GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN COMMISSION
GÉNÉRALE DES PÊCHES POUR LA MÉDITERRANÉE

Workshop on algal and jellyfish blooms in the Mediterranean and Black Sea

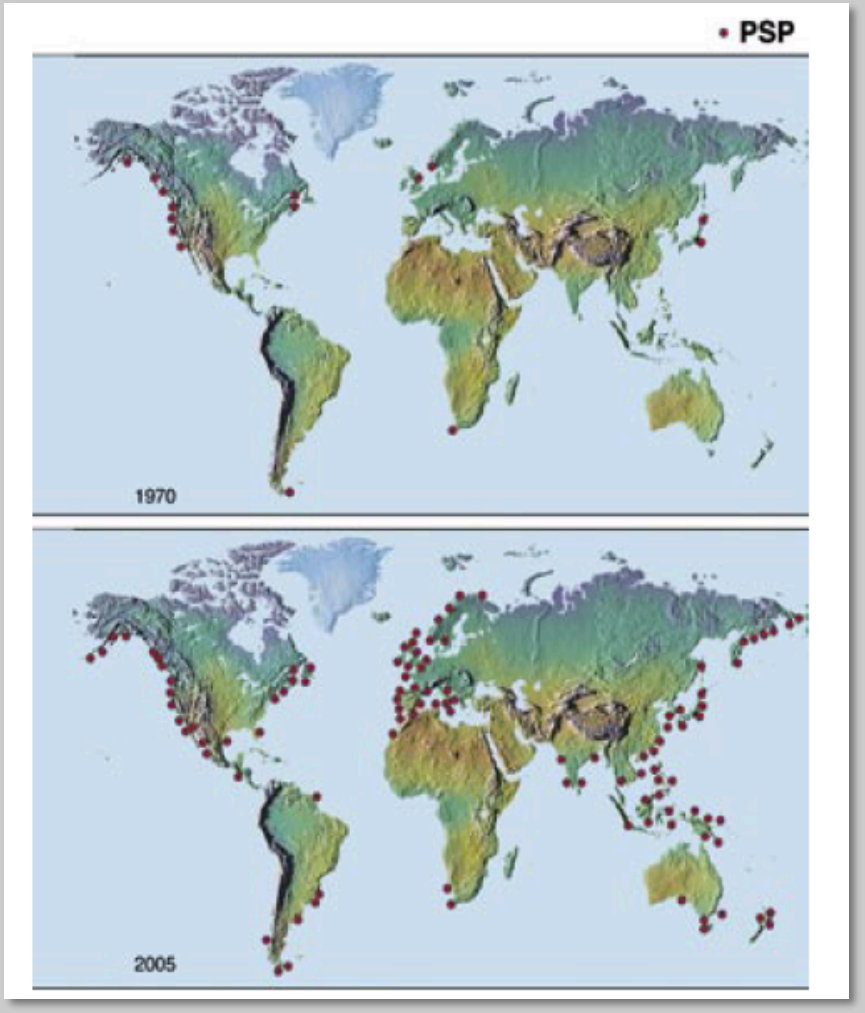
Istanbul, Turkey, 6th/8th October 2010

HARMFUL ALGAL BLOOMS IN THE MEDITERRANEAN SEA

Antonella Penna,
Dept. BioMolecular Sciences,
University of Urbino, Italy

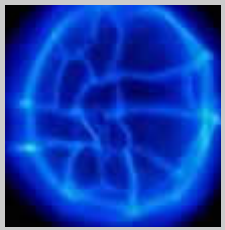
EU-FP5 Strategy Project EVK3-CT-2001-00046
EU-FP6 Seed Project GOCE-CT-2005-003875

RECENT TRENDS



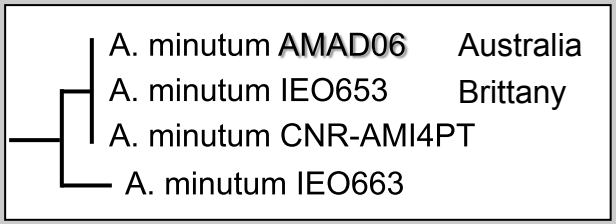
Cumulative global increase in the distribution of the causative organism and PSP toxins in shellfish

- Global Climate Change:
  acidification and temperature increases
- Hidden flora:
  use of innovative and more sensitive methods
- Natural dispersal
- Ballast waters
- Sediment resuspension
- Mariculture industry
- Accelerated eutrophication of coastal waters due to human activities



Phytoplankton high-biomass proliferation: a PSP toxin producer *Alexandrium minutum*

ITS-5.8 S rDNA based genotype



- Abundance increases over the biomass normal values
- Natural events or caused by anthropic system use
- They can cause noxious effects on the:
  - marine ecosystems,
  - human health,
  - fisheries, aquaculture, tourism

Penna A., Fraga S., Masò M., Giacobbe M.G., Bravo I., Vila M., Garcés E., Bertozzini E., Andreoni F., Luglié A., Vernesi C. 2008. Phylogenetic relationships among the Mediterranean *Alexandrium* (Dinophyceae) species based on sequences of 5.8S gene and internal transcribed spacers of the rRNA operon**.** *Eur. J. Phycol.,* 43: 163-178.

HAB Effects

Ecosystem

Effect	Group	Organism
Fauna mortality	Dinoflagellates	*Alexandrium* *Gymnodinium*
Hypoxia, anoxia, H2S	Dinoflagellates	*Prorocentrum*
Impact on feeding behaviour	Pelagophyceans	*Aureococcus*

Fishery and aquaculture

Effect	Group	Organism
Haemolytic, hepatotoxic, osmoregulatory effects and other unspecified toxicity	Dinoflagellates Raphidophyceans Prymnesiophyceans Dinoflagellates Cyanobacteria	*Amphidinium,* *Cochlodinium,* *Pfiesteira, Karenia* *Heterosigna,* *Chattonella,* *Chrysochromulina,* *Prymnesium,* *Microcystis*
Hypoxia, anoxia, H2S	Dinoflagellates	*Prorocentrum*
Impact on feeding behaviour	Pelagophyceans	*Aureococcus*
Mechanical damages	Diatoms	*Chaetoceros*
Gill clogging, necrosis	Prymnesiophyceans	*Phaeocystis*

Human health

Sindrom	Group	Organism
Paralytic shellfish poisoning (PSP)	Dinoflagellates	*Alexandrium* *Pyrodinium* *Gymnodinium*
Diarrhetic shellfish poisoning (DSP)	Dinoflagellates	*Dinophysis* *Prorocentrum*
Neurotoxic shellfish poisoning (NSP)	Cyanobacteria Dinoflagellates	*Karenia*
Amnesic shellfish poisoning (ASP)	Diatoms	*Pseudo-nitzschia*
Ciguatera fish poisoning (CFP)	Dinoflagellates	*Gambierdiscus*
Azaspiracid shellfish poisoning (AZP)	Dinoflagellates	*Protoperidinium*
Respiratory problems and skin irritations	Dinoflagellates	*Karenia, Ostreopsis*
Epatotoxicity	Cyanobacteria	*Microcystis, Nodularia*

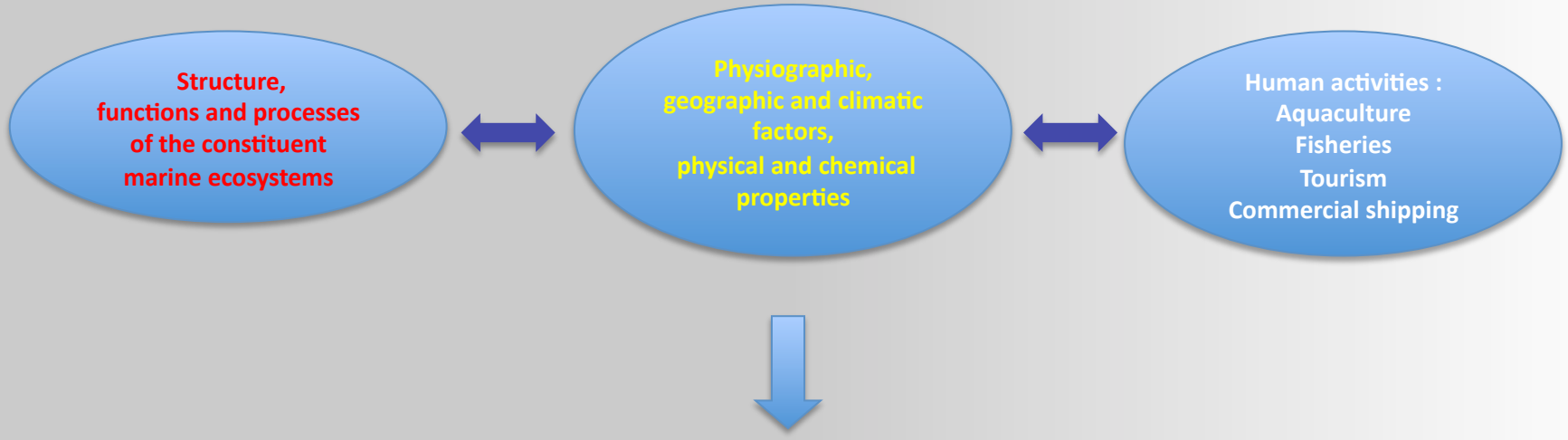
Tourism and recreational activities

Effect	Group	Organism
Foams, mucilages, discolorations, unpleasent smell	Dinoflagellates Prymnesiophyceans Diatoms Cyanobacteria	*Noctiluca, Alexandrium* *Phaeocystis* *Cylindrotheca* *Nodularia, Aphanizomenon,* *Microcystis, Lynghya*

Implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC)

The main objective:

to achieve or maintain good environmental status in the marine environment by the year 2020.



THE USE OF THE MARINE ENVIRONMENT IS AT LEVEL THAT IS SUSTAINABLE

The Marine Strategy must be adapted and made operational at regional and sub-regional scale based on common principles to all European waters.

Mediterranean Region

Sub-regions:

> the Western Mediterranean Sea
> the Adriatic Sea
> the Ionian Sea and Central Mediterranean Sea
> the Aegean-Levantine Sea

Member States shall, where practical and appropriate, use existing regional institutional cooperation structures, including those under Regional Sea Conventions, covering that marine region or sub-region.

JRC EUROPEAN COMMISSION

ICES CIEM

The MFWD requires a set of "criteria" and "methodological standards" to be established for the assessment of the Good Environmental Status (GES) to be defined between marine regions or subregions

Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems

Human – induced eutrophication has to be minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, Harmful algae blooms and O_2 deficiency in bottom waters

⇐ **GES**

DESCRIPTORS

- **D1-Biodiversity** ✸
- **D2-Non indigenous species** ✸
- **D3-Fisheries**
- **D4-Food web**
- **D5-Eutrophication** ✸ **HARMFUL ALGAL BLOOMS**
- **D6-Seafloor integrity**
- **D7-Hydrografic condition**
- **D8-Contaminants**
- **D9-Contaminats in seafood**
- **D10-Litter**
- **D11-Noise**

ROLE OF NUTRIENTS

Heisler et al. 2009, Harmful Algae

- DEGRADED WATER QUALITY from increased nutrient pollution promotes the development and persistence of many HABs and is one of the reasons for their expansion
- The composition–not just the total quantity–of the NUTRIENT POOL impacts HABs;
- High-biomass blooms must have EXOGENOUS NUTRIENTS to be sustained;
- Both chronic and episodic NUTRIENT DELIVERY promote HAB development;
- Recently DEVELOPED TOOLS AND TECHNIQUES are already improving the detection of some HABs, and emerging technologies are rapidly advancing toward operational status for the prediction of HABs and their toxins;
- Experimental studies are critical to further the understanding about the ROLE OF NUTRIENTS in HABs expression, and will strengthen prediction and mitigation of HABs;
- MANAGEMENT OF NUTRIENT INPUTS to the watershed can lead to significant reduction in HABs.

COASTAL CIRCULATION

- In nutrient rich environments, coastal circulation patterns determine the occurrence and persistence of massive dinoflagellate blooms.

- Relatively low shear environment, shoreward transport, and reduced flushing rates are essential for this type of persistent bloom manifestation.

PHYSICAL-BIOLOGICAL COUPLING

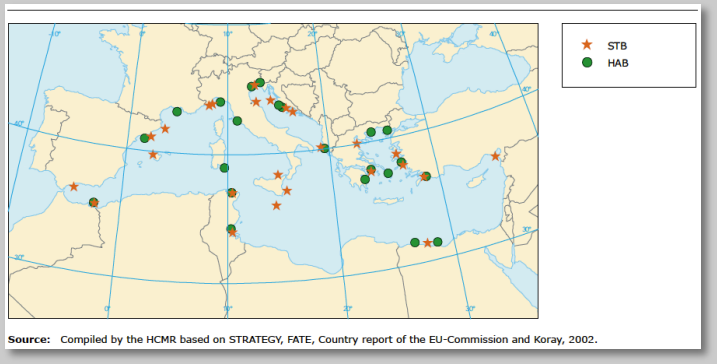
- Coupling between coastal circulation and vertical migration patterns promotes cell accumulation in the near-shore

Basterretxea et al. 2007, Mar. Ecol. Prog. Ser. 352: 53–65

EU-FP6 Seed Project GOCE-CT-2005-003875

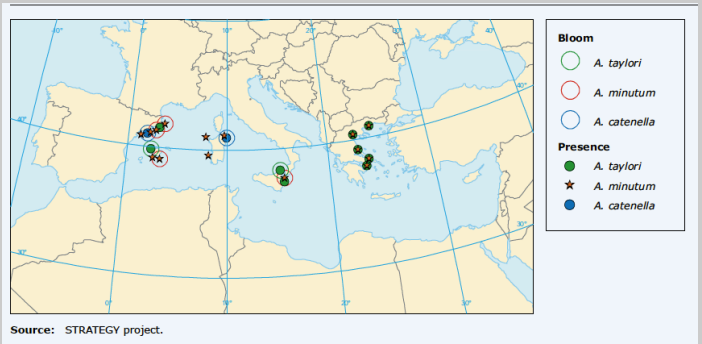
GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN COMMISSION
GÉNÉRALE DES PÊCHES POUR LA MÉDITERRANÉE

Harmful Algal Blooms (HABs) and Seafood Toxin Blooms (STBs) in the Mediterranean Sea



Source: Compiled by the HCMR based on STRATEGY, FATE, Country report of the EU-Commission and Koray, 2002.

Presence of *Alexandrium species and areas affected by blooms during first* sampling period (March–October 2002) in the Mediterranean Sea



Source: STRATEGY project.

EU-FP5 Strategy Project EVK3-CT-2001-00046

Pressures from human activities and their impacts

- sewage and urban run-off
  - nutrients

Habitat destruction and physical alteration

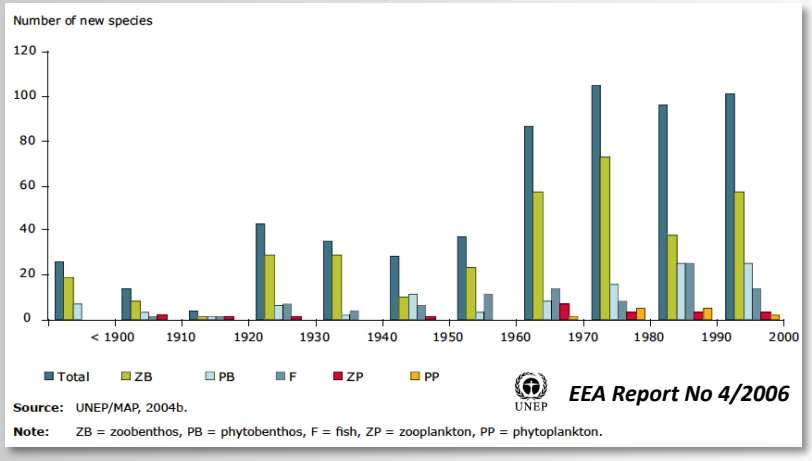
- shoreline construction and alteration
- wetland and salt-marsh alteration
- marine waters and coastal watershed alteration

EUTROPHIC CONDITIONS can cause changes in the phytoplankton population for both native and allochthonous species

ALLOCHTHONOUS species can be more susceptible forming harmful algal bloom than native phytoplankton species while affected by eutrophic conditions

INVASIVE alien phytoplankton species are known to cause harmful algal blooms including those resulting in production of PSP and DSP toxins or causing fish kils

Rate of detection of exotic species in the Mediterranean



ALEXANDRIUM CATENELLA: A TOXIC RIBOTYPE EXPANDING IN THE NW MEDITERRANEAN SEA

Penna et al. Strategy report , Athens 2004

- In the NW Mediterranean area a clear *MONOMORPHISM* of *A. catenella* isolates is present
- In the temperate Japanese area it is evident a *POLYMORPHISM*
- Genetic variability absence in the NW Mediterranean area
- Founder effect of *A. catenella* in the NW Mediterranean originating from Temperate Asia

- HYPOTHESIS OF THE INTRODUCTION OF *A. catenella* INTO MEDITERRANEAN

Penna A., Garcés E., Vila M., Giacobbe M.G., Fraga S., Luglié A., Bravo I., Bertozzini E., Vernesi C. 2005. *Alexandrium catenella* (Dinophyceae), a toxic ribotype expanding in the NW Mediterranean Sea. *Mar. Biol.,* 148: 13-23.

IMPACT OF ALLOCHTONOUS SPECIES:

- Indicators of climatic changes >> tropicalization of the Mediterranean Sea
- Indicators of disturbance >> polluted or physically degraded environments are more prone to invasion than pristine site

ROLE OF RESTING STAGES

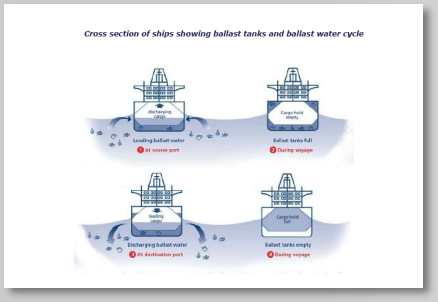
- Species dispersal,
- Genetic recombination,
- Seeding for bloom initiation,
- Survival during unfavorable condition
- Reservoir of potential diversity for decades

Analyses of the temporal abundance of resting cysts are essential for the development of conceptual models of bloom dynamics

Cyst abundance in the sediment is considered to reflect the potential for subsequent blooms

ROLE OF DISPERSION

- Natural by currents
- Plastic mediated
- Human assisted : ballast water, mollusc stock, dredging of sediments

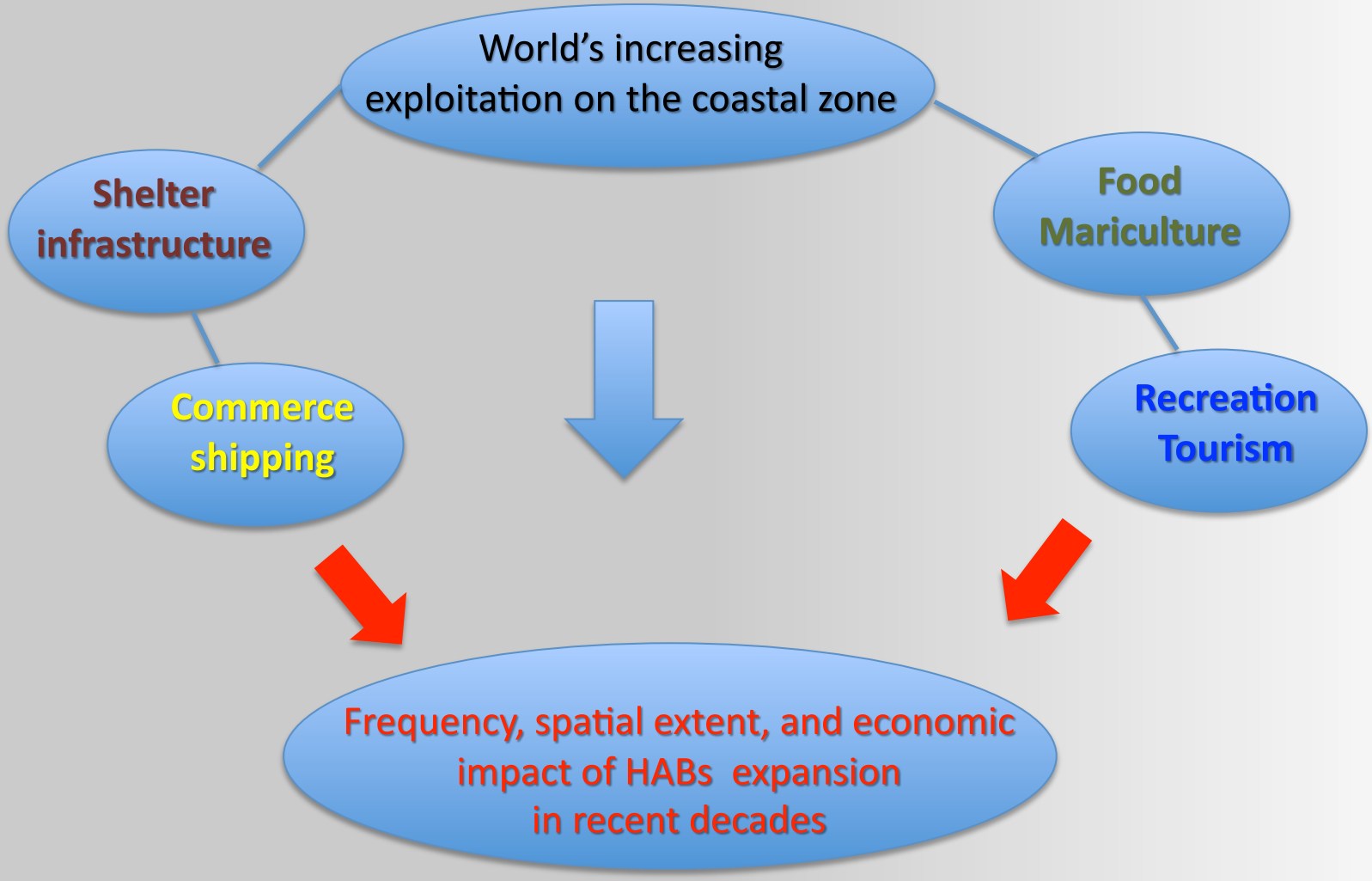


EU-FP5 Strategy Project EVK3-CT-2001-00046

NEW INVASIVE SPECIES IN THE MEDITERRANEAN SEA
Benthic toxic dinoflagellates

Alien or hidden flora?

- *Ostreopsis* spp. occurrence
- Epiphytic on soft and hard substrata
- Toxic blooms with aerosol
- High biomass proliferation, biofilm or mucilage
- Human intoxication
- Water quality deterioration
- Benthic communities suffering or mortalities


World's increasing exploitation on the coastal zone
Shelter infrastructure
Food Mariculture
Commerce shipping
Recreation Tourism
Frequency, spatial extent, and economic impact of HABs expansion in recent decades

PLAN ACTION OF HARMFUL ALGAL BLOOMS

- CONTROL HAB: monitoring of HAB events through the integrated innovative methodologies

- SCIENTIFIC AWARENESS: new toxin and species occurrences, as well as a holistic approach of study

- MITIGATION STRATEGY: - input of nutrients through the assessment of sewage treatment and discharge
- regulation of human mediated transport
- pollution (prevention of risk of HAB alien species dispersal)
- infrastructure (alteration of natural hydrodynamic of coastal circulation)

- PREDICTION ACTION: empirical modelling for the decision making

OCEAN CLIMATE CHANGE AND COMMUNITY RESPONSE OF PHYTOPLANKTON/HAB

Prediction of the impact of global climate change on marine HABs is rather difficulty,

- Increasing temperature,
- Enhanced surface stratification,
- Alteration of ocean currents,
- Intensification or weakening of local nutrient upwelling,
- Stimulation of photosynthesis by elevated CO_2,
- Reduced calcification through ocean acidification,
- Heavy precipitation and storm events

Contradictory species or even strain specific responses

Hallegraeff J. Phycol. 2010

MEDITERRANEAN HAB NETWORKS AND RELATED PROGRAMMES

- IOC-HAB Programme: HAB programmes coordinated by the International Oceanographic Commission (IOC) of UNESCO; Paris, France

- GEOHAB: Global Ecology and Oceanography of Harmful Algal Blooms

- The French Phytoplankton and Phycotoxin Monitoring Network: REPHY, Ifremer, France

- DETAL: Detection of toxic algae using molecular probes; Banyuls-sur-Mer, France

- RED IBérica de ALgas nocivas y biotoxinas: Iberian network on harmful algae and biotoxins; in Spanish, Portuguese and English

- Ecology and Evolution of Plankton: Stazione Zoologica Anton Dohrn di Napoli, Naples, Italy

- BENTOX-NET A network for the study of *Ostreopsis* spp.

- **The projects of the EUROHAB initiative (Mediterranean countries):**

  - **BIOHAB (Biological control of harmful algal blooms in European coastal waters: Role of eutrophication) (France, Spain)**
  - **HABES (Harmful Algal Bloom Expert system), Harmful Introductions by Ships) (Spain)**
  - **STRATEGY (New strategy of monitoring and management of HABs in the Mediterranean Sea) (France, Greece, Italy, Spain)**
  - **ALIENS (Algal introductions to European shores) (France, Italy, Spain)**
  - **FATE (Transfer and fate of Harmful Algal Bloom toxins in European marine waters) (Greece)**
  - **SEED (Life history transformations among HAB species, and the environmental and physiological factors that regulate them) (Spain, Italy, Finlan, Estonia, Sweden, UK, Ireland, USA)**

EU- FP5 STRATEGY
EVK3-CT-00046-2001
"New Strategy of Monitoring and Management in the Mediterranean Sea"