GFCM

Workshop on

“*Algal and Jellyfish Blooms in the Mediterranean and Black Sea*”

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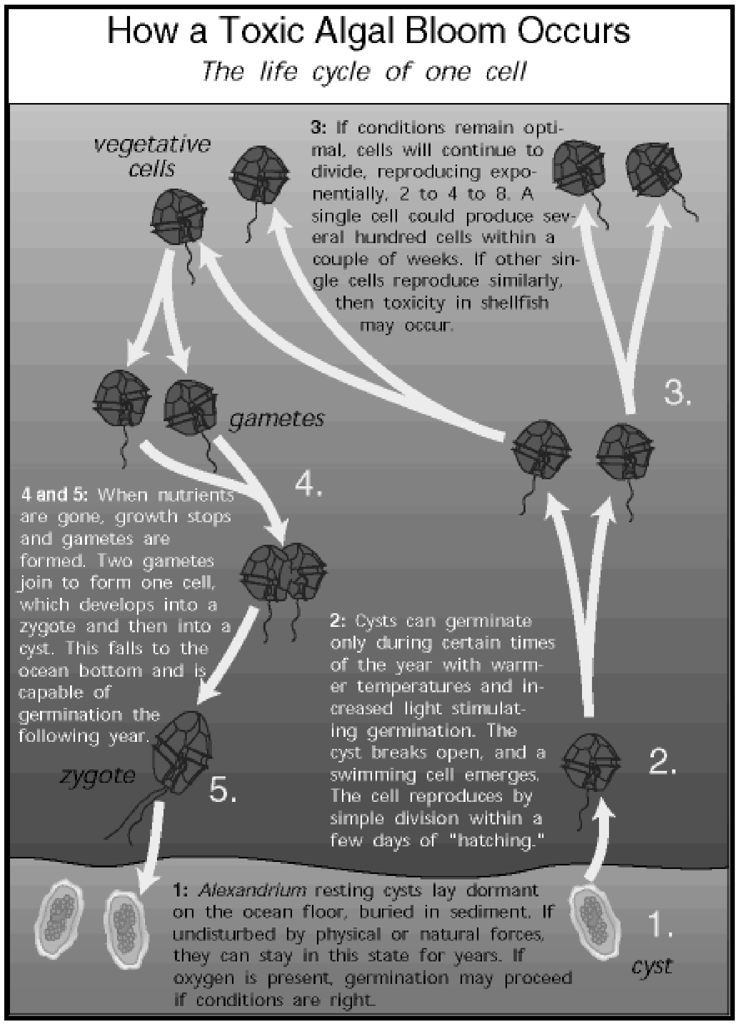
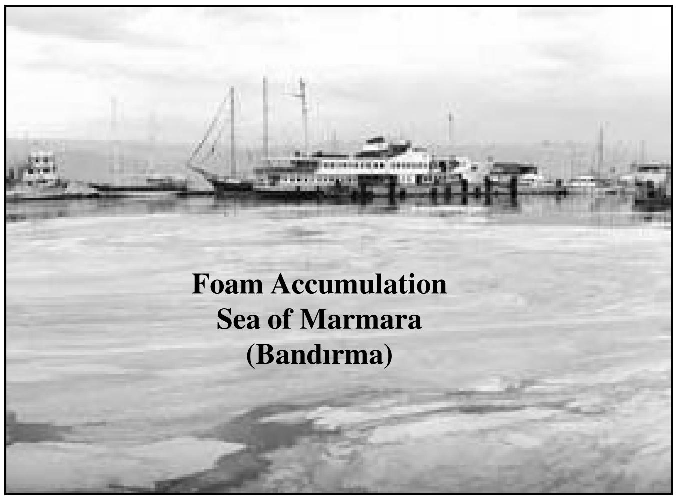
Algal Blooms in the Mediterranean and Black Sea

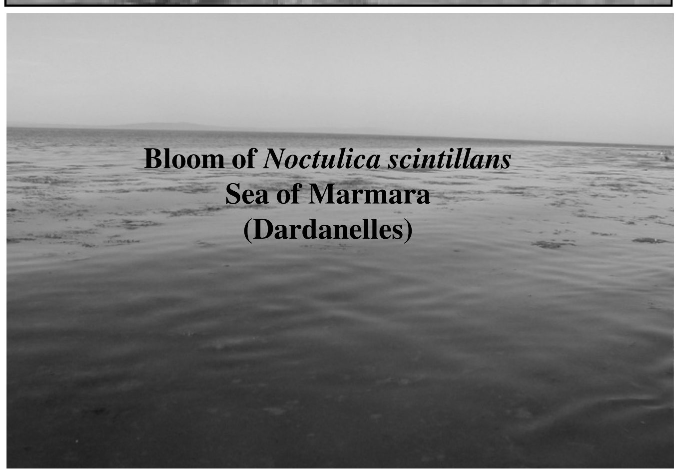


- Harmful algal blooms (HABs) have been increasing in prevalence in the Mediterranean for the past 25 years to the point where they are common in coastal areas of the Mediterranean.
- **These blooms affect negatively human health, dynamic ecosystem structure, marine mammals, the fishing, aquaculture, and recreation industries.**

Algal Blooms in the Mediterranean and Black Sea



Foam Accumulation
Sea of Marmara
(Bandırma)



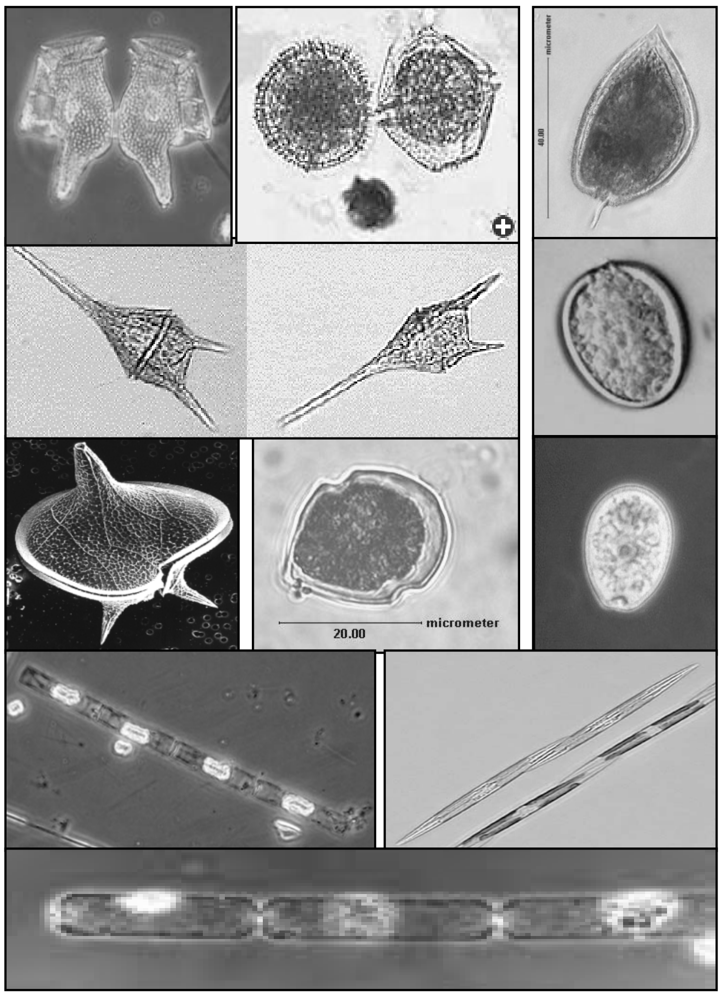
Bloom of *Noctulica scintillans*
Sea of Marmara
(Dardanelles)

- Intensive accumulations of phytoplankton, benthic micro- and macroalgae and, sometimes, colorless heterotrophic protists are increasingly reported along the coastal areas of all continents (Sellner et al. 2003) often causing visible water discoloration (*Glibert 2007*).

- **In fact, extensive blooms of these organisms can discolour the water giving rise to red, mahogany, brown, or green tides, and also can float on the surface in foam, cover beaches with biomass or exudates such as foam and deplete oxygen levels due to excessive respiration or decomposition (***Sellner et al. 2003, Glibert 2007***).**

- Phytoplankton blooms, micro-algal blooms, toxic algae, red tides, or harmful algae, are all terms for this naturally occurring these phenomena (*IOC HAB Programme 2010*).

Algal Blooms in the Mediterranean and Black Sea

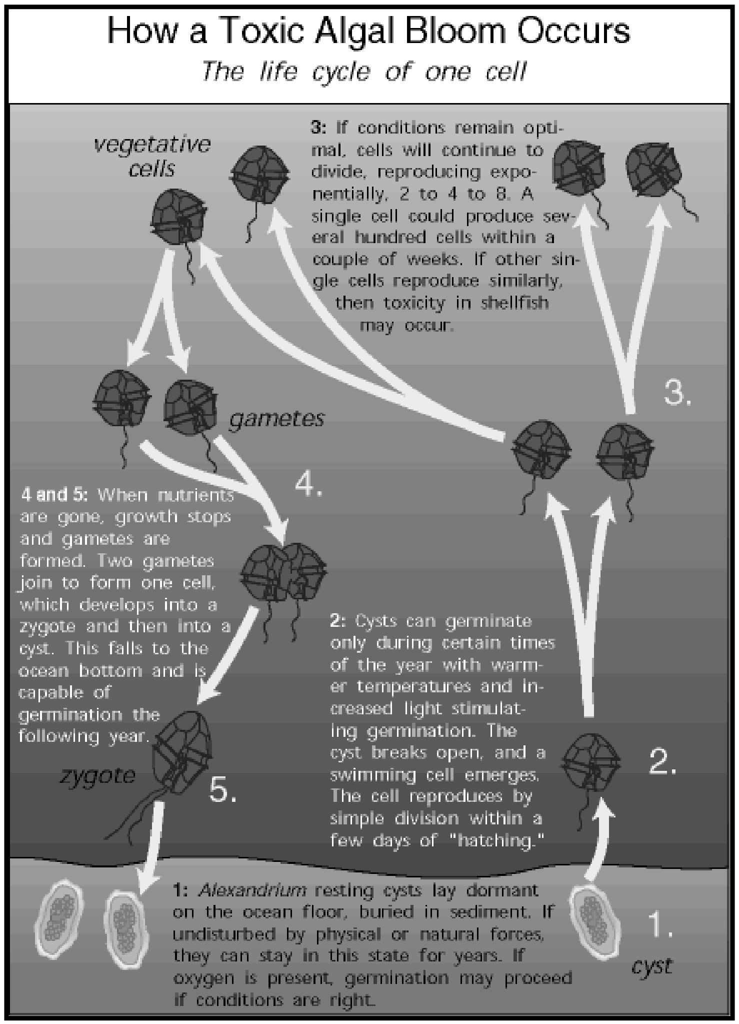


- **About 300 species of microalgae are reported at times to form mass occurrence, so called "blooms" and nearly one fourth of these species are known to be toxic or to produce toxins** (*IOC HAB Programme 2010*)**.**

- The more scientist generally refers to these events with the term, 'Harmful Algal Bloom' or it's abbreviation "HAB" (*IOC HAB Programme 2010*).

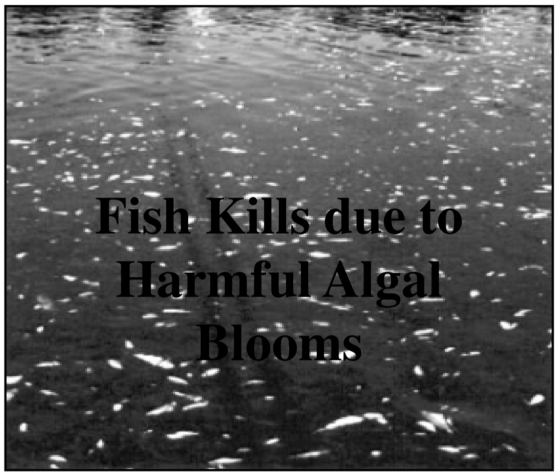
- **In fact, rapid growth and thereby dense accumulation of microalgae or phytoplankton in marine or brackish waters can cause massive fish kills, contaminate seafood with toxins and change ecosystems in ways that humans feel as harmful (***IOC HAB Programme 2010***).**

Algal Blooms in the Mediterranean and Black Sea



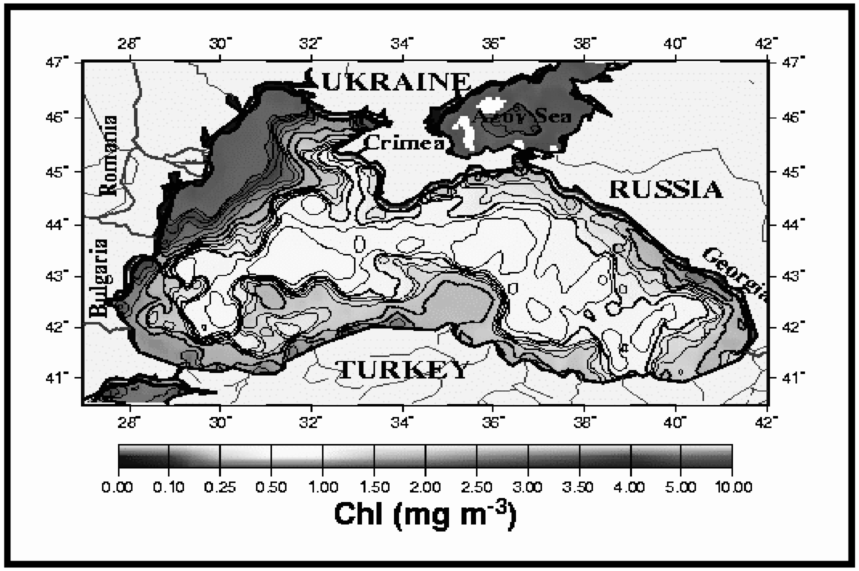
- HABs statement is not only used for toxic algal blooms but also used for no toxic algal blooms.
- **Therefore, a comprehensive classification of HABs divides two groups of organisms: (1) the toxin producers – which can contaminate seafood such as fish and shellfish – and (2) the no toxin but highbiomass producers – which can cause anoxia or hyperoxia and thereby indiscriminate kills of marine life after reaching dense concentrations (*Smayda 1997*, *IOC HAB Programme 2010*).**
- This type of bloom can also lead to fish starvation or cause harmful mechanical and physical damage and chemical effects attributable to physicalchemical reactions, phycotoxins, or other metabolites (*Smayda 1997*).
- **Some HABs have characteristics of both (*IOC HAB Programme 2010*).**

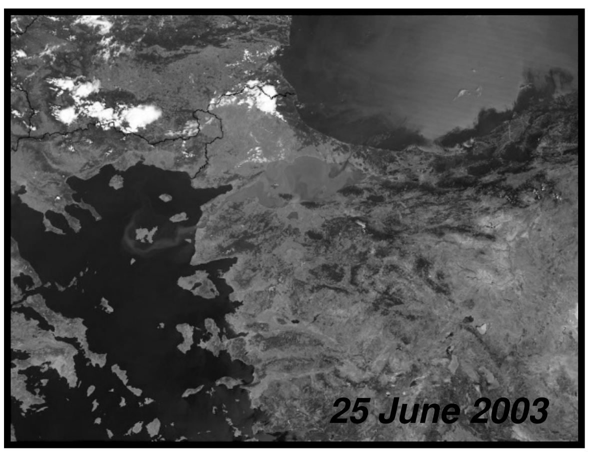
Algal Blooms in the Mediterranean and Black Sea



- Harmful algal blooms which produce toxin activate their effects thanks to the synthesis of toxins compounds that can modify cellular process of other organisms from plankton to humans.
- **The most serious effects of HABs include fish, bird, and mammal (including human) mortalities, respiratory or digestive tract problems, memory loss, seizures, lesions and skin irritation, as well as losses of coastal resources such as benthic flora and fauna (***Sellner et al. 2003***).**
- Reasons for the increasing interest in HABs include not only public safety concerns associated with protecting human health, but also adverse effects on living resources of many coastal systems, economic losses attributed to reduced tourism, recreation, or seafood related industries, and costs required to maintain public advisory services and monitoring programs for shellfish toxins, water quality, and plankton composition (*Sellner et al. 2003*).

Algal Blooms in the Mediterranean and Black Sea





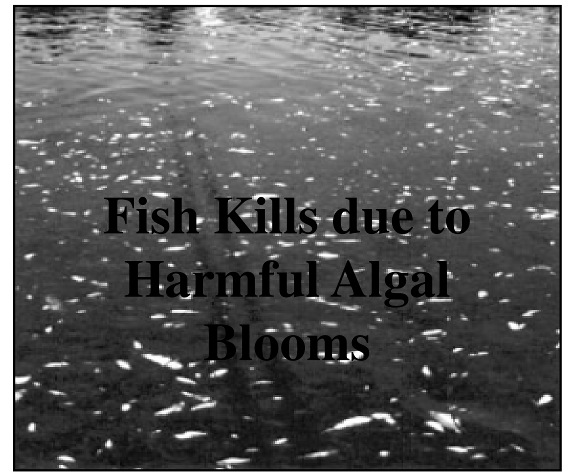
- Many of the syndromes and other harmful effects belong to dinoflagellate species. However, there is an increasing number of species recognized as toxic in other algal classes and harmful species are now found in previous groups of algae. The most important ones of them are compiled at least 5 groups (IOC HAB Programme 2010):

  - *Cyanophycae* (blue-green algae)
  - *Dinophycae* (dinoflagellates)
  - *Prymnesiophycae* (*Haptophycae*)
  - *Bacillariophycae* (diatoms)
  - *Raphidophycae*

Algal and Jellyfish Blooms in the Mediterranean and Black Sea

- Here, in Turkey Seas, thereby Mediterranean ecosystem, the effects of microalgal blooms include seawater discoloration, offshore and inshore fish kills, bird, marine reptile and marine mammal mortalities, respiratory irritation in humans, and economic losses, especially in view of fisheries, in the millions to local coastal communities.

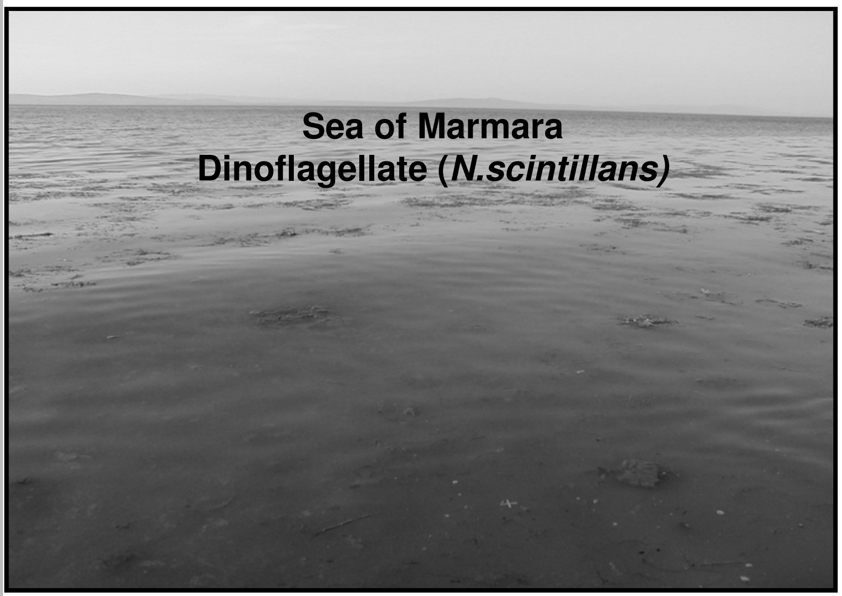
- **As with many HABs, microalgal toxins can be associated with shellfish such as oysters and clams, and these sources of toxicity can cause public health concerns (Koray et al., 2001).**



- The Mediterranean and Black Sea basins have been experiencing various algal blooms events during the last 55 years mostly in areas such as bays, lagoons, ports beaches and estuaries. It was in 1955's spring that fish mortalities associated with red-tides first reported by W. Nümann from a Turkish cost of the Agean Sea.

- **Since then, red-tides and other noxious algal blooms mainly due to progressive eutrophication from terrestrial inputs were observed almost each year by reporters and Turkish and other scientists (Koray et al., 2001).**

Algal Blooms in the Mediterranean and Black Sea



- Phytoplanktonic members of the list clearly has showed a yearly succession and their total biomass increased from oligotrophic toward the eutrophic zones of the not only bays, but also all of the seas such as Turkish Strait System and Black sea.

- For instance, excessive bloom of a coccolithophore *E. huxleyi* in Sea of Marmara showed a pronounced expansion effecting all of the system in early summer, 2003 (Turkoglu, 2008a).

- Moreover, the system was a common area in view of foaming anymore (Turkoglu, 2008b; Balkıs et al., 2010; Tufekci et al., 2010).

- During the pronounced and widespread blooms of dinoflagellates such as *P. micans*, *N. scintillans*, *A. minutum*, *G. simplex*, *S. trochoidea,* seawater is remarkably discolored red or orange.

- Coccolithophorides such as *E. huxleyi*, diatoms such as *Pseudonitzschia* spp., *Rhizosolenia* spp., and euglenoids (*Eutreptiella gymnastica*) are also associated with different discoloration of seawater such as milky and turquoise due to the bloom of *E.huxlei* or green due to the algal blooms of all of the diatoms, euglenoids and prasinophytes in Turkish Seas (Koray et al., 2001; Turkoglu and Koray, 2004; Turkoglu, 2008a).

Algal Blooms in the Mediterranean and Black Sea

Table 1. Harmful microalgae of Turkish seas (***Abbreviations used***: **mc**, maximum cell number in one liter; **z**, depth of maximum cell abundance; **L**, LLoyd patchines index; **T**, type of noxious effect: **PSP**, paralytic Shellfish Poison; **DSP**, Diarrhetic Shellfish Poison; **ASP**, Amnesic Shellfish Poison; **HT**, Hepatotoxic; **HO**, hyperoxia; **AO**, anoxia; **NH_3**, Ammoniac; **?**, unknown)

➢**According to the results of these researches, since 1980, the most common species causing red-tides in the Turkish seas are presented in Table 1 (Koray et al., 2001).**

Species	Colour	mc	Z (m)	L	T
CYANOPHYCEAE					
Anabaena spiroides	reddish-brown	?	?	?	HT
A. variabilis	reddish-brown	?	?	?	HT
DINOPHYCEAE					
Alexandrium minutum	reddish-brown	10^7	2.41	2.90	PSP
Ceratium furca	orange	$4.0 \cdot 10^4$	3.98	4.76	HO-AO
Dinophysis acuminata	orange	?	?	?	DSP
D. acuta	orange	?	?	?	DSP
D. caudata	orange	?	?	?	DSP
D. fortii	orange	?	?	?	DSP
D. mitra	orange	?	?	?	DSP
D. rotundata	orange	?	?	?	DSP
D. sacculus	orange	?	?	?	DSP
D. tripos	orange	?	?	?	DSP
Gonyaulax grindleyi	orange	?	?	?	DSP
G. polyedra	reddish-brown	$5.0 \cdot 10^4$	2.96	7.42	?
G. spinifera	reddish-brown	$2.0 \cdot 10^4$	2.56	7.47	PSP?
Gymnodinium simplex	greenish-brown	?	?	?	?
Gyrodinium spirale	orange	?	?	?	?
Noctiluca scintillans	pink	$2.0 \cdot 10^4$	0.50	2.00	NH_3
Oxytoxum scolopax	Pale orange	$2.0\ 10^4$	5.00	12.50	?
Prorocentrum cassubicum	Pale orange	?	?	?	DSP
P. dentatum	orange	$6.0 \cdot 10^6$	?	?	HO-AO
P. lima	orange	?	?	?	DSP
P. micans	orange	$9.0 \cdot 10^7$	3.45	2.60	HO-AO
P. triestinum	orange	$6.0 \cdot 10^4$	3.32	2.10	HO-AO
P. minimum	pale brown	?	?	?	?
Protoperidinium longipes	orange	$2.0 \cdot 10^4$	5.20	18.41	?
P. steinii	orange	$7.0 \cdot 10^4$	2.54	9.09	?
Scripsiella trochoidea	brown	$6.0 \cdot 10^6$	0.44	13.32	?

Species	Colour	mc	Z (m)	L	T
PRYMNESIOPHYCEAE					
Emiliania huxlei	milky	10^6	?	?	?
BACILLARIOPHYCEAE					
Biddulphiales					
Coscinodiscus granii	greenish-brown	$2.0 \cdot 10^3$	7.03	2.18	HO-AO
Thalassiosira allenii	pale green	10^6	2.55	3.67	HO-AO
T. anguste-lineata	greenish-orange	10^5	5.30	3.60	HO-AO
T. rotula	greenish-orange	$2.0\ 10^4$	8.94	3.86	HO-AO
Bacillariales					
Cylindrotheca closterium	pale green	10^5	3.38	2.08	?
Phaeodactylum tricornutum	pale brown	10^7	3.26	1.27	?
Pseudo-nitzschia delicatissima	milky	?	?	?	ASP
P. pseudodelicatissima	milky	?	?	?	ASP
P. pungens	pale green	$8.0 \cdot 10^6$	0.50	?	?
EUGLENOPHYCEAE					
Eutreptiella gymnastica	green	$7.0 \cdot 10^5$	1.68	3.01	HO-AO
PRASINOPHYCEAE					
Pyramimonas propulsa	green	$3.7 \cdot 10^7$	?	?	?

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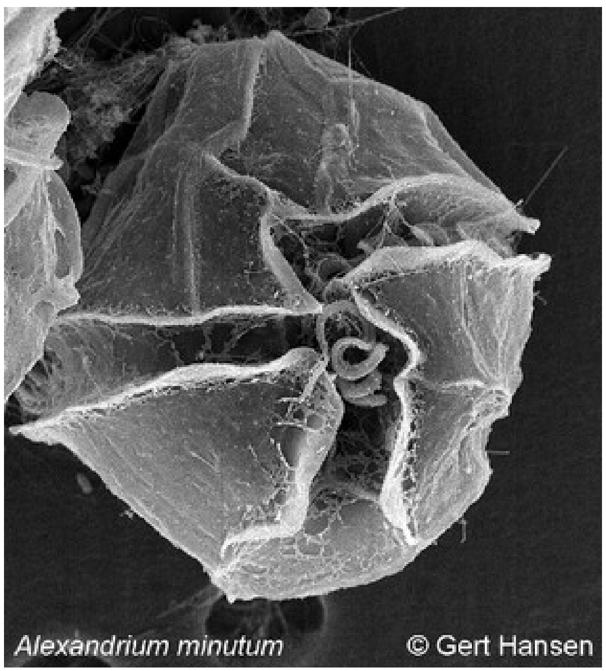

- **Among these, only *A. minutum* have long been known as toxic and to be associated with bivalves and fish mortality. Although there is no clear evidence on PSP in the bay of Izmir (Eastern Aegean Sea), death of fishes due to this species is always characterized with visible yellowish color which can be observed on total body and gills.**

- Levels of *A. minutum* exceeding 6-10 millions cells per liter when toxicity occurs. However, during the algal blooms of the bay of Izmir (Aegean Sea), demersal and pelagic fishes also exhibit anoxia symptoms.

- **These symptoms are also followed both during non-toxic bloomings of the diatoms *Thalassiosira anguste-lineata*, *T. allenii* and euglenoid *Eutreptiella gymnastica* at nights.**

- Thousands of the crap *Carcinus mediterraneus* migrate onto land at night when oxygen deficiency occurs. On the contrary, air bubbles are formed by high rate of photosynthesis during the day, seawater is supersaturated by dissolved oxygen and concentration frequently reach 17-22 mg L^{-1}, where air bubbles are observed on surface during bloomings.

- **This hyperoxia may be another risk factor for some marine consumers (Koray et al., 2001). *Ceratium fusus, Dinophysis acuminata, D. acuta, D. caudata, D. fortii, D. mitra, D. rotundata, D. sacculus, D. tripos, Gonyaulax grindleyi, Prorocentrum cassubicum* and *P. lima* are the other risky species found in the plankton of Turkish seas (Koray et al., 2001).**

Algal Blooms in the Mediterranean and Black Sea


A nutritious meal of mussels can cause illness and even death when algal toxins are present.

- **As summarized above, although the impact of algal blooms on some fishes (***mullets, sardines, anchovies, gobiids***) is frequently observed, little is known about which factor plays a major role on mortalities, anoxia or PSP reason respiratory paralysis, and how it influences the organisms.**

- Both anoxic and hyperoxic layers (***frequently overlaps with sub-surface cell maxima layer***) that are respectively formed by decomposition of the sedimented cells and high photosynthetic rate in the middle of bloomings are unfavourable environments for many marine pelagic organisms.

- **In examining the impacts of toxic or non-toxic red-tide organisms in the Turkish seas shellfish populations (*Mytilus galloprovincialis, Tapes decussata, Cardium edule, Venus* spp.).**

- However, because little use of shellfishes as food is currently made during springs, toxicity is rarely a risk factor for inhabitants in Turkey (Koray et al., 2001).

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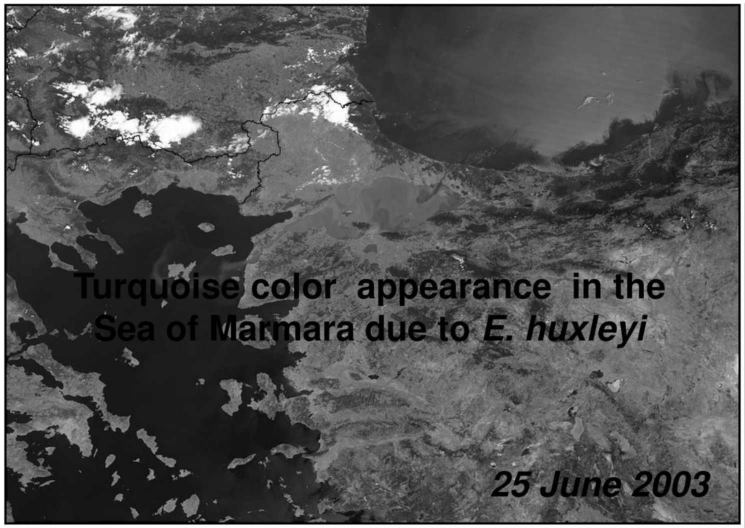
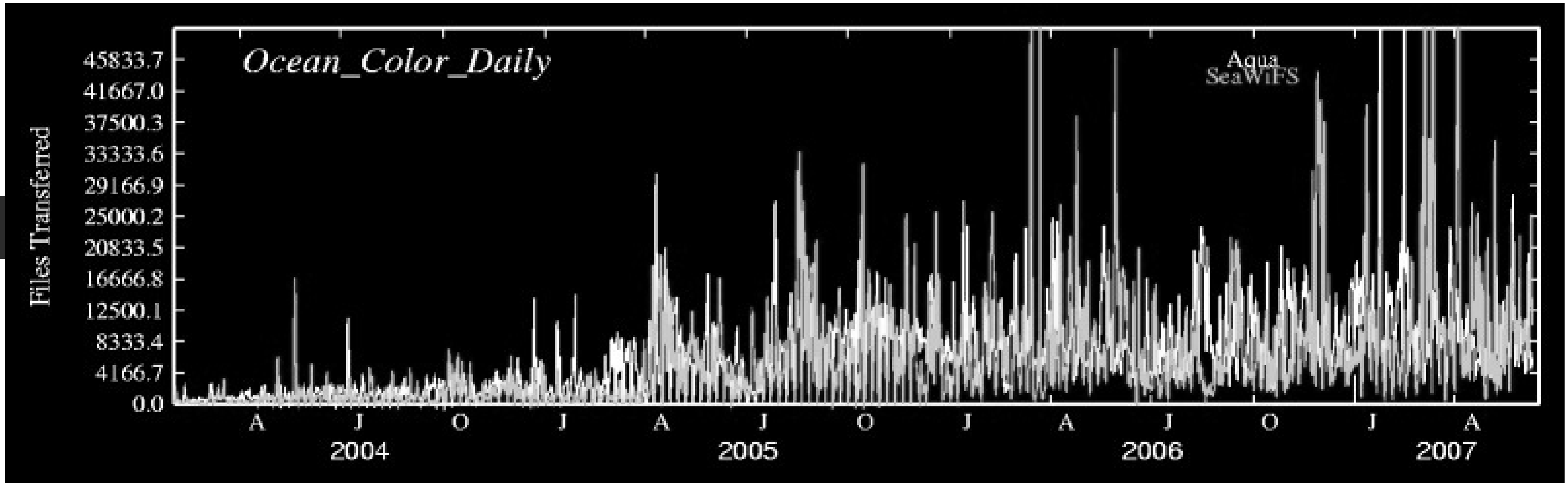


- **<u>In the Black Sea and Turkish Straits System,</u>** Coccolithophore *E. huxleyi* is one of the most abundant phytoplankton (*Cokacar et al. 2001; Turkoglu 2008a, 2008b*) which also occure globally in the oceans in early summer periods (*Hattori et al., 2004*).

- In summer, high surface irradiance, shallow stratification with a mixed layer depth of about 20 m, anomalies in salinity and temperature, low phosphate and silicate concentrations compose favorable conditions for *E. huxleyi* bloom in the Turkis Strait system and Black Sea (*Cokacar et al. 2001, 2004; Turkoglu, 2008, 2010*).

- **However, following a very excessive summer bloom of coccolithophore in June and July 2003 (Turkoglu, 2008), a winter bloom was observed for the first time between late December 2003 and early January 2004 in the Dardanelles (**Turkoglu, 2010**).**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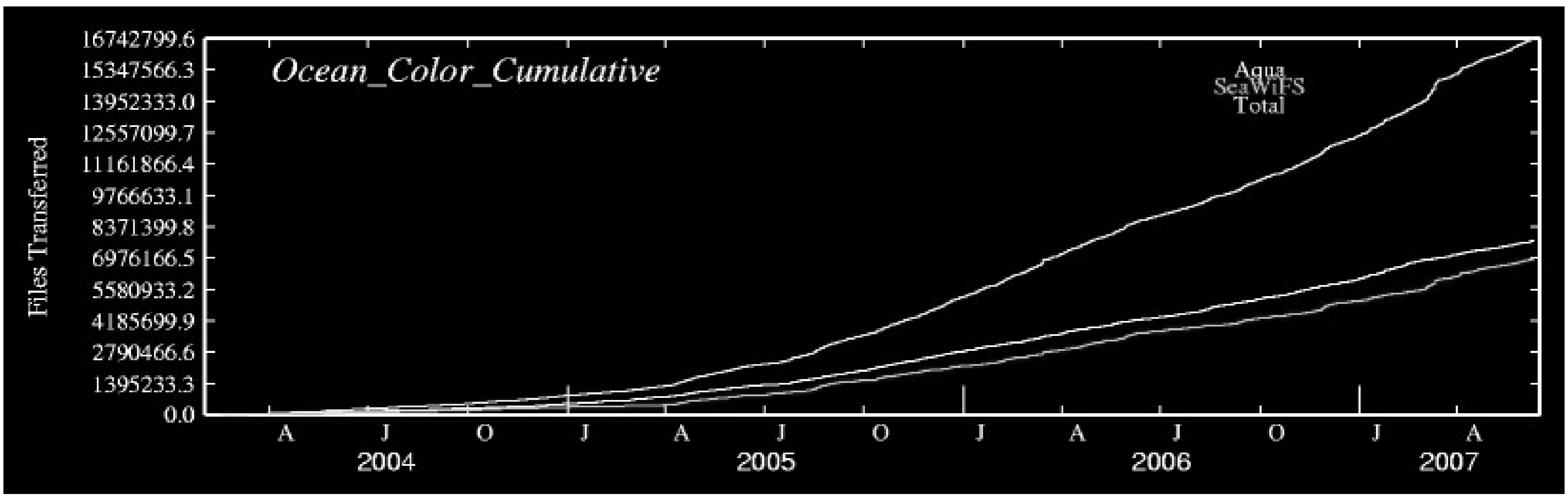
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References

1. **Balkis, N., Atabay, H., Turetgen, I., Albayrak, S., Balkis, H., Tufekci, V., 2010.** Role of single-celled organisms in mucilage formation on the shores of Buyukada Island (the Marmara Sea). *Journal of the Marine Biological Association of the United Kingdom*, doi: 10.1017/S0025315410000081.
2. **Glibert, P.M., 2007.** Eutrophication and Harmful Algal Blooms: A Complex Global Issue, Examples from the Arabian Seas including Kuwait Bay, and an Introduction to the Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) Programme. International Journal of Oceans and Oceanography ISSN 0973-2667. 2(1):157-169
3. **Cokacar, T., Kubilay, N., Oguz T., 2001.** Structure of Emiliania huxleyi blooms in the Black Sea surface waters as detected by SeaWIFS imagery. Geophysical Research Letters 28, 4607–4610.
4. **Cokacar, T., Oguz, T., Kubilay, N., 2004.** Satellite-detected early summer coccolithophore blooms and their interannual variability in the Black Sea. Deep-Sea Research I 51, 1017–1031.
5. **Hattori, H., Koike, M., Tachikawa, K., Saito, H., Nagasawa, K., 2004.** Spatial variability of living coccolithophore distribution in the Western Subarctic Pacific and Western Bering Sea. Journal of Oceanography 60, 505–515.
6. **IOC HAB Programme, 2010.** What are Harmful Algae? http://www.ioc-unesco.org/hab/
7. **Koray, T., Gokpinar, S., Yurga, L., Turkoglu, M., Polat, S., 2001.** Harmful Marine Microalgae (algal blooms, red-tides, color tides, outbreaks) from Turkish Seas. http://plankweb.ege.edu.tr/blooming.html (2010).
8. **Sellner, K.G., Doucette, G.J., Kirkpatrick, G.J., 2003.** Harmful algal blooms: Causes, impacts and detection. J Ind Microbiol Biotechnol, 30: 383-406.
9. **Smayda, T.J., 1997.** What is a bloom? A commentary. Limnol Oceanog., 42: 1132–1136.
10. **Tufekci, V., Balkis, N.,, Polat, B.Ç., Ediger, D., Mantikci, M., 2010.** Phytoplankton Composition and Environmental Conditions of the Mucilage Event in the Sea of Marmara. Turk. J. Biol., 34 (2): 199-210.
11. **Turkoglu M., Koray, T., 2004.** Algal blooms in surface waters of the Sinop Bay in the Black Sea, Turkey. Pakistan Journal of Biological Sciences 7:1577-1585.
12. **Turkoglu, M., 2008a.** Synchronous blooms of the coccolithophore Emiliania huxleyi (Lohmann) Hay & Mohler and three dinoflagellates in the Dardanelles (Turkish Straits System). Journal of the Marine and Biological Association of the United Kingdom, 88 (3): 433-441.
13. **Turkoglu, M., 2008b.** Is different coloring and foam formation in marine waters of Turkish Strait Systems result of excessive oganic material accumulation and global climate change? Çanakkale Environmental Problems Symposium, Bulletin Book (Oral Presentation), p.223. 05-06 June, Çanakkale, Turkey (in Turkish).
14. **Turkoglu, M., 2010.** Winter bloom and ecological behaviors of coccolithophore Emiliania huxleyi (Lohmann) Hay & Mohler, 1967 in the Dardanelles (Turkish Straits System). Hydrology Research, 41 (2): 104-114.

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