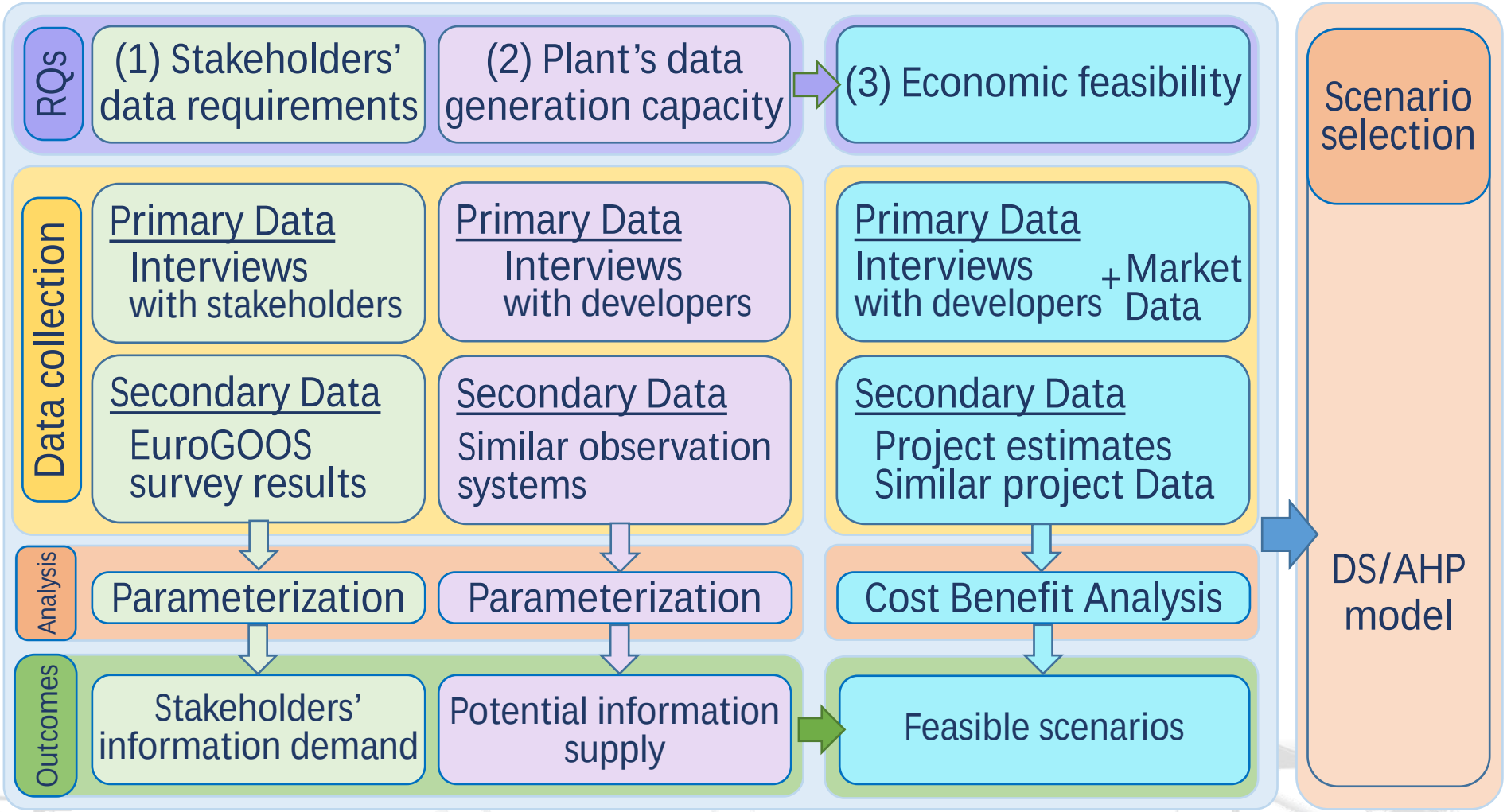



Diagram of floating type ocean current turbine system

Source:
IHI Corp,"**Power Generation Using the Kuroshio Current"[5]**


Source: Headquarters for Ocean Policy, Japan 2014

# Research Flow



# Data Collection

**Primary Data** – Key informant interviews and Focus group discussions with,

(n=Number of Key informants)

1. Government Officials
   - Wakayama prefecture government officials (n=2)
2. Fishery and Fishery Research Agencies
   - Fisherman outside the area (n=1)
   - Wakayama Higashi Fishery Union and local fishermen (n=6)
   - Wakayama prefecture fishery research and experiment station (n=2) + pref. government officials (n=3)
3. Researchers (n=2)
4. Project Development Team Representatives (n=3)

**Secondary Data** – Literature, OCP Project Estimates & analysis of other relevant projects, Market data

# Scenario Selection – DS/AHP Model [Beynon, M. J. (2005)]

Decision hierarchy

What is the optimum Information sharing level?

Criteria

- C1. Monetary Costs & Benefits
- C2. Ocean observation improvements
- C3. Stakeholder engagement

Alternatives

- S1. No information sharing system
- S2. Sharing all data required by stakeholders
- S3. Sharing data obtained for operating the plant

A1 à Disapproves the Hypothesis

A2 & A3 à Proves the Hypothesis

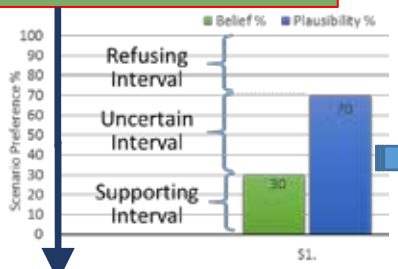
Stakeholder Inputs

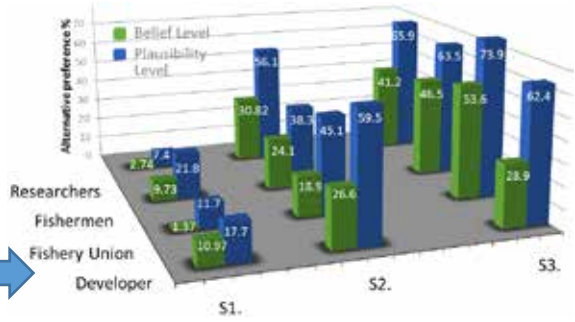
**Pairwise comparison of Criteria** → Criteria Weights

**Favorability of alternative(s) with respect to each criteria** → Criteria wise probabilities of alternative(s)

Final probabilities of alternatives with respect to all criteria

Belief & Plausibility levels of Stakeholder-wise Alternatives Preferences




Belief & Plausibility levels of GROUP Alternatives Preferences

# Results & Discussion

Stakeholders' Oceanographic information requirements

Information generation potential of the CMS

Costs and Benefits of the proposed system

Preferred information sharing level

# R.Q.1 – Information Requirement

ERS = EuroGOOS Requirement Survey

| | Required Oceanographic Parameters | Mainly required by | | Includes in ERS | |
|---|---|---|---|---|---|
| | | Fisheries | Researchers | Top 10 | Top 20 |
| 1 | Sea Surface Temperature (SST) | P | P | P | - |
| 2 | Temperature distribution along the depth | P | - | x | x |
| 3 | Sea Surface Salinity (SSS) | - | P | P | - |
| 4 | Ocean Current / Tidal velocity and direction | P | P | P | - |
| 5 | Wave Profile | P | P | P | - |
| 6 | Wind profile | P | P | x | x |
| 7 | Phytoplankton & Zooplankton | P | P | P | - |
| 8 | Underwater Video or the fish count | P | - | x | x |
| 9 | Marine Mammal Observation | - | P | x | x |
| 10 | Nitrate & Dissolved Oxygen levels | - | P | - | P |
| 11 | Underwater noise & Passive acoustic monitoring | P | P | x | x |
| 12 | Suspended sediments | P | P | - | P |

Primary Data from the Stakeholder interviews

Secondary data from Europe

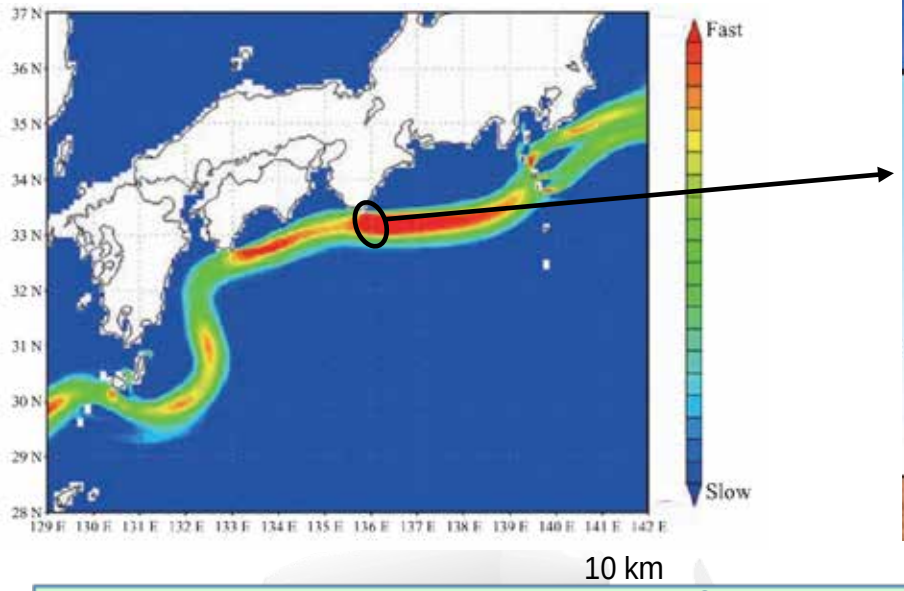
# R.Q.2 – Information Generation potential

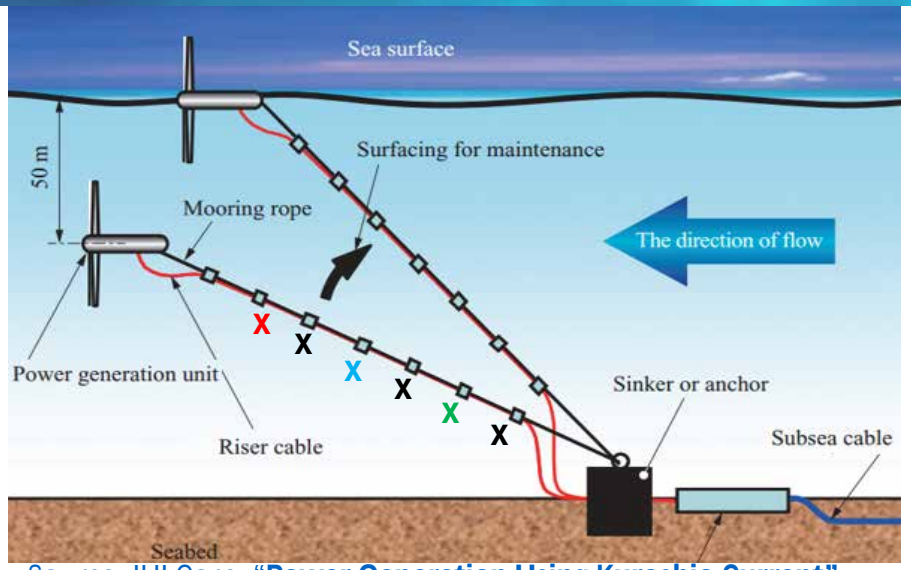
| | Oceanographic Parameters which can be monitored by the CMS | Availability from the CMS | Existing applications | |
|---|---|---|---|---|
| | | | Commercial | R&D, Scientific |
| 1 | Ambient water temperature (at ~50 m depth) | Parameters monitored for the operation of the power plant (Basic CMS) | P | P |
| 2 | Ocean/Tidal current velocity | | P | P |
| 3 | Wave heights | | P | P |
| 4 | Ambient noise levels | | - | P |
| 5 | Marine mammal observation | | - | P |
| 6 | Marine growth around the anchors | | - | P |
| 7 | Underwater audio/video | | - | P |
| 8 | Depth wise temperature distribution | by doing incremental changes to the standard CMS | P | P |
| 9 | Fish count | | - | P |
| 10 | Salinity level & Dissolved Oxygen levels | | P | P |
| 11 | Suspended sediments | | - | P |

Primary Data from the developer interviews & Project design specifications

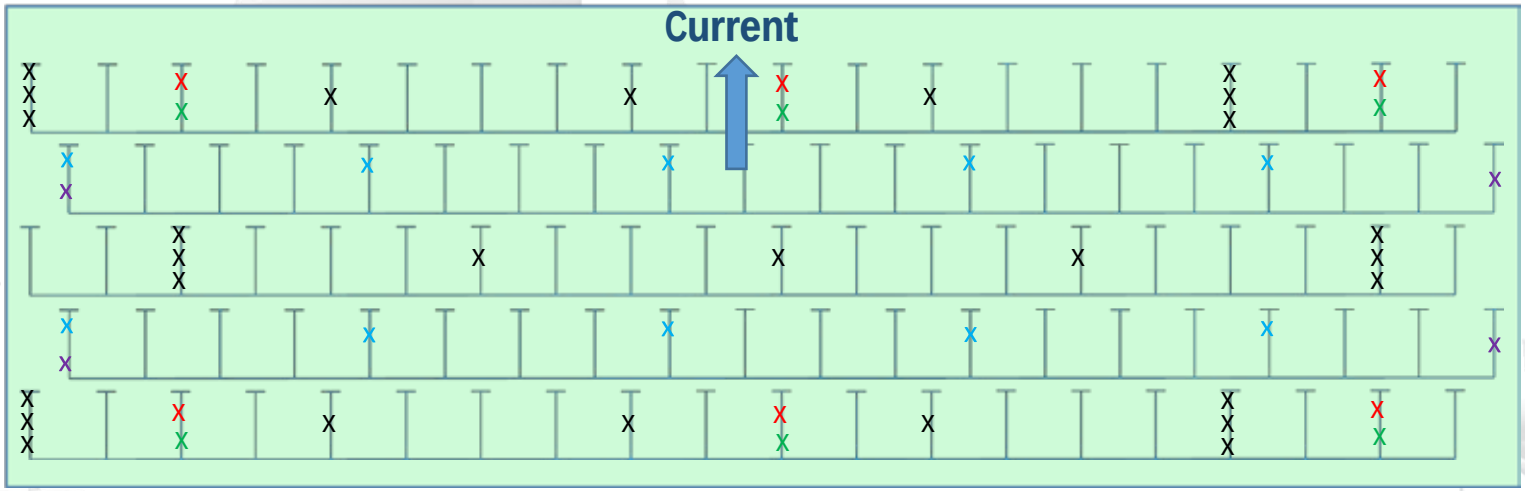
Secondary data from existing ocean monitoring systems

# R.Q.3 – (Worst case) Incremental Costs




Source: IHI Corp, "**Power Generation Using Kuroshio Current**"




Plan view of turbine farm with proposed additional ocean monitoring devices

**Required Sensors**

- X =CTDs
- X =ADCPs
- X =Video, Hydrophone
- X =Fish detectors
- X =Bio-chemical sensors

*Additional startup cost ≈ ¥ 132-193 mil.*

*Additional recurrent cost ≈ ¥ 160 mil./ yr.*

# R.Q.3 – Benefits

## Potential benefits for fishery

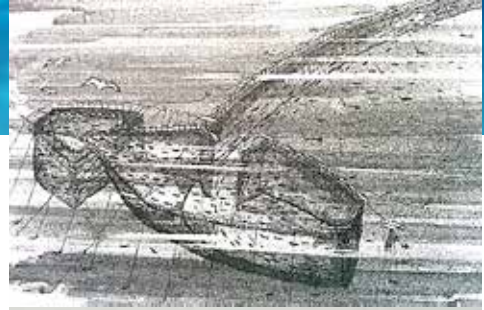
- Efficient fishing area selection
- Damage reduction by accurate 'Kyucho' prediction
- Reduced transportation costs from real time in-situ data
- More reliable simulation of fish migration patterns

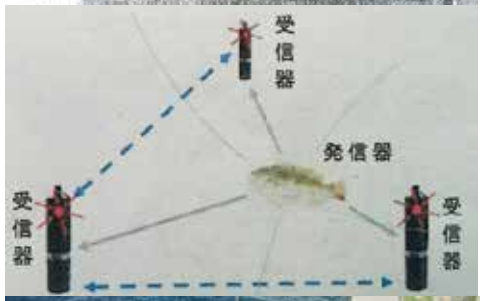
## Potential benefits for Researchers

- Environmental impact monitoring
- More efficient fish migration pattern simulation
- Improvements in existing data sets used for modelling

## Other indirect benefits

- Potential for developing related industries (Forecasting etc.)

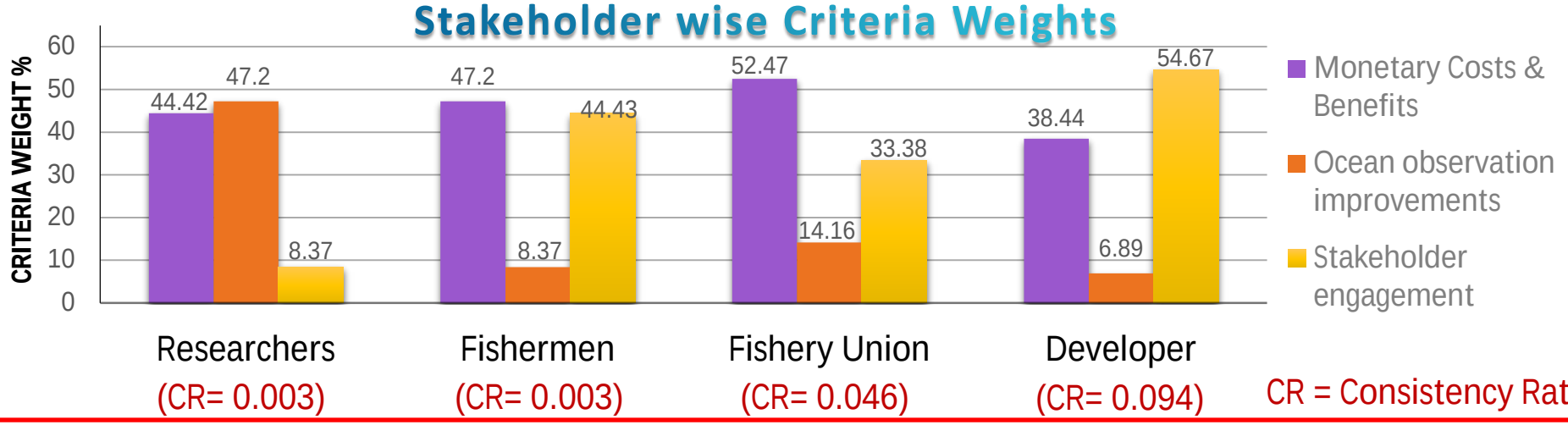


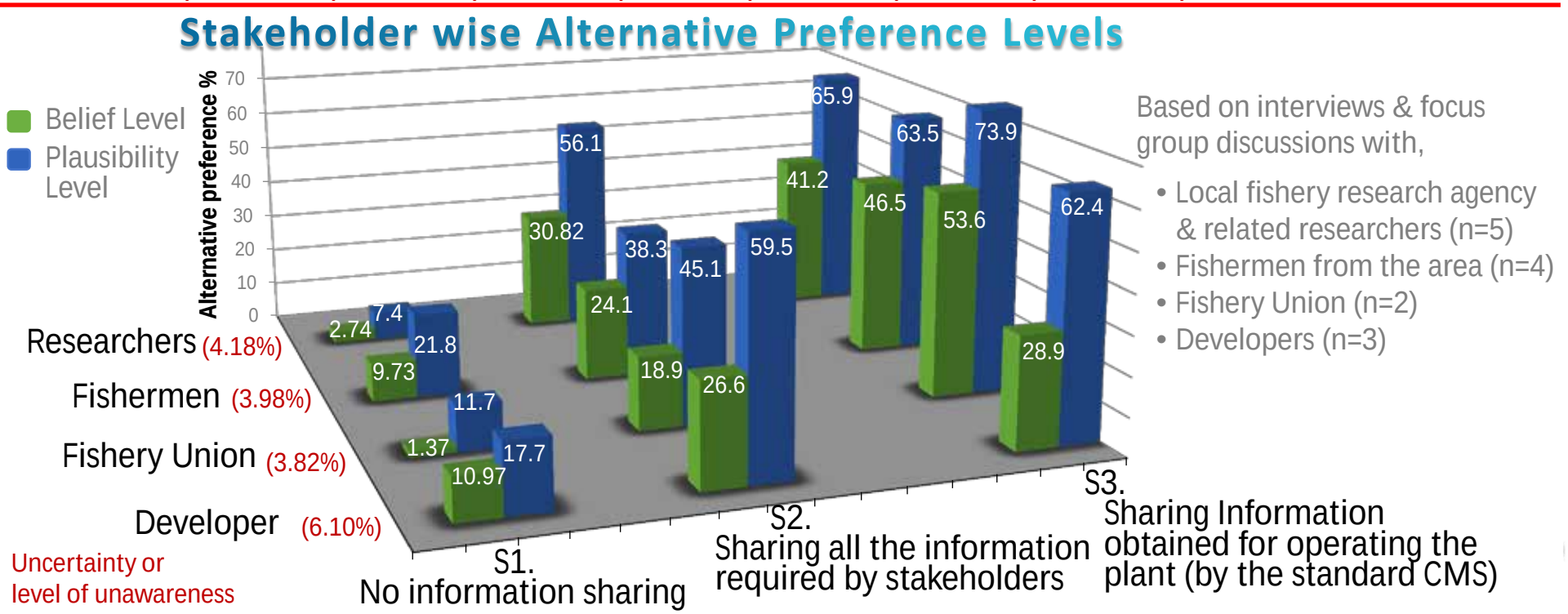



Source : Wakayama Prefecture Fishery Research Experiment Station

*Avg. WTP of a fishery Union ≈ ¥ 0.1 - 0.5 mil./fisherman/yr. Sensitivity analysis shows WTP is reliable if 1% - 5% improvement occurs in the mentioned benefits*

# Stakeholder wise preference



# Conclusion

Summary of Results

# Results Summary

- Most of the physical oceanographic parameters which are in high demand, can be obtained from the CMS of the OCP power plant with minimum additional cost.
- Most of the biochemical parameters also possible with incremental changes to the standard CMS.
- At least 50% of the additional annual cost can be covered by the fishery Union's WTP, even for the second scenario.
  (¥0.1 mil./yr./fishermen * 800 fishermen = ¥80 mil./yr. à 50% of ¥160 mil.)
- Significant difference exists in stakeholder wise criteria weightings.
- Despite the criteria weighting differences, all the stakeholders preferred the proposed information sharing scheme as per the third scenario.

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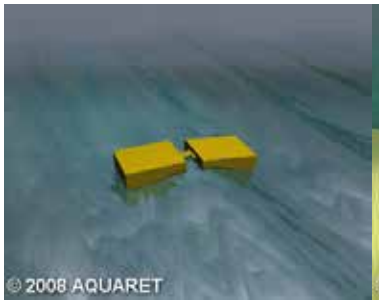
# THANK YOU !

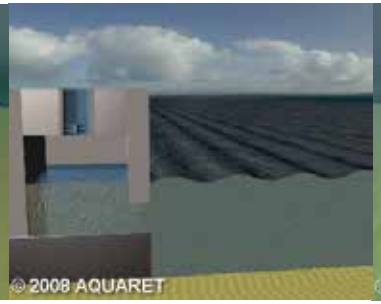

Information
Sharing System
Ocean
Monitoring
Industrial
Development
Environment
Viable
Economic
Sustainable
Bearable
Equitable
Social
Stakeholder
Engagement

# What is Marine Renewable Energy (MRE)?

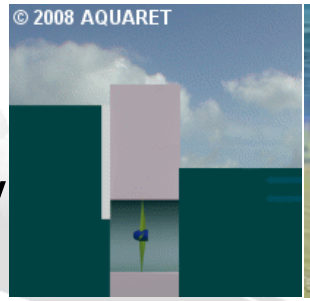
ØRenewable energy sources harnessed from ocean areas such as,

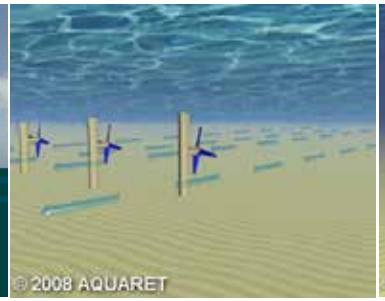
- Wave Energy

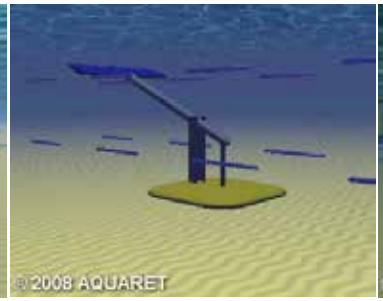


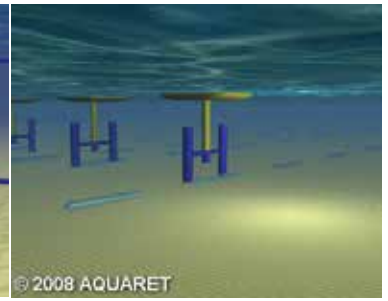



- Tidal & Ocean Current Energy



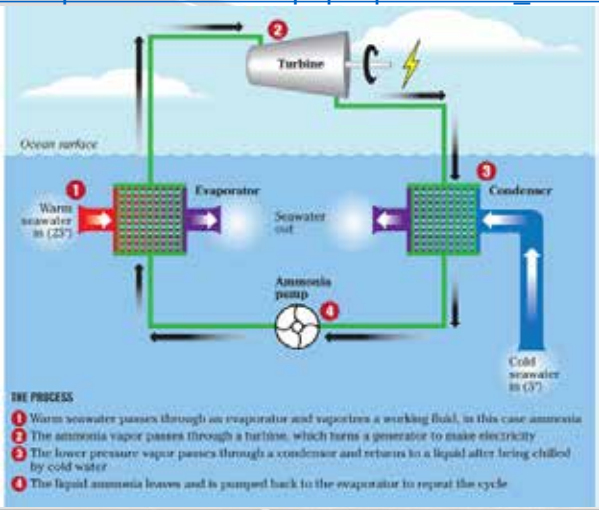






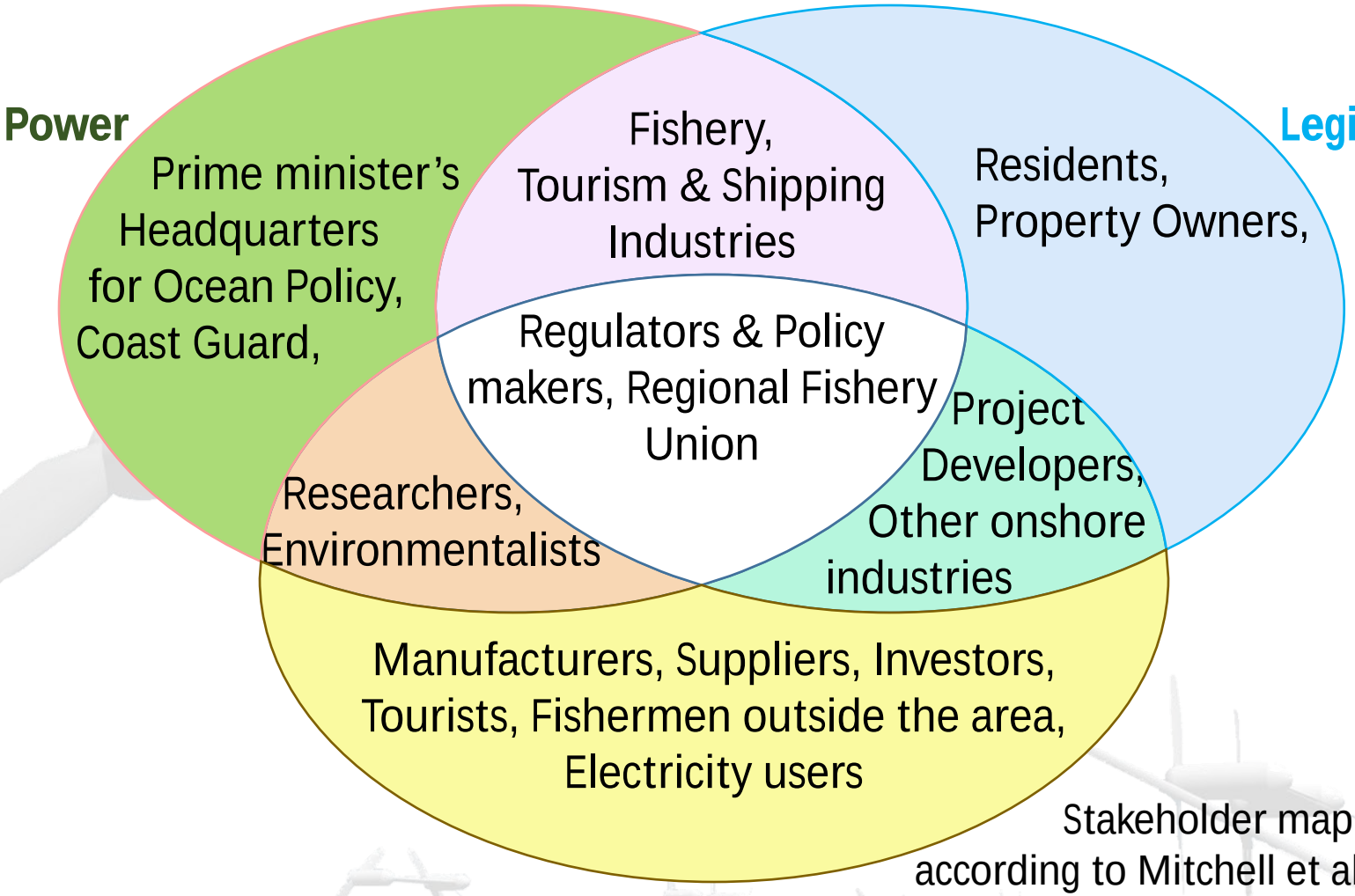

http://www.aquaret.com/index.php?option=com_content&view=article&id=203&Itemid=344&lang=en

- Ocean Thermal Energy Conversion



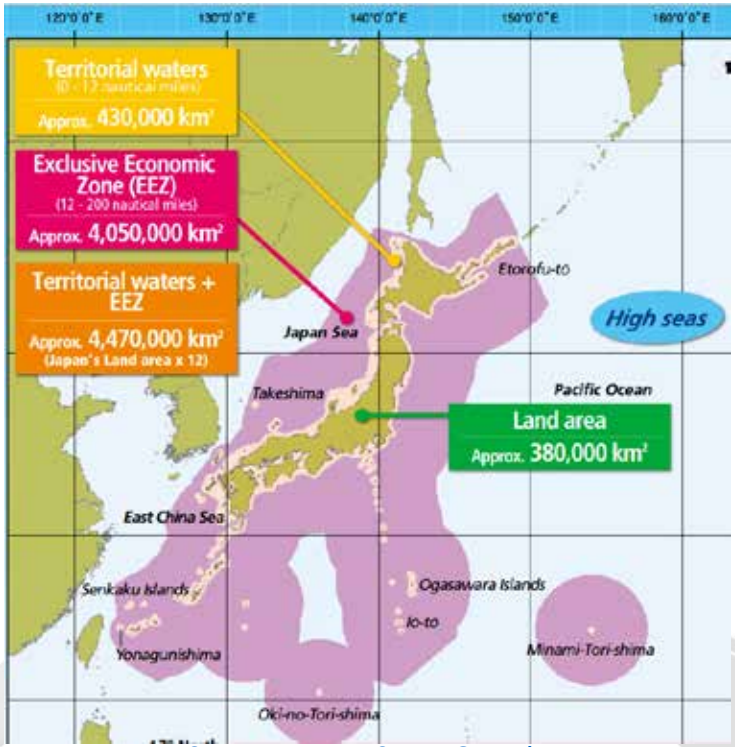

http://hawaiienergyoptions.blogspot.jp/

# Stakeholder Identification

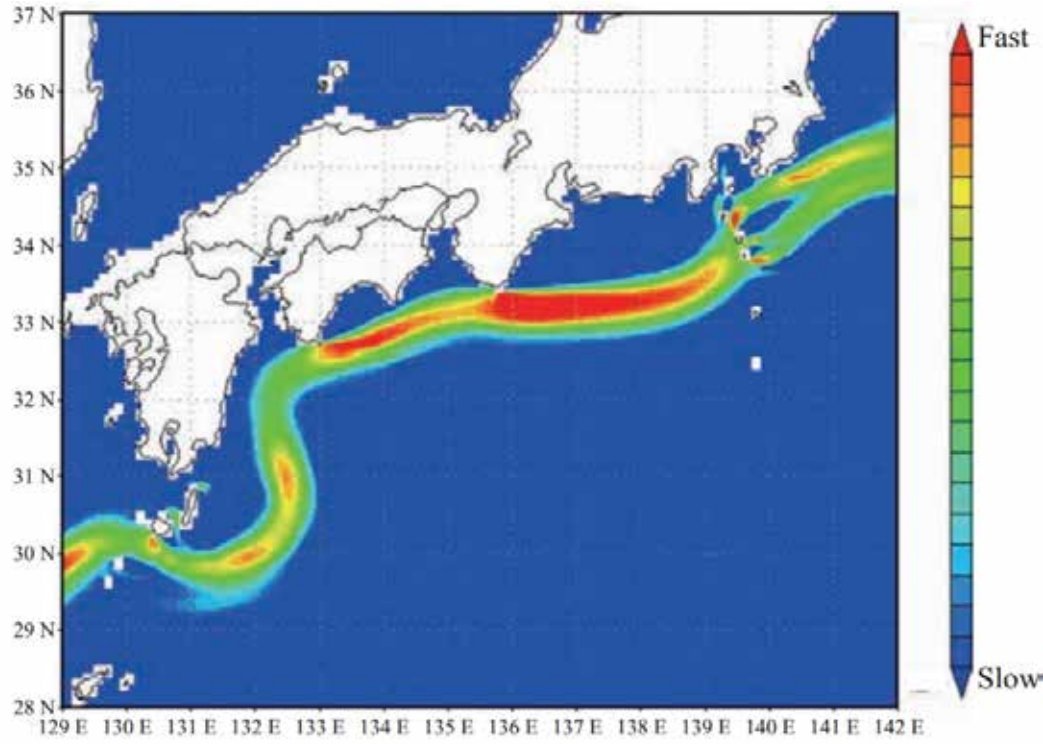



Stakeholder map created according to Mitchell et al., (1997)

# Marine Renewable Energy in Japan




Source: Japan Coast Guard




Source: IHI Corp, "**Power Generation Using the Kuroshio Current**"

- Japan has world's sixth largest Exclusive Economic Zones (EEZ)
- 'Kuroshio Current' flows near the coastal areas of Japan stably throughout the year

*Japan can generate 5% of its domestic electricity demand if 10% of the estimated power can be extracted from the Kuroshio Current.*

# Examples from the Japan's history

- Protests against the Offshore wind farm development in Yasuoka, Shimonoseki.
- *Large compensation for fisheries as well as restrictions on rocket launching period for 'Tanegashima Space Centre', JAXA*



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**Fish Or The Future**

Tokyo -- January 28, 1997 -- The sweeteners may continue but the fishermen will soon no longer tell Japan when it can and can't launch its rockets. For thirty years a few fishermen in Kagoshima told Japan when it could launch it rockets and made the government pay a small fortune in compensation each time a rocket went up. But not for much longer

http://www.spacedaily.com/spacenet/text/fish.html

(http://www.jaxa.jp/press/2010/07/20100729_tnsc_j.html)

Tanegashima Space Center, JAXA.

# Prefectural Government

Concerns raised by the Wakayama Prefecture Government officials

| | Potential Benefits or key drivers | Potential Costs or key barriers |
|---|---|---|
| 1 | Improved the efficiency and safety of offshore operations | Additional financial costs to the OCP project development and deployment |
| 2 | Opportunity for new local industries such as monitoring & forecasting, suppliers etc. | Difficulty to coordinate with all the possible stakeholders |
| 3 | Better resource management & planning | Potential data management issues |
| 4 | Effective in gaining the stakeholder support for project development | Potential over exploitation of natural resources |
| 5 | Potential for local economic development by other indirect means | Potential impacts to the local and traditional socio-economic activities |

# Group Preference

Decision hierarchy

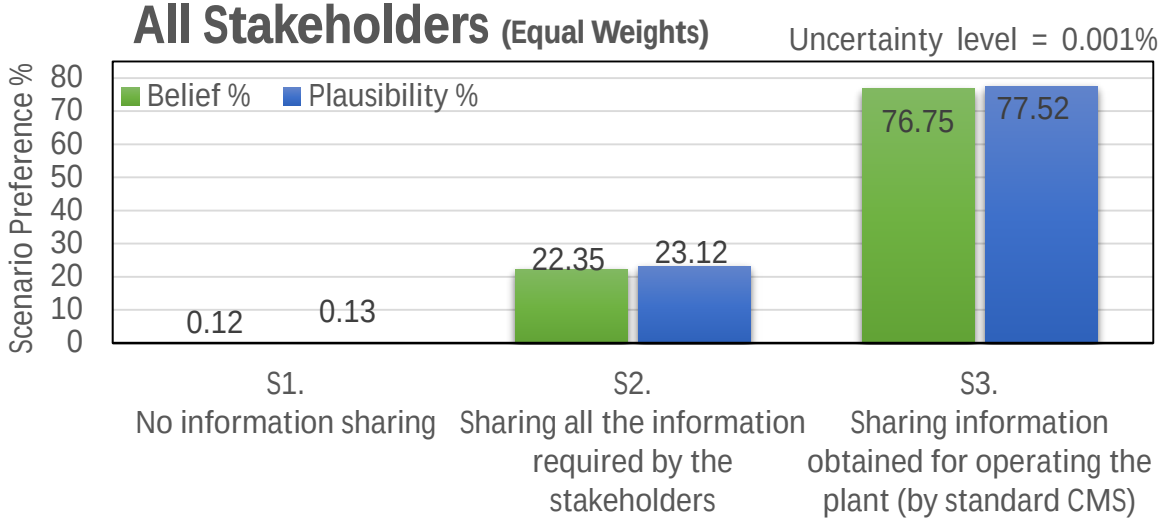
What is the optimum Information sharing level?

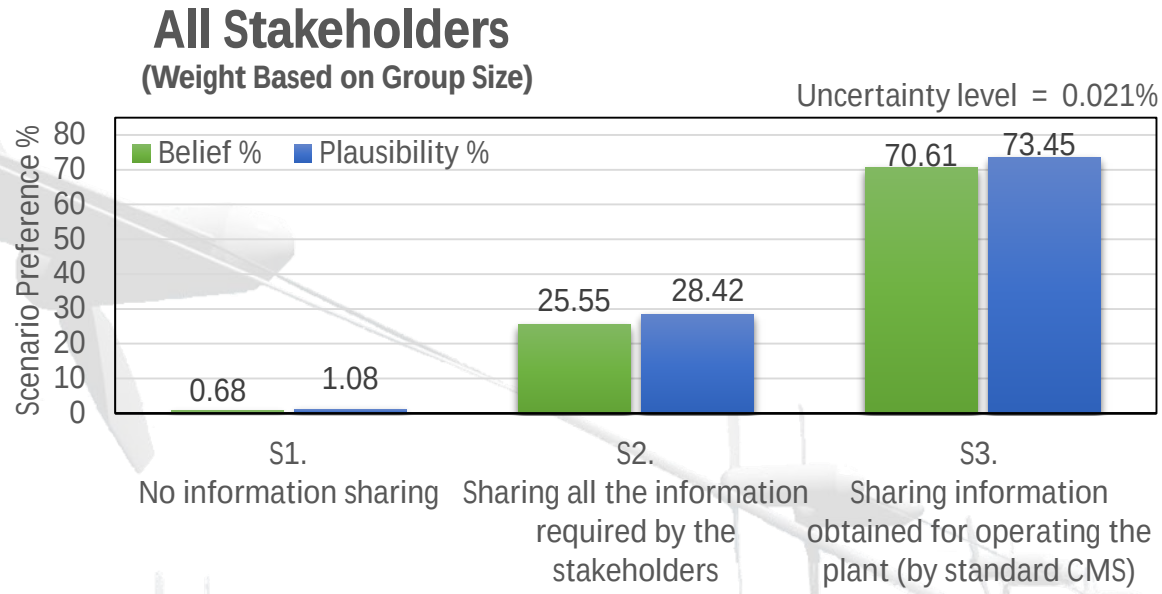
Criteria

- C1. Researchers (n=5)
- C2. Fishermen (n=4)
- C3. Fishery Union (n= 2)
- C4. Developers (n=3)

Alternatives

- S1. No information sharing system
- S2. Sharing all data required by stakeholders
- S3. Sharing data obtained by the standard CMS

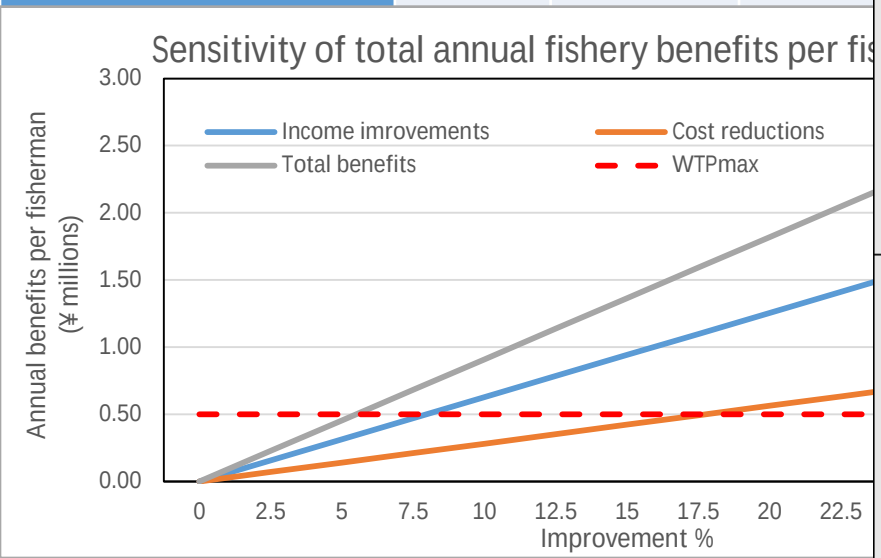



Information sharing according to the third scenario is preferred by all stakeholders

# Sensitivity analysis

| Annual Figures per fisherman | 2006-2012 Avg. ¥ (mil.) | 2006-2012 Avg. % of Income | Potent to hav Impac |
|---|---|---|---|
| Fishery Income | 6.28 | | ✓ |
| Fishery cost | 4.00 | | |
| Labor Cost | 0.48 | 11.90% | x |
| Equipment Cost | 0.32 | 8.08% | x |
| Repair Cost | 0.28 | 6.91% | ✓ |
| Fuel Cost | 0.78 | 19.42% | ✓ |
| Sales Commissions | 0.39 | 9.68% | x |
| Depreciation | 0.64 | 15.91% | ✓ |
| Others | 1.12 | 28.10% | ✓ |
| Fishery Net Earnings | 2.28 | 36.22% | |




| *Net Improvement | | Depreciation ,Repair & Other cost reductions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Income increase | Fuel cost reduction | 0.0% | 1.0% | 2.5% | 5.0% | 7.5% | 10.0% | 12.5% | 15.0% |
| 0.0% | 0.0% | 0.0000 | 0.0204 | 0.0510 | 0.1020 | 0.1530 | 0.2040 | 0.2550 | 0.3060 |
| | 1.0% | 0.0078 | 0.0282 | 0.0588 | 0.1098 | 0.1608 | 0.2118 | 0.2628 | 0.3138 |
| | 2.5% | 0.0195 | 0.0399 | 0.0705 | 0.1215 | 0.1725 | 0.2235 | 0.2745 | 0.3255 |
| | 5.0% | 0.0390 | 0.0594 | 0.0900 | 0.1410 | 0.1920 | 0.2430 | 0.2940 | 0.3450 |
| | 7.5% | 0.0585 | 0.0789 | 0.1095 | 0.1605 | 0.2115 | 0.2625 | 0.3135 | 0.3645 |
| | 10.0% | 0.0780 | 0.0984 | 0.1290 | 0.1800 | 0.2310 | 0.2820 | 0.3330 | 0.3840 |
| | 12.5% | 0.0975 | 0.1179 | 0.1485 | 0.1995 | 0.2505 | 0.3015 | 0.3525 | 0.4035 |
| | 15.0% | 0.1170 | 0.1374 | 0.1680 | 0.2190 | 0.2700 | 0.3210 | 0.3720 | 0.4230 |
| 1.0% | 0.0% | 0.0628 | 0.0832 | 0.1138 | 0.1648 | 0.2158 | 0.2668 | 0.3178 | 0.3688 |
| | 1.0% | 0.0706 | 0.0910 | 0.1216 | 0.1726 | 0.2236 | 0.2746 | 0.3256 | 0.3766 |
| | 2.5% | 0.0823 | 0.1027 | 0.1333 | 0.1843 | 0.2353 | 0.2863 | 0.3373 | 0.3883 |
| | 5.0% | 0.1018 | 0.1222 | 0.1528 | 0.2038 | 0.2548 | 0.3058 | 0.3568 | 0.4078 |
| | 7.5% | 0.1213 | 0.1417 | 0.1723 | 0.2233 | 0.2743 | 0.3253 | 0.3763 | 0.4273 |
| | 10.0% | 0.1408 | 0.1612 | 0.1918 | 0.2428 | 0.2938 | 0.3448 | 0.3958 | 0.4468 |
| | 12.5% | 0.1603 | 0.1807 | 0.2113 | 0.2623 | 0.3133 | 0.3643 | 0.4153 | 0.4663 |
| | 15.0% | 0.1798 | 0.2002 | 0.2308 | 0.2818 | 0.3328 | 0.3838 | 0.4348 | 0.4858 |
| 2.5% | 0.0% | 0.1570 | 0.1774 | 0.2080 | 0.2590 | 0.3100 | 0.3610 | 0.4120 | 0.4630 |
| | 1.0% | 0.1648 | 0.1852 | 0.2158 | 0.2668 | 0.3178 | 0.3688 | 0.4198 | 0.4708 |
| | 2.5% | 0.1765 | 0.1969 | 0.2275 | 0.2785 | 0.3295 | 0.3805 | 0.4315 | 0.4825 |
| | 5.0% | 0.1960 | 0.2164 | 0.2470 | 0.2980 | 0.3490 | 0.4000 | 0.4510 | 0.5020 |
| | 7.5% | 0.2155 | 0.2359 | 0.2665 | 0.3175 | 0.3685 | 0.4195 | 0.4705 | 0.5215 |
| | 10.0% | 0.2350 | 0.2554 | 0.2860 | 0.3370 | 0.3880 | 0.4390 | 0.4900 | 0.5410 |
| | 12.5% | 0.2545 | 0.2749 | 0.3055 | 0.3565 | 0.4075 | 0.4585 | 0.5095 | 0.5605 |
| | 15.0% | 0.2740 | 0.2944 | 0.3250 | 0.3760 | 0.4270 | 0.4780 | 0.5290 | 0.5800 |
| 5.0% | 0.0% | 0.3140 | 0.3344 | 0.3650 | 0.4160 | 0.4670 | 0.5180 | 0.5690 | 0.6200 |
| | 1.0% | 0.3218 | 0.3422 | 0.3728 | 0.4238 | 0.4748 | 0.5258 | 0.5768 | 0.6278 |
| | 2.5% | 0.3335 | 0.3539 | 0.3845 | 0.4355 | 0.4865 | 0.5375 | 0.5885 | 0.6395 |
| | 5.0% | 0.3530 | 0.3734 | 0.4040 | 0.4550 | 0.5060 | 0.5570 | 0.6080 | 0.6590 |
| | 7.5% | 0.3725 | 0.3929 | 0.4235 | 0.4745 | 0.5255 | 0.5765 | 0.6275 | 0.6785 |
| | 10.0% | 0.3920 | 0.4124 | 0.4430 | 0.4940 | 0.5450 | 0.5960 | 0.6470 | 0.6980 |
| | 12.5% | 0.4115 | 0.4319 | 0.4625 | 0.5135 | 0.5645 | 0.6155 | 0.6665 | 0.7175 |