
WP 3 Identifying and quantifying the main driving forces of ecosystem changes influencing the aquaculture sector and developing the appropriate environmental indicators

objective 1

to identify and **quantitatively assess the role and the relative importance** of the **different forcing factors**: (aquaculture, fisheries, pollution, eutrophication, habitat destruction etc.) and environmental variations **affecting the water quality** in aquaculture zones and the major ecosystem services provided

step 1

relative importance of different driving forces

identification of major issues:

- partners contribution
 - major issues in different countries/areas
 - experience
 - bibliographic documentation
 - other information sources
 - literature search
 - EEA reports
 - GOOS reports
 - GESAMP reports
-

step 1

relative importance of different driving forces

		Major Environmental Issues							Forcing Factors			
AREA	Northern Europe	UK										
		Germany	Environmental protection									
		Norway										
		Sweden										
	Mediterranean	Slovenia	Overfishing	HABs	Chemical pollution	Extreme meteorological events	Maritime Traffic		Eutrophication	Fisheries		
		Croatia										
		Israel	Water quality	HABs	Chemical pollution				Aquaculture	Fisheries	Eutrophication	
		Greece	Water quality	Habitat Destruction	Chemical pollution				Turism	Fisheries	Wastes	
		Italy	Water quality	HABs	Chemical pollution	High concentrations of nutrients	Mucilage events	Other source of pollution	Aquaculture	Fisheries	Eutrophication	Pollution
		France										
	Atlantic	Spain										
		Portugal										

partners contribution

step 2

relative importance of different driving forces

identification of major issues → HOTO-Table *

discrimination between
shellfish – finfish

issues of importance to
aquaculture

include other interactions

↓
modifications
(with partners
contribution)
←

step 2

relative importance of different driving forces

	SEAFOOD				DISPOSAL			HUMAN ACTIVITIES						CRITICAL HABITATS						
	Finfish	Shellfish	Fish culture	Shellfish culture	Municipal	Industrial	Agroforestry	Tourism	Maritime Operations	Fishing Practices	Oil/Gas Extraction Production	Mineral Extraction	Coral Reef Systems	Estuaries	Temperate & Tropical Wetlands Including Mangroves	Submerged Macrophyte Communities	Other Spawning & nursing Areas	Coastal Area Development	Hydrological Cycles Alterations	Recreation Water
Algal toxins	↑1	↑1	↑1	↑1				↑1					↑3							↑2
Artificial radionuclides						←1			←3					↑						
Dissolved oxygen	↑1	↑1	←3	↑1	←3	↑1	←1	←1	←2	←3			↑	↑1	↑3	↑3	↑2	←2	←3	
Herbicides/Pesticides/Biocides	↑2	↑2	←3	↑2	←3	↑2	←2	←3	←1	←2			↑2	↓2	↑2	↑2	↑2	←2	←3	
Human pathogens	↑1	↑1	←3	↑1	←3	↑1	←1	←1	←2	↑1								←2		↑1
Litter/plastics	↑3	↑3	←3	←3	←1	←1	←3	←2	↑1	←2	←3		↑	↑	↑	↑		←2		↑2
Metals and organometals	↑1	↑2	↑3	↑3	←2	←1	←2		←3			←1	↑2					←2		
Nutrients			←2	↑3	←2	↑3	←1	←1	←2	↑3			↑2	↑2	↑	↑2		←3	←1	
PAHs	↑3	↑2	↑3	↑3	←2	←2	←3		←3			←1	↑2					←3		
Petroleum Hydrocarbon/ Oil	↑3	↑1	↑3	↑3	←1	←2	←3	↑1	←1				↑3	↑2	↑1	↑3	↑1			↑2
Phytoplankton abundance/diversity	↑1	↑1	←3	↑2	←3	↑1	←2	←2	←1	←2	↑3		↑2			↑3		←3	←1	
Pharmaceuticals	↑1	↑1	←2	↑	←2	↑	←3	←2	←3					↑						
Suspended particulate matter		↑3	←3	↑3	←3	↑3	←1	←2	←1	←3	↑2		←1	↑2		↑3	↑3	←2	←1	↑3
Synthetic Organics/POPs	↑3	↑2	↑3	↑3	←3	←1	←2						↑3	↑2	↑3			←3		
Exotic species	↑	↑	←2	↑	←2	↑			←1				↑	↑	↑	↑				
Habitat destruction			←2	←2	←3	←3	←3	←3	←3	←1	←1	←1						←1	←1	
Predators			←3	↑1	←3	↑1			←2	←1	←1	←1						←2		
Wind			↑1	↑1						↑	↑		↑	↑	↑	↑				
Light conditions	↑	↑	↑	↑									↑	↑	↑	↑				
Photoperiod			↑	↑									↑	↑	↑	↑				
Water temperature	↑	↑	↑	↑									↑	↑	↑	↑				
Salinity	↑	↑	↑	↑									↑	↑	↑				←1	
Turbidity	↑	↑	←3	↑	←3	↑	←1	←2	←1	←3	←3	←2	↑	↑	↑	↑		←2	←1	
pH	↑	↑	←2	↑	←2	↑	←2	←2	←2				↑	↑	↑					
Benthic effects			←2	←2						←1	←1	←1							←	
Genetic pollution			←3	←3																

modified HOTO-Table

step 3

relative importance of different driving forces

aq/cult ranking	contribution	significance to aquaculture													
5	3	1	Dissolved oxygen	MUNICIPAL	INDUSTRIAL	AGROFORESTRY	COASTAL AREA DEVELOPEMENT	TOURISM	FISH CULTURE	SHELLFISH CULTURE	MARITIME	OIL/GAS EXTR PROD	HYDRO CYCLE ALTERATION		
5	3	1	Human pathogens	MUNICIPAL	TOURISM	COASTAL AREA DEVELOPEMENT	MARITIME	FISH CULTURE							
6	3	1	Phytoplankton abundance/diversity	AGROFORESTRY	HYDRO CYCLE ALTERATION	MUNICIPAL	TOURISM	INDUSTRIAL	FISH CULTURE	COASTAL AREA DEVELOPEMENT					
5	3	2	Herbicides/Pesticides/Biocides	AGROFORESTRY	TOURISM	MUNICIPAL	COASTAL AREA DEVELOPEMENT	INDUSTRIAL	FISH CULTURE	MARITIME					
0			Artificial radionuclides	INDUSTRIAL	MARITIME										
0	3		PAHs	OIL/GAS EXTR PROD	INDUSTRIAL	MUNICIPAL	MARITIME	AGROFORESTRY	COASTAL AREA DEVELOPEMENT						
0	3		Petroleum Hydrocarbon/ Oil	OIL/GAS EXTR PROD	MARITIME	MUNICIPAL	INDUSTRIAL	AGROFORESTRY							
0	3		Synthetic Organics/POPs	INDUSTRIAL	AGROFORESTRY	MUNICIPAL	MARITIME	COASTAL AREA DEVELOPEMENT							
0	?		Water temperature	INDUSTRIAL											
0	?		Salinity	HYDRO CYCLE ALTERATION											
1	2		Genetic pollution	FISH CULTURE	SHELLFISH CULTURE										
2	2	?	Pharmaceuticals	INDUSTRIAL	FISH CULTURE	SHELLFISH CULTURE	MUNICIPAL	AGROFORESTRY							
2	2	?	Exotic species	MARITIME	FISH CULTURE	SHELLFISH CULTURE									
3	2	?	pH	INDUSTRIAL	MUNICIPAL	AGROFORESTRY	FISH CULTURE								
4	2		Benthic effects	FISHING	MINERAL EXTRACTION	OIL/GAS EXTRACTION	FISH CULTURE	SHELLFISH CULTURE							
5	2	3	Nutrients	HYDRO CYCLE ALTERATION	MUNICIPAL	AGROFORESTRY	INDUSTRIAL	TOURISM	FISH CULTURE	COASTAL AREA DEVELOPEMENT	MARITIME				
6	3	1	Predators	MARITIME	FISHING	OIL/GAS EXTRACTION	COASTAL AREA DEVELOPEMENT	TOURISM	FISH CULTURE						
6	2		Habitat destruction	FISHING	HYDRO CYCLE ALTERATION	COASTAL AREA DEVELOPEMENT	MINERAL EXTRACTION	OIL/GAS EXTRACTION	FISH CULTURE	SHELLFISH CULTURE	MUNICIPAL	AGROFORESTRY	INDUSTRIAL	MARITIME	TOURISM
6	3		Litter/plastics	MUNICIPAL	INDUSTRIAL	TOURISM	MARITIME	COASTAL AREA DEVELOPEMENT	AGROFORESTRY	FISHING	FISH CULTURE				
6	3	3	Metals & Organometals	INDUSTRIAL	MINERAL EXTRACTION	MUNICIPAL	AGROFORESTRY	COASTAL AREA DEVELOPEMENT	MARITIME	FISH CULTURE					
8	3	?	Turbidity	MUNICIPAL	AGROFORESTRY	MARITIME	HYDRO CYCLE ALTERATION	COASTAL AREA DEVELOPEMENT	MINERAL EXTRACTION	INDUSTRIAL	FISH CULTURE	SHELLFISH CULTURE	TOURISM	FISHING	OIL/GAS EXTRACTION
8	3	3	Suspended particulate matter	MUNICIPAL	AGROFORESTRY	MARITIME	HYDRO CYCLE ALTERATION	INDUSTRIAL	MINERAL EXTRACTION	COASTAL AREA DEVELOPEMENT	FISH CULTURE	TOURISM	FISHING	OIL/GAS EXTR PROD	

objective 2

to suggest the **best methods for obtaining reference levels** and associated indicators useful to monitor the **impact of anthropogenic factors on aquaculture**

objective 2

methodology for estimating reference levels

(example)

1. aquaculture is affected by dissolved O_2
 2. what are the thresholds? (literature review)
 3. how often are these thresholds reached in aquaculture?
 4. what is the contribution of other uses to this situation?
-

objective 2

methodology for estimating reference levels

(example)

- ⇒ municipal wastes
- ⇒ industrial wastes
- ⇒ agroforestry etc

alternatively of and the quantification of damage
abatement (subjective data)

objective 2

identifying risks of anthropogenic impacts on aquaculture

Greece

	2001	2002	2003	2004	2005	Total	%
Disease	51	71	62	48	2	234	55.5%
Storms	19	14	14	15	14	76	18.0%
Predator attack	9	11	13	6		39	9.2%
Hatcheries death	11	13	7	7	1	39	9.2%
Transportation	6	5	4	1	1	17	4.0%
test	4					4	0.9%
Storms - equipment	1			1	1	3	0.7%
Thermal inversion			3			3	0.7%
Unidentified		1		1		2	0.5%
Hatcheries low O2		1	1			2	0.5%
Illegal actions	1			1		2	0.5%
Equipment	1					1	0.2%
Total	103	116	104	80	19	422	100.0%

aquaculture losses (number of cases/events)

objective 2

identifying risks of anthropogenic impacts on aquaculture

Spain

	2001	2002	2003	2004	Total	(%)
Boat collision				1	1	3,45
Disease			3		3	10,34
Oil spill		1			1	3,45
Predators attack		1	1		2	6,90
Storms	3	5	7	7	22	75,86
Total	3	7	11	8	29	100

aquaculture losses (number of cases/events)

following step 3

*identifying risks of anthropogenic impacts on
aquaculture*

HUMAN ACTIVITIES	AQUACULTURE	FISHING	TOURISM	MUNICIPAL WASTE DISPOSAL	INDUSTRIAL WASTE DISPOSAL	AGROFORESTRY	MARITIME	OIL/GAS EXTRACTION	MINERAL EXTRACTION	COASTAL AREA DEVELOPMENT
AQUACULTURE	??	3	2							
FISHING	3									
TOURISM	2	2								
MUNICIPAL WASTE DISPOSAL	1	1	1							
INDUSTRIAL WASTE DISPOSAL	1	1	1							
AGROFORESTRY	1	2	2							
MARITIME	2	2	2							
OIL/GAS EXTRACTION	2	2	2							
MINERAL EXTRACTION	2	2	2							
COASTAL AREA DEVELOPMENT	2	2	??							

human activities & aquaculture

objective 2

identifying risks of anthropogenic impacts on aquaculture

shellfish

		Major Environmental Factors Affecting Aquaculture												
		Competition for space	Fisheries	Dredging	Tanker accidents	Maritimes	Municipal Wastes	Industrial Wastes	HABs	Authorities	Diseases	Biofouling	Agriculture	
AREA	Northern Europe	UK												
		Germany							✓		✓			
		Norway												
		Sweden									✓			
	Mediterranean	Slovenia	✓	✓			✓	✓						
		Croatia												
		Israel											✓	
		Greece												
		Italy								✓				
	Atlantic	France												
		Spain			✓	✓		✓	✓					
		Portugal			✓	✓	✓			✓				✓

partners contribution

objective 2

identifying risks of anthropogenic impacts on aquaculture

finfish

		Major Environmental Factors Affecting Aquaculture									
		Competition for space	Fisheries	Dredging	Tanker accidents	Maritimes	Municipal Wastes	Industrial Wastes	HABs	Authorities	
AREA	Northern Europe	UK									
		Germany									
		Norway									
		Sweden									✓
	Mediterranean	Slovenia	✓	✓			✓	✓			
		Croatia									
		Israel									
		Greece									
		Atlantic	France								
	Spain				✓	✓		✓	✓		

partners contribution

objective 3

to identify **indicators of incompatibilities**
between uses and/or minimal distances required
to avoid conflicts over environmental issues

objective 3

indicators of incompatibilities

AREA						
Northern Europe		Mediterranean			Atlantic	
Germany	Sweden	Israel	Greece	Italy	Spain	Portugal
Bathymetry	Area	Offshore of Mediterranean	Distance from touristic facilities	No criteria at present	Quality of water	Several Authorities involved
Wave, wind and current regime	Water recycling	Criteria based on American, European, Canadian guidelines	Distance from touristic beaches		Renewal of water	
Geomorphology			Distance from significant coasts		Wave regime	
			Distance from settlements		Bathymetry	
Restricted cultured beds (up to 2000 ha in 2006)			Distance from harbours, marinas and athletic facilities		Wind regime	
Further from Zone 1 of protected areas			Distance from industrial areas		Avoidance of protected areas, beaches, ports, harbours, sweage disposal areas, military settlements	
Short distance between culture sites and mussel seed beds			Distance from sewage outfall		EIA analysis	
Away from shipping activities			Distance from rocky islet coasts			

site selection criteria, partners contribution

objective 3

indicators of incompatibilities

incompatibilities between aquaculture and other uses

AREA					
Northern Europe		Mediterranean			
					Atlantic
Germany	Sweden	Israel	Greece	Italy	Spain
Shipping	Area	Tourism	Tourism	Tourism	Tourism
Environmental protection	Water recycling	Local boatmen	Fisheries	Fisheries	Maritime
		Navy	Maritime		Military
		Coastal development	Urbanization		Urbanization

partners contribution

objective 3

indicators of incompatibilities

Table 1: Relationships between aquaculture and other uses of coastal area

ACTIVITY	INDUSTRY AND HARBOR	URBANIZATION	TOURISM AND RECREATION	AGRICULTURE		FISHERIES
				INTENSIVE	EXTENSIVE	
SPATIAL RESOURCES	<ul style="list-style-type: none"> - land reclaiming (-) - shipping traffic (-) - military zones (-) - dredging (-) 	<ul style="list-style-type: none"> - land use (-) - land reclaiming (-) 	<ul style="list-style-type: none"> - land reclaiming (-) - harbors (-) - sailing, bathing (-) - fishing (-) - historical sites (-) 	<ul style="list-style-type: none"> - coastal land (-) 	<ul style="list-style-type: none"> - coastal land (-) 	<ul style="list-style-type: none"> - spawning areas (-) - nurseries (-) - artificial reefs (-) - fishing zones (-)
QUALITY OF ENVIRONMENT	<ul style="list-style-type: none"> - pollutants (-) - ballast water (-) - warmed water (+) 	<ul style="list-style-type: none"> - sewage (-) - organic matter (-) - bacteria and viruses (-) - nutrients (-) 	<ul style="list-style-type: none"> - sewage (-) - antifouling paints (-) 	<ul style="list-style-type: none"> - fertilizers (-) - pesticides (-) - organic matter (-) - suspended solids (-) - freshwater management (-) 	<ul style="list-style-type: none"> - nutrients (+) - organic matter (+) - freshwater management (+/-) 	<ul style="list-style-type: none"> - disease transmission (-) - genetic escape (-)
ECONOMY	<ul style="list-style-type: none"> - infrastructure (+) - attraction of investment (+/-) 	<ul style="list-style-type: none"> - market (+) - infrastructure (+) 	<ul style="list-style-type: none"> - attraction of investment (+/-) - seasonal employment (+/-) - local market (+) - infrastructure (+) 	<ul style="list-style-type: none"> - infrastructure (+) 	<ul style="list-style-type: none"> - infrastructure (+) 	<ul style="list-style-type: none"> - attraction of investment (+) - market (+) - infrastructure (+) - fish meal for aquafeeds (+)
SOCIAL RESOURCES		<ul style="list-style-type: none"> - living habitats (-) 	<ul style="list-style-type: none"> - eco tourism (+) - seascape (-) - wildlife (-) 			<ul style="list-style-type: none"> - internal competition (-) - education (+)
REGULATIONS	<ul style="list-style-type: none"> - areas around (-) - harbors reserved (-) - military zones (-) 	<ul style="list-style-type: none"> - municipality (-) - policy (+/-) 	<ul style="list-style-type: none"> - protected area (-) - wild fauna and flora (-) - environmental standards (+) 			<ul style="list-style-type: none"> - sanctuaries for fisheries (+/-)

(+) in favor of aquaculture development

(-) negative effect relationship to aquaculture development

objective 3

indicators of incompatibilities

Table 4: Criteria to be considered in selecting sites for aquaculture in marine environment

BIOPHYSICAL CHARACTERISTICS	SUPPORTING INFRASTRUCTURE	SOCIAL & ECONOMIC CONSIDERATION
Exposure	Road and communications	Local demand and supply
Depth	Electricity	International market
Current (velocity, direction)	Fish-feed manufacture	Cost of basic supply for goods
Wind (fetch, speed and direction)	Slaughtering facilities	Capital cost
Waves	Waste disposal facilities	Risks & Insurance
Topography (slope, threshold)	Health service	Employment
Substrate	Advisory service	Regulations
Suspended matter	Expertise	
Available land	Education	
Water quality-min. max. and variations (T C, %O, ppt Sal.)	Repair and maintenance	
Water quantity		
Space		
Trophic status		
Fouling		
Existing cultivated species		
Predators		

objective 3

indicators of incompatibilities

Table 5.1 - Indicative separation distances for marine fish farms in Scotland (Crown Estate Commission, 1989)

Distance to	Salmon farms (approx miles)	Shellfish farms (approx miles)	Provisos
Distance from			
Salmon farms	5	2	A
Shellfish farms	2	1	A
Public viewpoints	1	0.5	B
Hotels/Tourist centres	1	0.5	B
Houses (other than staff houses)	0.5	0.25	B
Wildlife colonies	0.5	0.25	C
Anchorage/Approaches	0.25	0.25	D
Fishing grounds	0.25	0.25	E

objective 4

to **assess indicators** of the **interactions**
between aquaculture and other major uses of
the coastal zone (fisheries, tourism &
recreation, shipping etc)

objective 5

to identify **potential ways for measuring the additional cost** caused by external environmental change

David Whitmarsh will obtain the synthesis of the available data and will analyse the associated costs on externalities

indicators

synthesis of all data



sources of pressures

indicators

source of pressure

weather-storms

disease and parasites

predator attack

indicator

frequency of storms, wave-height, fetch openness

production by other farms, water quality issues

colonies of *birds*, colonies of *seals*, nesting beaches for sea turtles, frequency of dolphins and tunas in the area

indicators

source of pressure

pollution

other issues

indicator

distance from land based sources

distance from waste discharge points

distance from harbours

distance from rivers

distance from major naval routes

distance from fishing grounds

distance from touristic facilities

distance from houses

problems – gaps

- imbalance between northern and southern Europe in terms of responses:
low input data from the high production areas
 - little quantification of effects/risks
ranking is used instead
 - problem of scale of effects and relevance to aquaculture zones
-