General Fisheries Commission for the Mediterranean

www.gfcm.org

Working Group on site selection and carrying capacity

I. Karakassis

outline

- The concepts
- Why each element is needed
- What we can propose from the work done so far
- What could be the future plans

SHoCMed: site selection and carrying capacity

- Aquaculture will need to produce more in the future to provide food for the expanding human population
- So we need to know:
  - what is the **upper limit** for this production and
  - how this production may be integrated in the marine ecosystems and particularly in the sensitive coastal zone

The problem of water

- Water resources are already under overexploitation, while human population increases exponentially
- In 2050 the human population will reach 9.2 billions (30% increase over today)

If things are like that...

- Perhaps the main source of animal protein will be the sea because it is the only ecosystem which does not depend on freshwater supply.

Will the Oceans Help Feed Humanity?

December 2009 / Vol. 59 No. 11 • BioScience 967

CARLOS M. DUARTE, MARIANNE HOLMER, YNGVAR OLSEN, DORIS SOTO, NÚRIA MARBÀ, JOANA GUIU, KENNY BLACK, AND IOANNIS KARAKASSIS

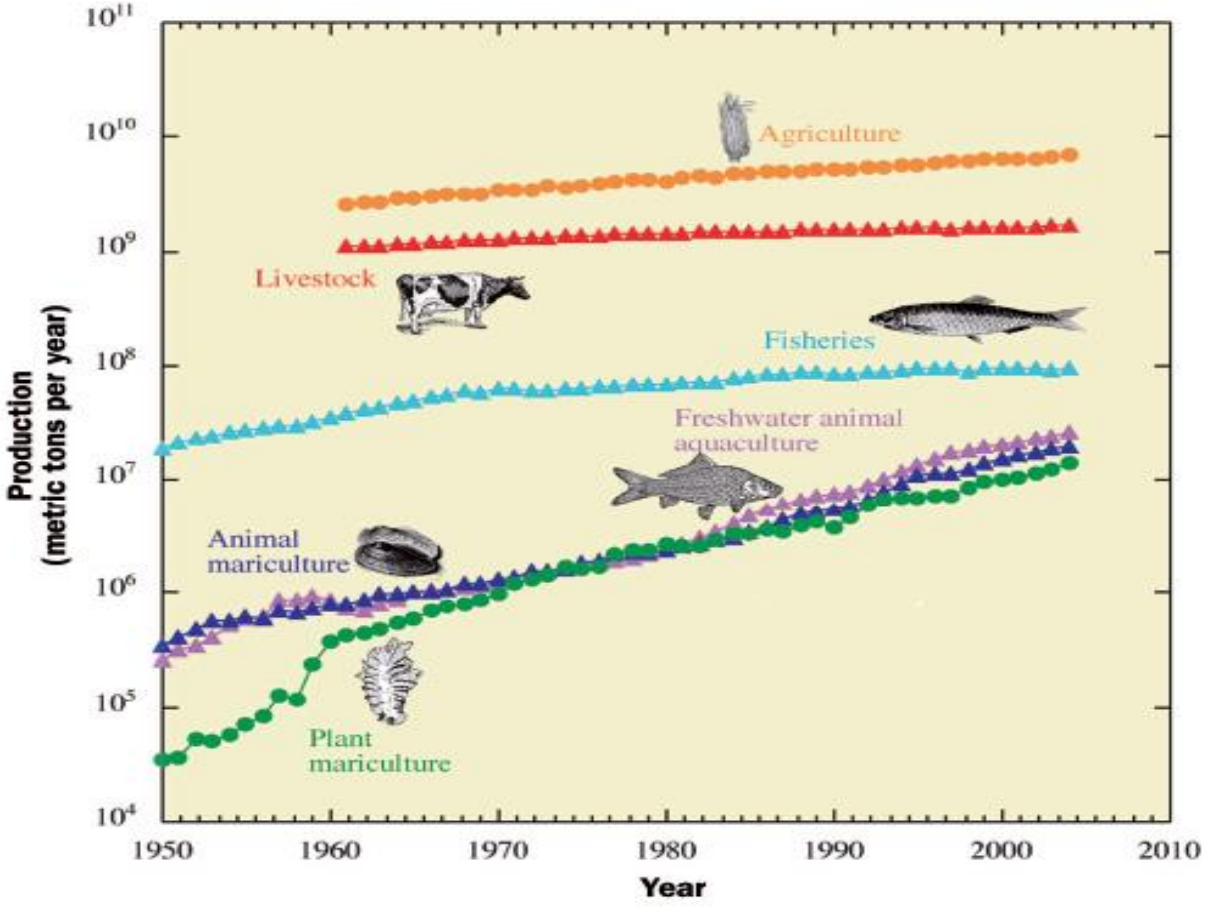

Figure 1. Trends in the global production of agriculture (nonfood items

SAMI project

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Table 2. Number of species accounting for 50%, 90%, and 100% of global food production in agriculture, livestock, marine fisheries, and mariculture, and percentage change of species diversification during this period.

	Number of species in 1994			Number of species in 2004			Percentage change from 1994 to 2004		
Group	50%	90%	100%	50%	90%	100%	50%	90%	100%
Agriculture	5	29	150	5	30	150	0.0	3.4	0.0
Livestock	1	4	16	1	5	16	0.0	25.0	0.0
Marine fisheries	13	134	987	17	145	1324	30.8	8.2	34.1
Mariculture	3	14	146	5	20	180	66.7	42.9	23.2

Note: A few of the items in FAO food production reports do not correspond to individual species, but rather to aggregates of an undefined number of species. Therefore, the actual number of species contributing 50% and 90% of food production should be slightly above the number that appears in this table.

Source: FAO 2006a, 2006b, 2006c, 2006d.

Aquaculture could be a solution …

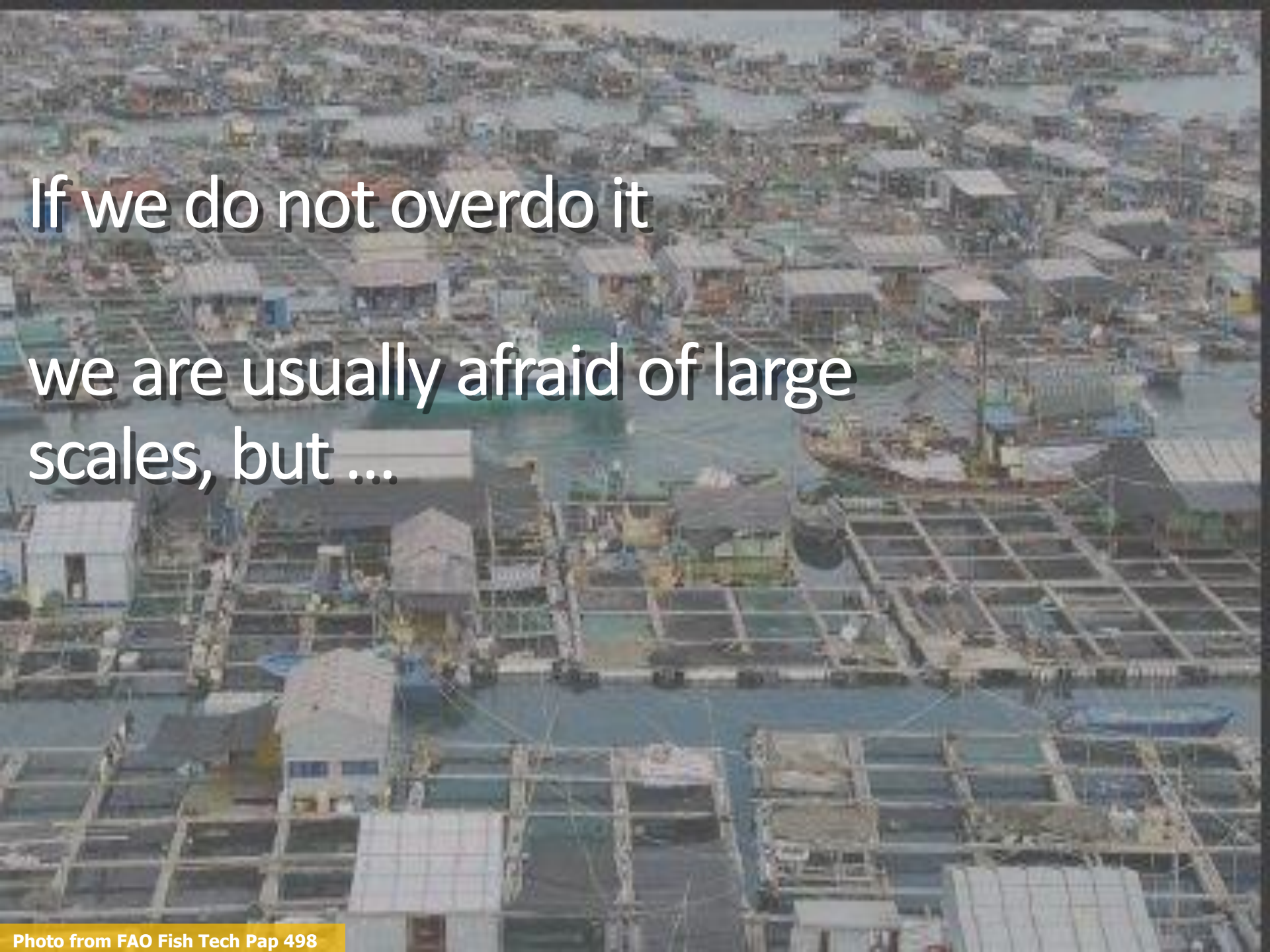


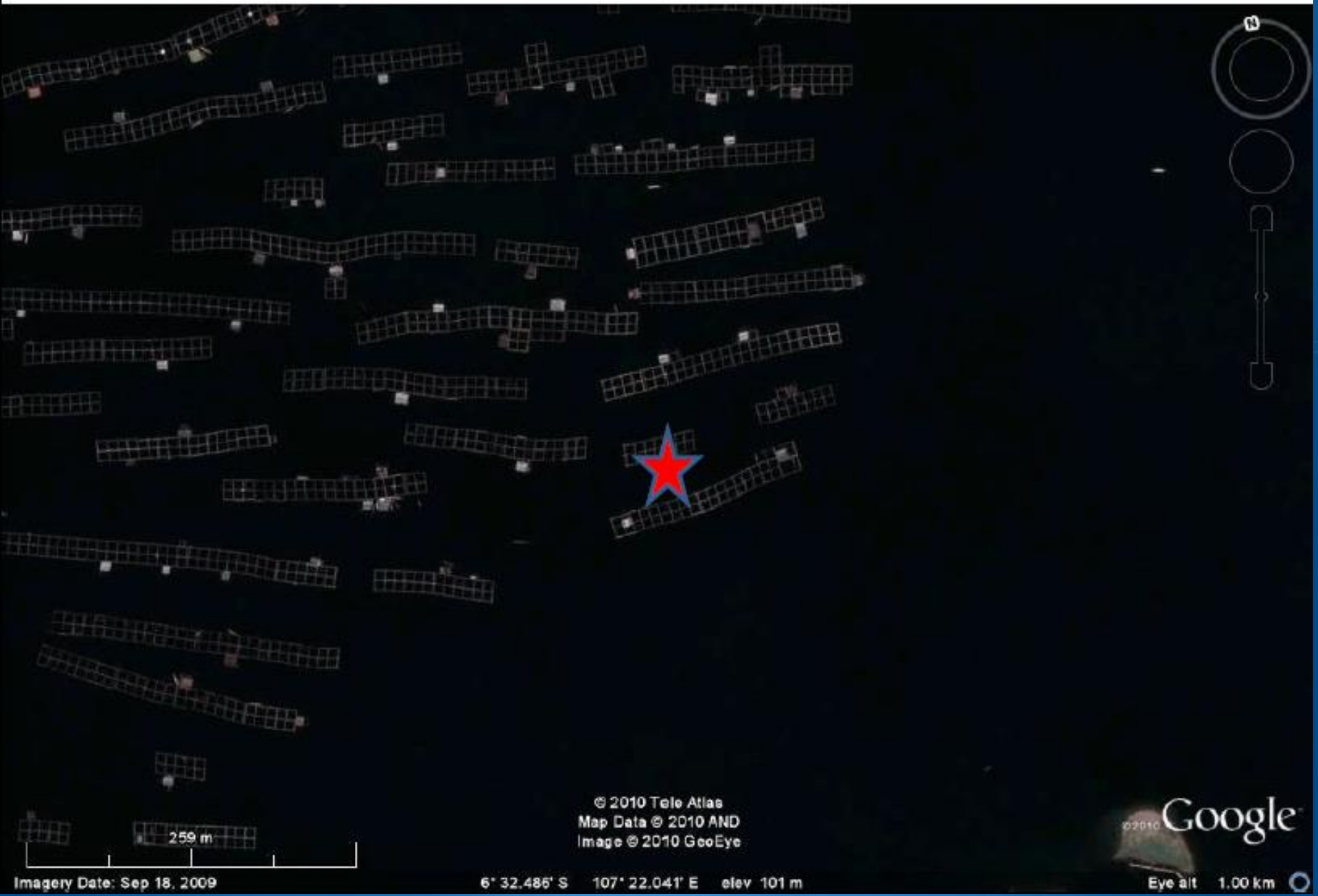
Photo from FAO Fish Tech Pap 498

Indonesia cages in freshwater dam

Indonesia cages in freshwater dam

Indonesia cages in freshwater dam

Indonesia cages in freshwater dam



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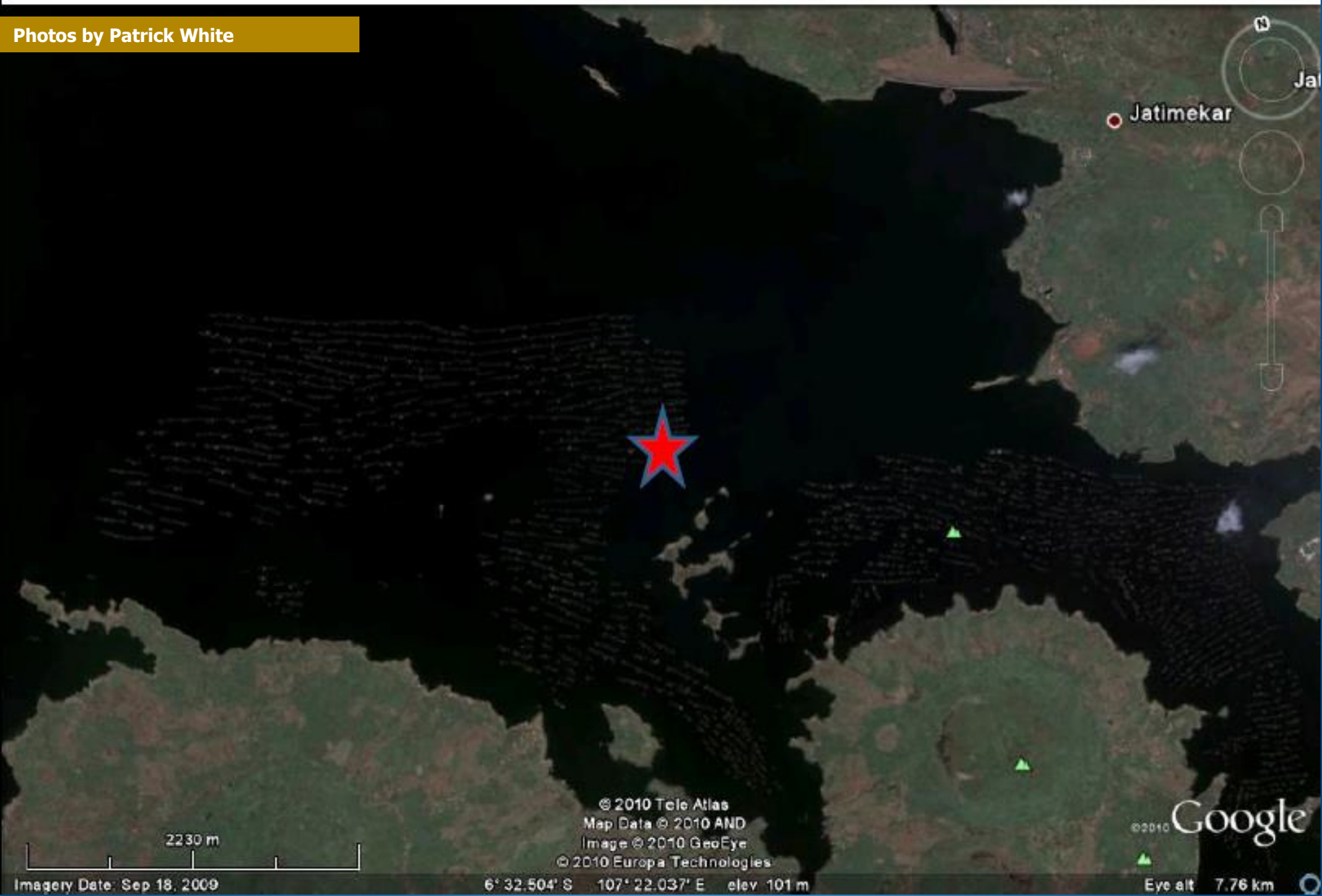
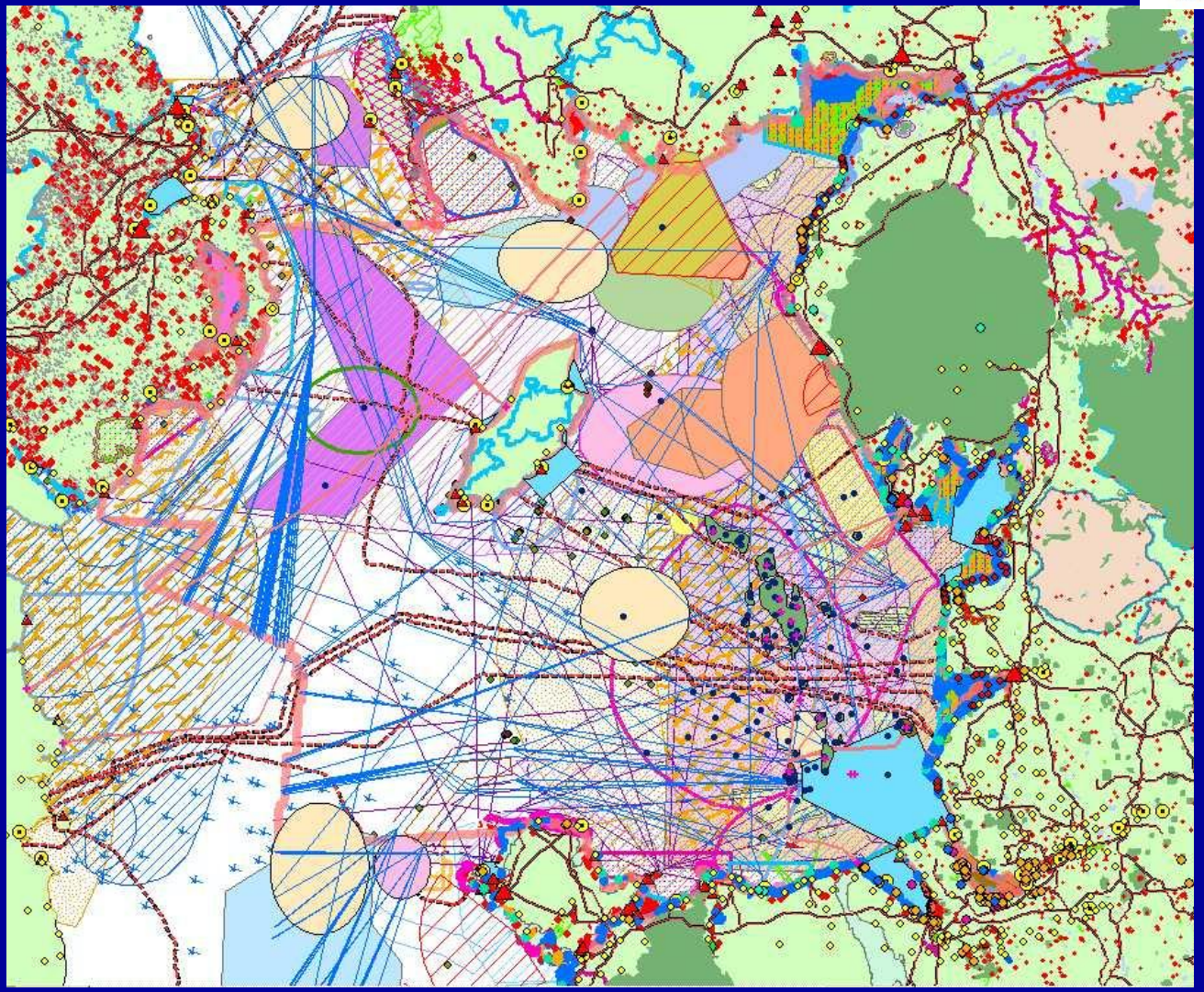
Photos by Patrick White




But there are other
uses in the coast as well

COMPETING CLAIMS

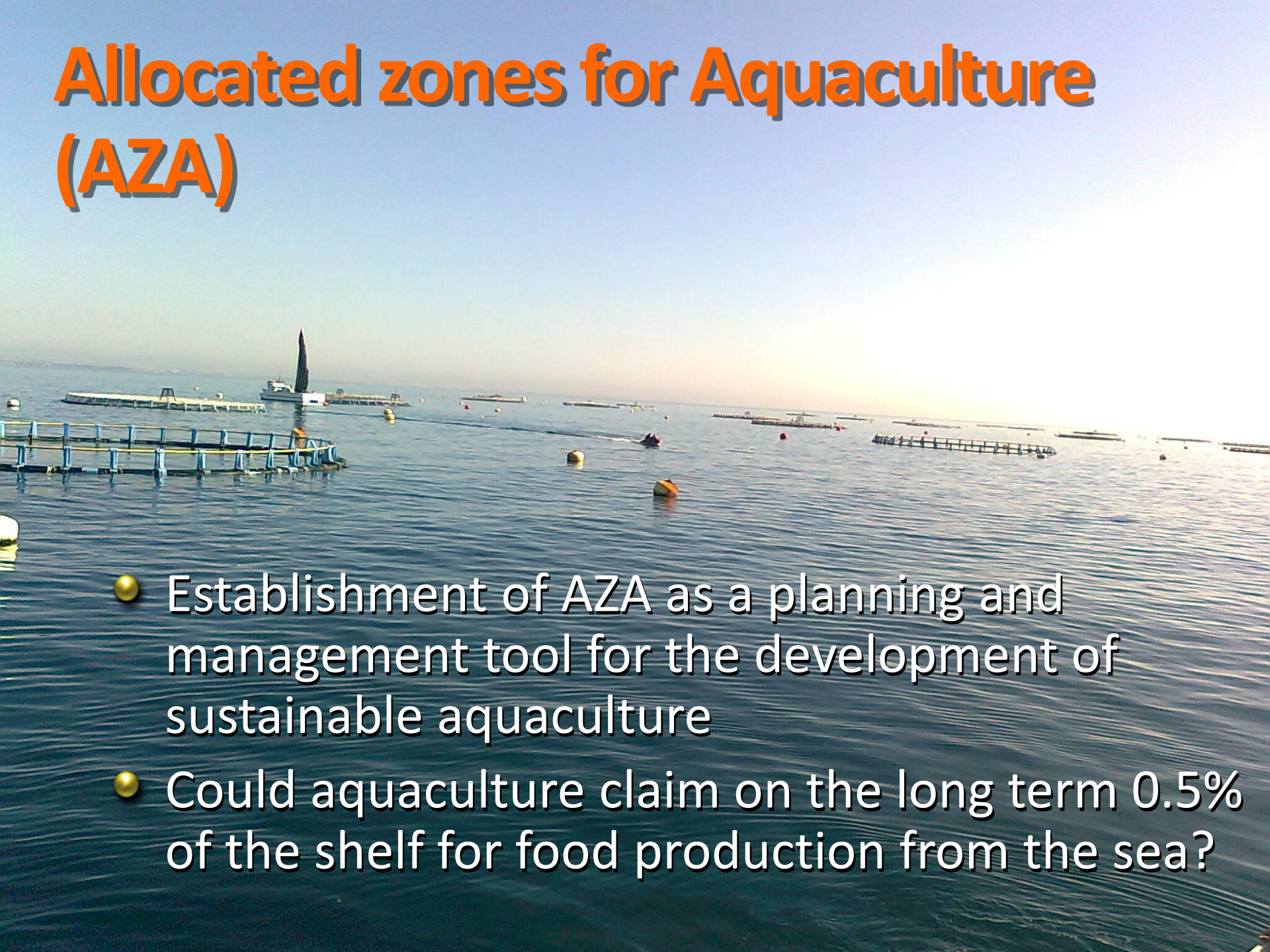
- Landuse
- Tourism
- Oil &Gas
- Mariculture
- Coastal Defence
- Ports & Navigation
- Military Activities
- Culture
- Conservation
- Dredging & Disposal
- Submarine Cables



- Fishing
- Renewable Energy
- Marine Recreation
- Mineral Extraction

- Kindly offered by Dr. Waddah Saab
- Fisheries & Maritime Affairs European

Allocated zones for Aquaculture (AZA)



- Establishment of AZA as a planning and management tool for the development of sustainable aquaculture
- Could aquaculture claim on the long term 0.5% of the shelf for food production from the sea?

CAQ WG on site selection and Carrying Capacity

tools

- **AZA**: to ensure some space in the coastal zone for food production
- **EQSs**: to ensure integrity of the environment but also quality terms for aquaculture production
- **AZE**: to ensure the potential for production under an agreed level of environmental change
- **Harmonization**: to ensure equal terms of competition of aquaculture across the Mediterranean and to increase the knowledge base for future development
- **Research and monitoring**: to foresee and avoid future negative aspects under a shift in production scale in Aquaculture which is likely to occur in the near future

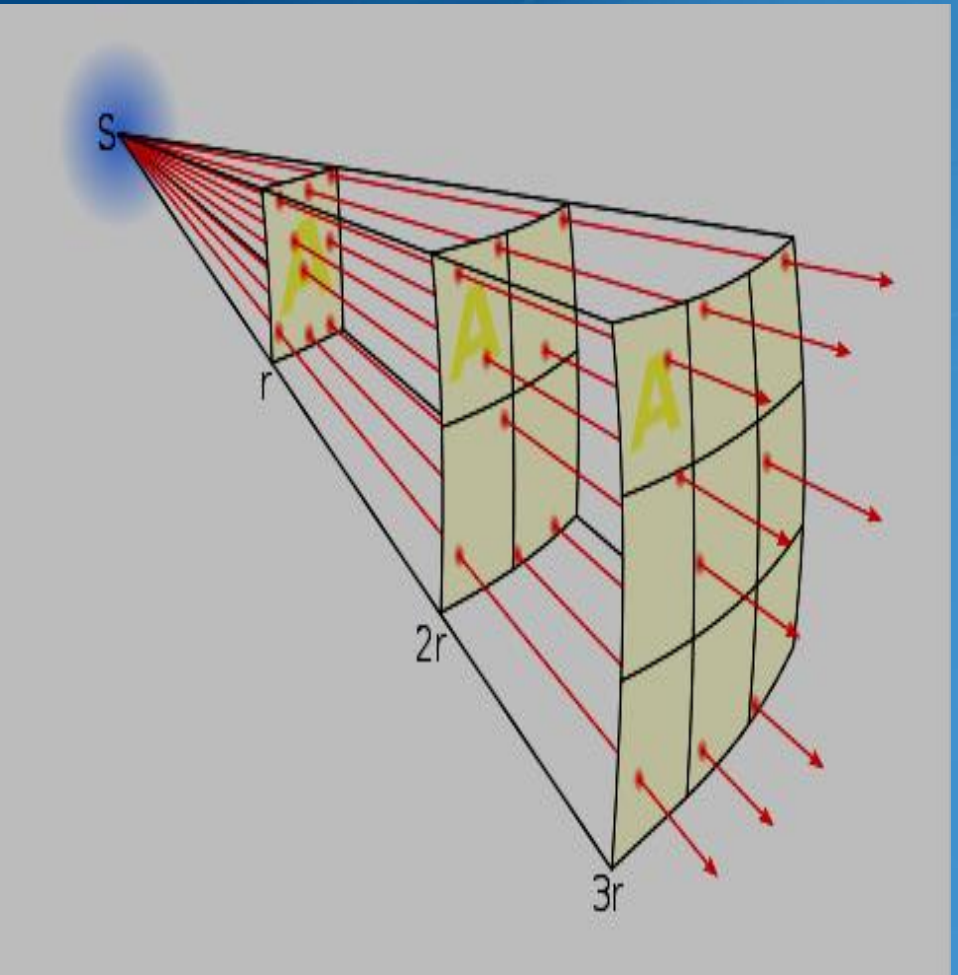
Effects of and on Aquaculture

Table 3: Modified version of the table provided by HOTO in 2001. As in the original table, numbers "3", "2", "1" denote increasing importance

VARIABLES	SEAFOOD	Finfish	Shellfish	Fish culture	Shellfish culture	WASTE DISPOSSAL	Municipal	Industrial	Agroforestry	TOURISM	MARITIME OPERATIONS	FISHING	OIL/GAS EXTRACTION PRODUCTION	MINERAL EXTRACTION	COASTAL AREA DEVELOPMENT	HYDROLOGICAL CYCLE ALTERATIONS	RECREATION WATER
Algal toxins		↑1	↑1	↑1	↑1					↑1							↑2
Artificial radionuclides		↑3	↑3	↑3	↑3			←1			←3						
Dissolved oxygen		↑1	↑1	←3 ↑1	←3 ↑1		←1	←1	←2	←3 ↑3	←3		←3		←2	←3	
Herbicides/Pesticides/Biocides		↑2	↑2	←3 ↑2	←3 ↑2		←2	←3	←1	←2	←3				←2		
Human pathogens		↑1	↑1	←3 ↑1	←3 ↑1		←1	←3		←2 ↑1	←3				←2		↑1
Litter/plastics		↑3	↑3	←3	←3		←1	←1	←3	←2 ↑1	←2	←3			←2		↑2
Metals and organometals		↑2	↑1	←3 ↑3	↑3		←2	←1	←2		←3			←1	←2		
Nutrients				←2 ↑3	←3 ↑3		←1	←1	←1	←2 ↑3	←3				←3	←1	
PAHs		↑3	↑2	↑3	↑2		←2	←2	←3		←3		←1		←3		
Petroleum Hydrocarbon/ Oil		↑3	↑1	↑3	↑1		←1	←2	←3	↑1	←1		←1				↑2
Phytoplankton abundance/diversity		↑1	↑1	↑2	←3 ↑1		←2	←2	←1	←2 ↑3					←3	←1	
Pharmaceuticals		↑3	↑3	←2 ↑3	←3 ↑3		←3	←2	←3								
Suspended particulate matter			↑2	↑2	←3 ↑2		←1	←2	←1	←3 ↑2	←1	←3	←3	←2	←2	←1	↑3
Synthetic Organics/POPs		↑3	↑2	↑3	↑2		←3	←1	←2		←3				←3		
Exotic species		↑2	↑2	←2 ↑3	←2 ↑3						←1						
Habitat destruction				←2	←2		←3	←3	←3	←2	←3	←1	←1	←1	←1	←1	
Predators		↑2	↑2	←3 ↑1	←3 ↑1					←2	←1	←1	←1		←2		
wind				↑1	↑1						↑3	↑3					
light conditions		↑3	↑3	↑3	↑3												
water temperature		↑2	↑2	↑2	↑2			←1								←3	
salinity		↑3	↑3	↑3	↑3			←2								←1	
turbidity		↑2	↑2	←3 ↑2	←3 ↑2		←1	←2	←1	←3	←1	←3	←3	←2	←2	←1	
pH		↑3	↑3	←2 ↑3	←2 ↑3		←2	←2	←2								
benthic effects				←2	←2							←1	←1	←1		←3	
Genetic pollution				←3	←3												

Inverse square low

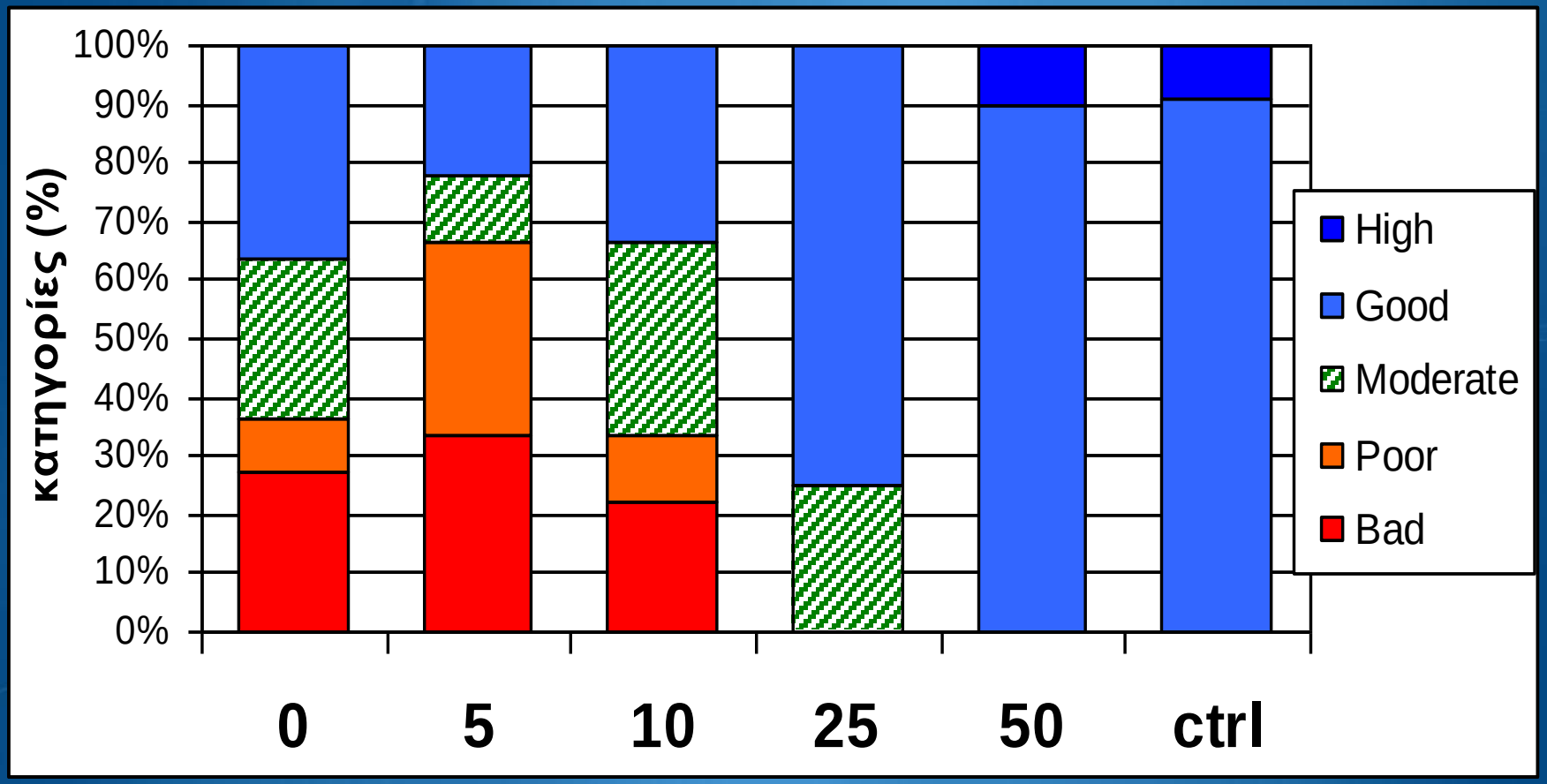
$$\text{Intensity} \propto \frac{1}{\text{distance}^2}$$



In physics, an inverse-square law is any physical law stating that a specified physical quantity or intensity is inversely proportional to the square of the distance from the source of that physical quantity.

Note	Distance(m)	Proportion
	10	1/ 100
	32	1/ 1,000
	50	1/ 2,500
	100	1/ 10,000

AMBI index, all samples & stations

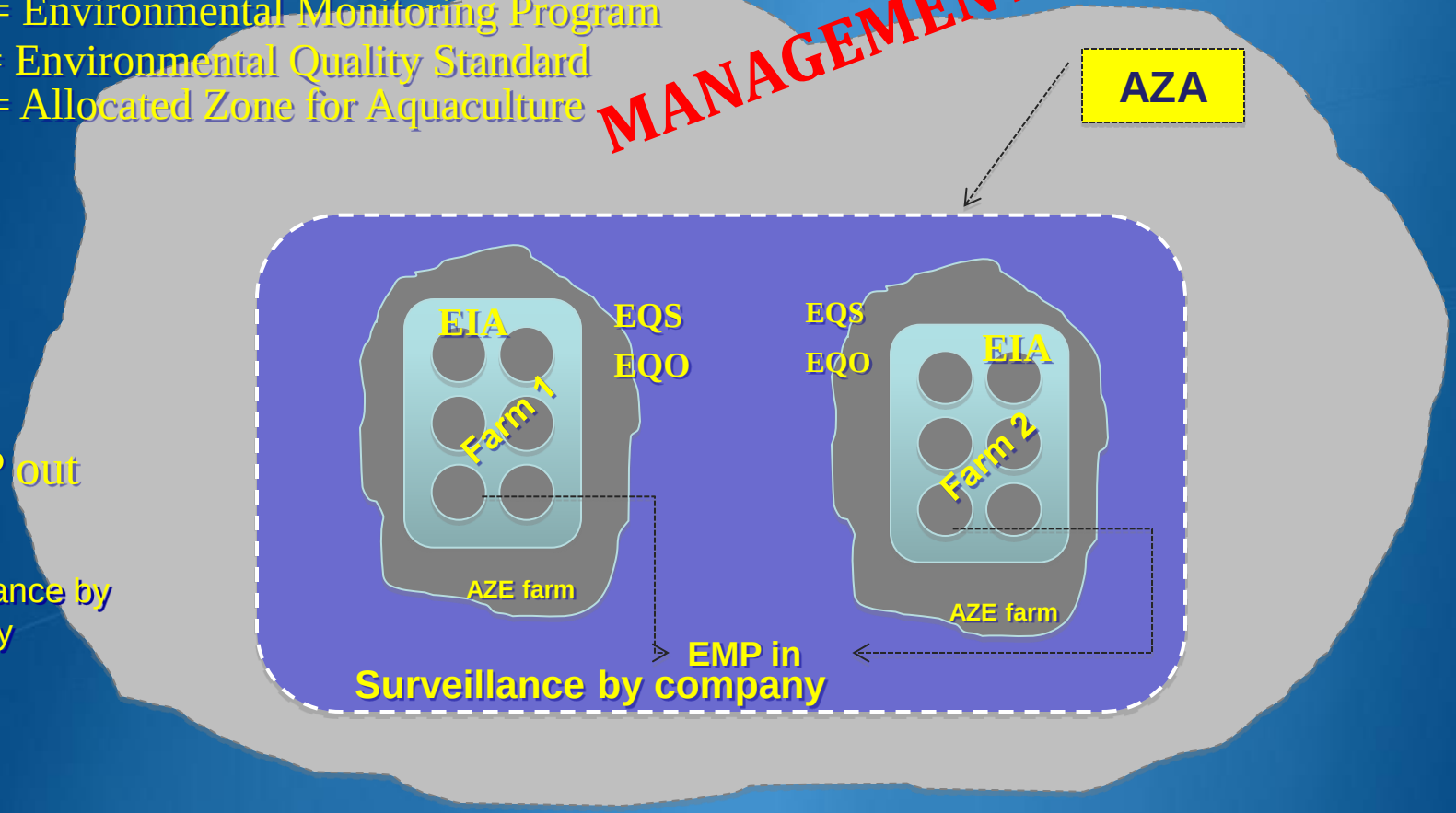


Distance (m)

AZA as a complex aquaculture & environmental ecosystem

AZE= Allowable Zone of Effects
EQO= Environmental Quality Objective
EMP= Environmental Monitoring Program
EQS= Environmental Quality Standard
AZA= Allocated Zone for Aquaculture

MANAGEMENT PLAN is needed



EQSs: necessity and potential problems

- More often than not, the aquaculture industry is reluctant to accept EQSs, assuming that their adoption will impose further burden, financial cost and implications with bureaucracy
- On the other hand, the farming industry also questions the value of monitoring in the absence of EQSs since, in this case, monitoring seems as an academic exercise rather than as a management tool
- The limited availability of knowledge on quantitative estimates of environmental change due to aquaculture operations, the volatile nature of the value attributed by the society on environmental change and the subjective nature of the regulatory decisions are strong reasons for denial of a broad harmonized system of EQSs

EQSs: necessity

Environmental quality standards are needed to:

- Protect the environment from poor management of aquaculture
- Protect the farmer from competing uses of the coastal zone
- Promote the image of aquaculture
- Ensure equal terms of competion
- Provide a yardstick for regulatory decisions by the competent authorities
- Foster the integration of aquaculture in the coastal zone
- Assist in the determination of the "carrying capacity" issue

Required properties of EQS indicators

- Easy to understand
- Reliable (reflecting real environmental change)
- Reliable (verifiable)
- Availability of technological infrastructure and analytical expertise
- Low cost of sampling and analysis

SHoCMed project:

Environmental Quality Standards (EQS) for the AZE derived from a Delphi exercise

The questionnaire concerns the monitoring of the environment around marine finfish cages and within the AZE (Allowable Zone of Effect)*, with particular regards to the physical, chemical and biological parameters of the benthic habitats and of the water column.

BENTHIC HABITATS:

- total organic matter
- sulphide
- total sulphur
- total phosphorus
- total nitrogen
- total carbon
- total organic carbon
- redox potential
- % of silt-clay
- grain size sediment structure
- total macrofaunal biomass
- number of species
- SHANNON INDEX
- AMBI (AZTI Marine Biotic Index)
- Capitellid polychaetes
- Beggiatoa

WATER COLUMN:

- dissolved oxygen
- chlorophyll
- turbidity

ENVIRONMENT SURROUNDING THE FARM:

- gas bubble
- farm litter

Number of Experts on Marine monitoring of environment around the fish cage and experts in marine aquaculture contacted for this Activity:

Total organic matter (%)

- Total responses: 28
- Experts approved: 22 (79%)
- Thresholds given by: 7

- Critique: The interpretation of the data depend on the natural background level. In a depository environment, the %OM will naturally be higher than in a area with strong currents. Samples should be taken at multiple distances from the farm and comparison should be made between several reference and farm sites.

Safe: 4%	Critical: 10%
2%	2%
3%	3%
3%	4%
5%	10%
5%	10%
5%	10%
	10%

- Notes: 1 expert suggesting as limit a 10-20% increase over reference values

Redox Potential (mV)

- Total responses: 27
- Experts approved: 20 (74%)
- Thresholds given by: 10

- **Comments:** This parameter is clearly important.
- at -2cm from sediment surface
- measurements are very variable
- difficult to get accurate results due to sediment heterogeneity

Safe:	**Critical:**
-100	50
-100	0
-50	-50
-50	-100
0	-100
0	-100
50	-100
50	-150
100	-150
	-200

- Notes: 1 expert suggesting as limit a 10-20% increase over reference values

How to choose

AN	Env. Variable	% considering usefull	total responses	# experts approved	# thresholds given	Safe	ctitical	Cost	EQS	inform	overall
1	total organic matter (%):	79%	28	22	7	4.0%	10.0%	L	High	High	
8	Redox potential (mV)	74%	27	20	10	0	-100	L	High	High	
17	Dissolved oxygen (mg/L)	82%	28	23	13	5	4	L	High	High	
20	Gas bubbles	79%	28	22				L	Q	High	Y
21	Litter in Surrounding area	89%	27	24				L	Q	High	Y
5	total nitrogen (%)	68%	28	19	7	0.10%	0.25%	L	High	Mod	M
7	total organic carbon (%L)	79%	28	22	9	2%	3%	M	High	High	
9	% of silt - clay:	86%	28	24	6	70%	85%	L	Mod	High	Y
22	Litter Far from the area:	54%	28	15				L	Q	Mod	
4	total phosphorus (%)	61%	28	17	6	0.05%	0.18%	L	Mod	Mod	
15	Capitellid polychaetes (%)	71%	28	20	7	28%	50%	M	High	Mod	Y?
18	Chlorophyll a (mg/L):	57%	28	16	3	2.4	5	L	Mod	Mod	
19	Turbidity (m)	61%	28	17	4	5	2.25	L	Mod	Mod	L
2	sulphide (%)	57%	28	16				L	None	Mod	
10	Grain size sediment structure (Î¼m)	71%	28	20				L	None	Mod	
11	Total macrofaunal biomass (g/m2)	71%	28	20	3	10	5	M	Mod	Mod	
3	total sulphur (mg/L)	43%	28	12				L	None	L	
6	total carbon (%)	32%	28	9				L	None	L	
12	Number of species	71%	28	20	6	10	3	H	Mod	Mod	
13	Diversity (Shannon index)	71%	28	20	4	2.25	1.5	H	Mod	Mod	
14	AMBI (AZTI Marine Biotic Index)	71%	28	20	6	3.3	5	H	Mod	Mod	
16	Beggiatoa (CFU/L)	63%	27	17	diverse			L	Q	Mod	

What we can propose from the work done so far

- Research for further elaboration of the AZA concept is needed
- Adoption of the Allowable Zone of Effect concept
- Pilot use of the EQSs proposed and meta-analysis to obtain Mediterranean standards
- A system for collection of monitoring data and adoption of a central data repository in each country for future common analysis

What we can propose from the work done so far -2

- Participation of stakeholders in the process of EQSs adoption
- Training to increase the capacity in environmental monitoring

What we can propose from the work done so far (3)

GFCM/CAQ supports the launching of research initiatives aiming at investigating the means to optimize the use of Allocated Zones for Aquaculture as a spatial planning tool for the integration of Aquaculture in the Coastal Zone by improving site management, reducing environmental impacts and increasing the level of social acceptability.

What could be the future plans

- Research on AZA (pilot action)
- Workshops on EQS indicator analysis from the Mediterranean (separately from Black Sea)
- Linking "carrying capacity" to EQS indicators
- Research on mitigation measures when exceeding EQS

AZA research (pilot project)

- Review of the characteristics of the existing aquaculture zonation schemes (common features, effectiveness, advantages and disadvantages), practices used and problems encountered
- Effect on local spatial planning and social acceptance
- Health of the stocks and parasitological issues, present status and anticipated issues regarding climatic change scenarios

AZA research (pilot project)

- Environmental issues (cumulative effects, negative and positive interactions and externalities)
- Managerial synergies in the AZA context (shared costs, common infrastructures, personnel safety issues, monitoring capacity)
- Optimization of size, distance and depth (environmental benefits and operational cost)

AZA research (pilot project)

- Compatibility with other uses of the marine environment
- Optimum Design of the AZA structure
- EQSs in the AZA.AZE and monitoring strategies
- Potential use of models in the AZA context (spatial distribution of effects, prediction, GIS modelling tools)

Thank you