RADIOLOGICAL IMPACT ASSESSMENT IN THE SOUTHEASTERN MEDITERRANEAN AREA

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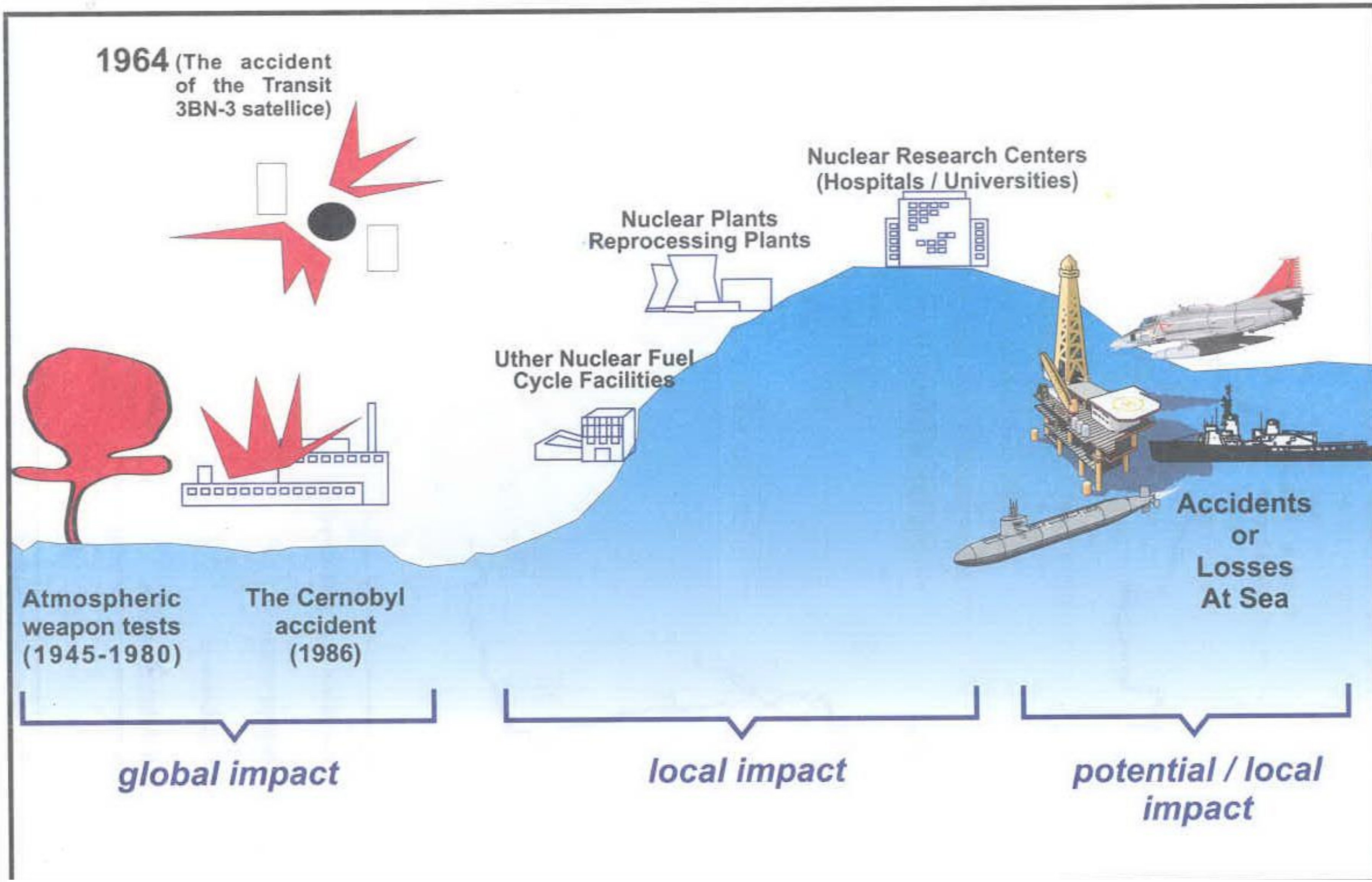
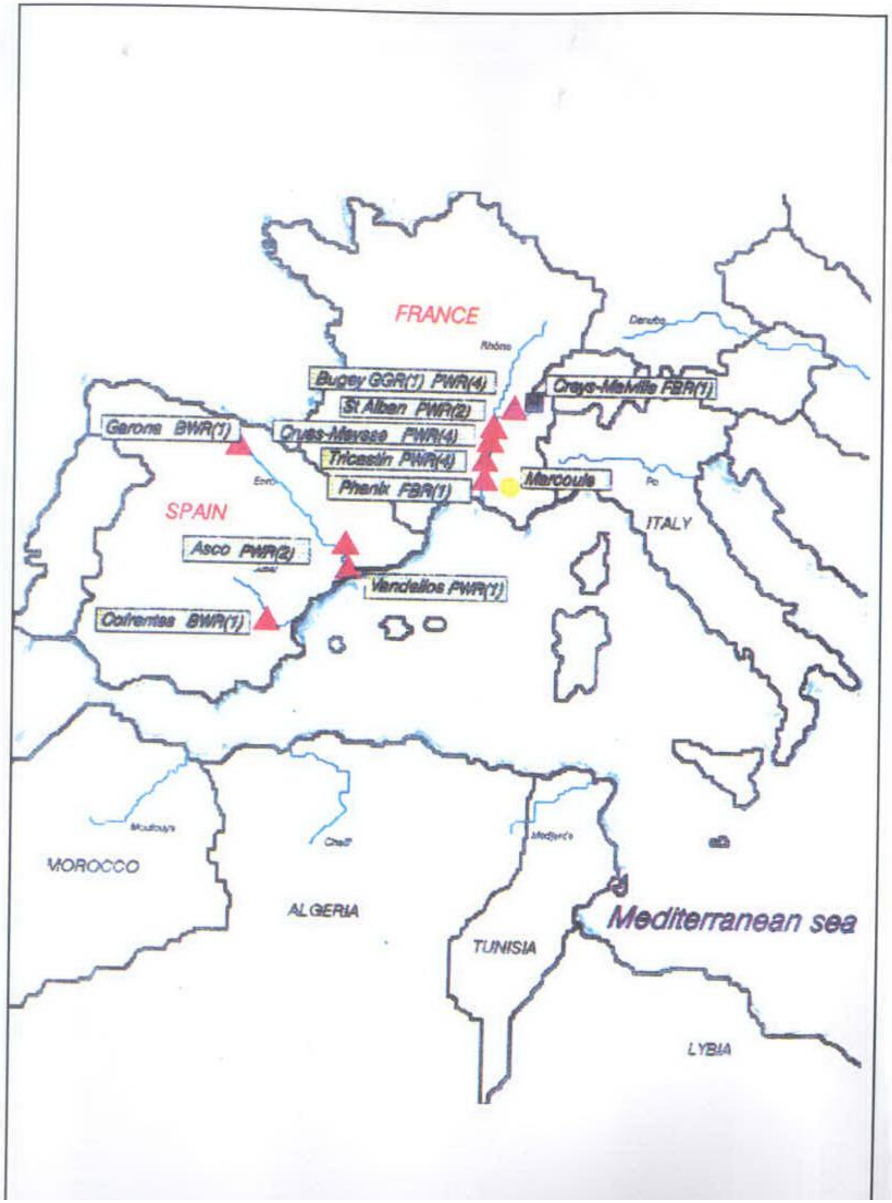
Introduction

- A description of the present status of the radioactive contamination in the Eastern Mediterranean Sea and bordering countries was obtained both from literature data and ad hoc measurements.
- No high level values were identified and the average concentration of ^{137}Cs in soil and sediments is of the order of the Bq/kg and in sea water is of the order of ten Bq/m^3.

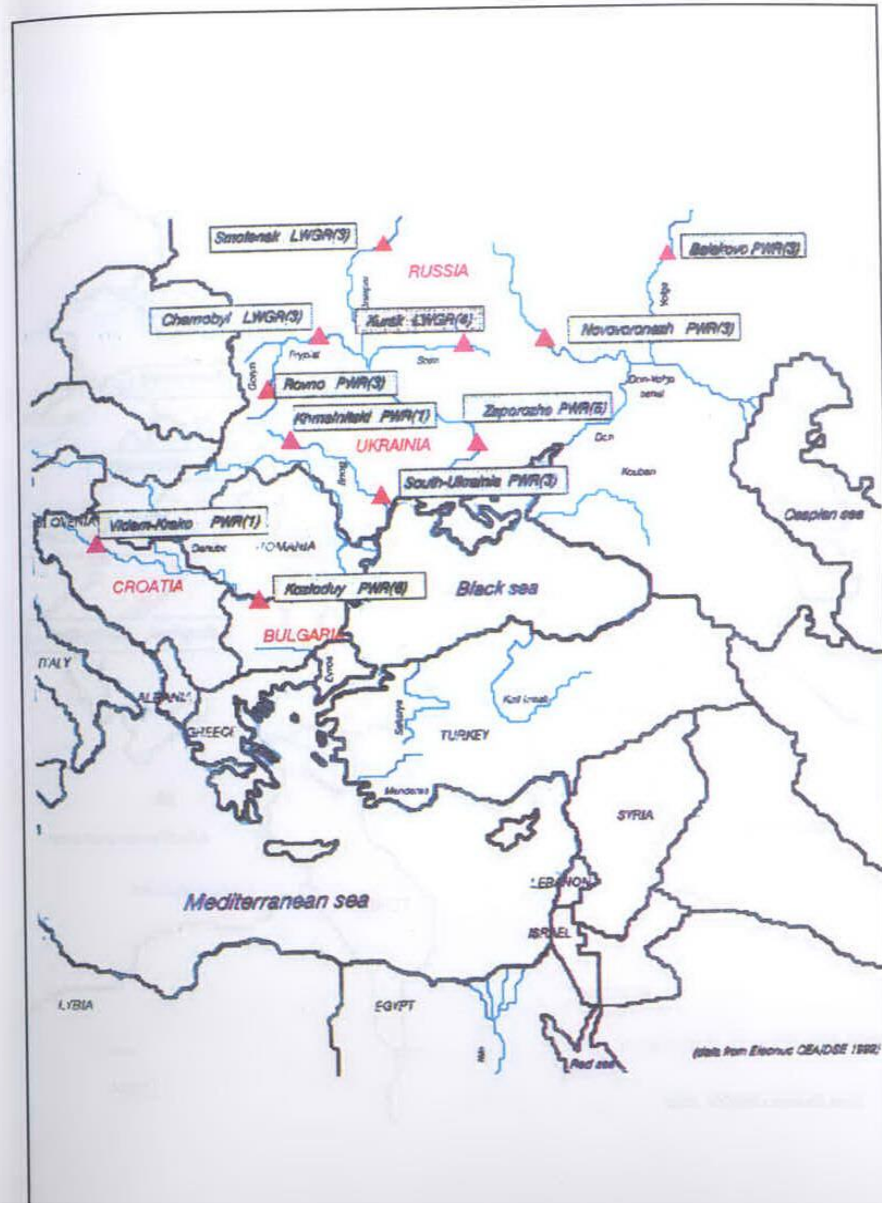
- The highest concentrations of ^{137}Cs have been detected in the **Aegean waters due to the inflow from the Black Sea which is influenced by the discharge from the Chernobyl area.**



The different sources of artificial radioactivity in the marine environment



Nuclear plants and reprocessing plant in the western Mediterranean basin.



Nuclear power plants in operation in the eastern Mediterranean basin.

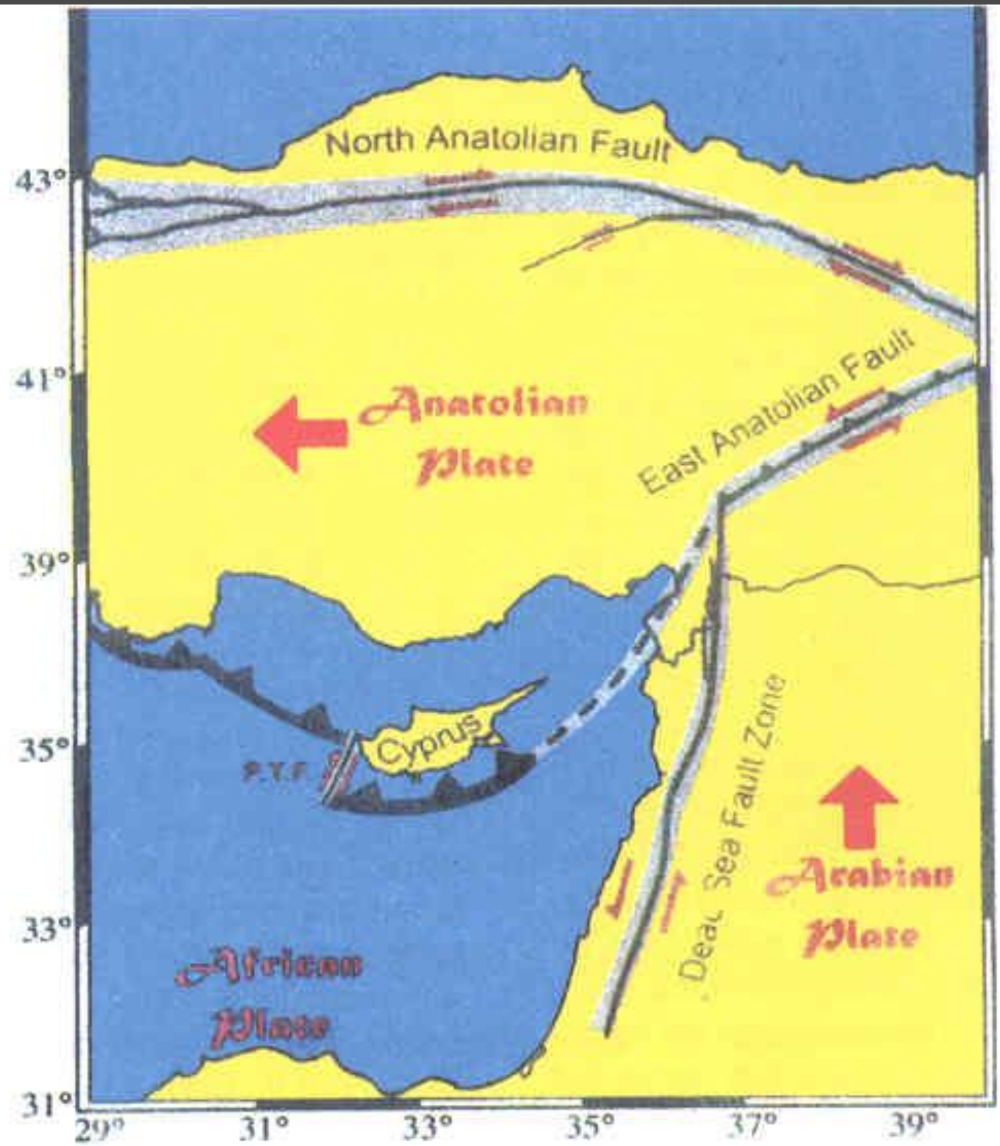
Table 1.1 - Technical specifications of the nuclear power plants in operation in countries bordering the Mediterranean Sea (Cigna et al., 1994 Willemenot et al., 1999).

Country	**Reactor type/ Name** *(number of units)*	**Net capacity** *(MWe)*
FRANCE	**PWR/ Bugey (4)** **PWR/ Cruas-Meysse (4)** **PWR/ St Alban (2)** **PWR/ Tricastin (4)**	4x920 3x880, 1x915 2x1335 4X915
SPAIN	**PWR/ Asco (2)** **BWR/ Cofrentes (1)** **BWR/ Garona (1)** **PWR/ Vandellos (1)**	2x887 994 460 943
SLOVENIA-CROATIA	*PWR/ Videm-krsko (1)*	632
BULGARIA	*VVER/ Kozloduy (6)*	4x408, 2x953
RUSSIA	*VVER/ Balakovo (3)* *RMBK/ Kursk (4)* *VVER/ Novovoronezh (3)* *RMBK/ Smolensk (3)*	3x950 4x925 2x385, 950 3x925
UKRAINE	RMBK/ Chernobyl (2) VVER/ Khmelnitski (1) VVER/ Rovno (3) VVER/ South-Ukraine(3) VVER/ Zaporozhe (5)	2x925 950 361, 384, 950 3x950 5x950

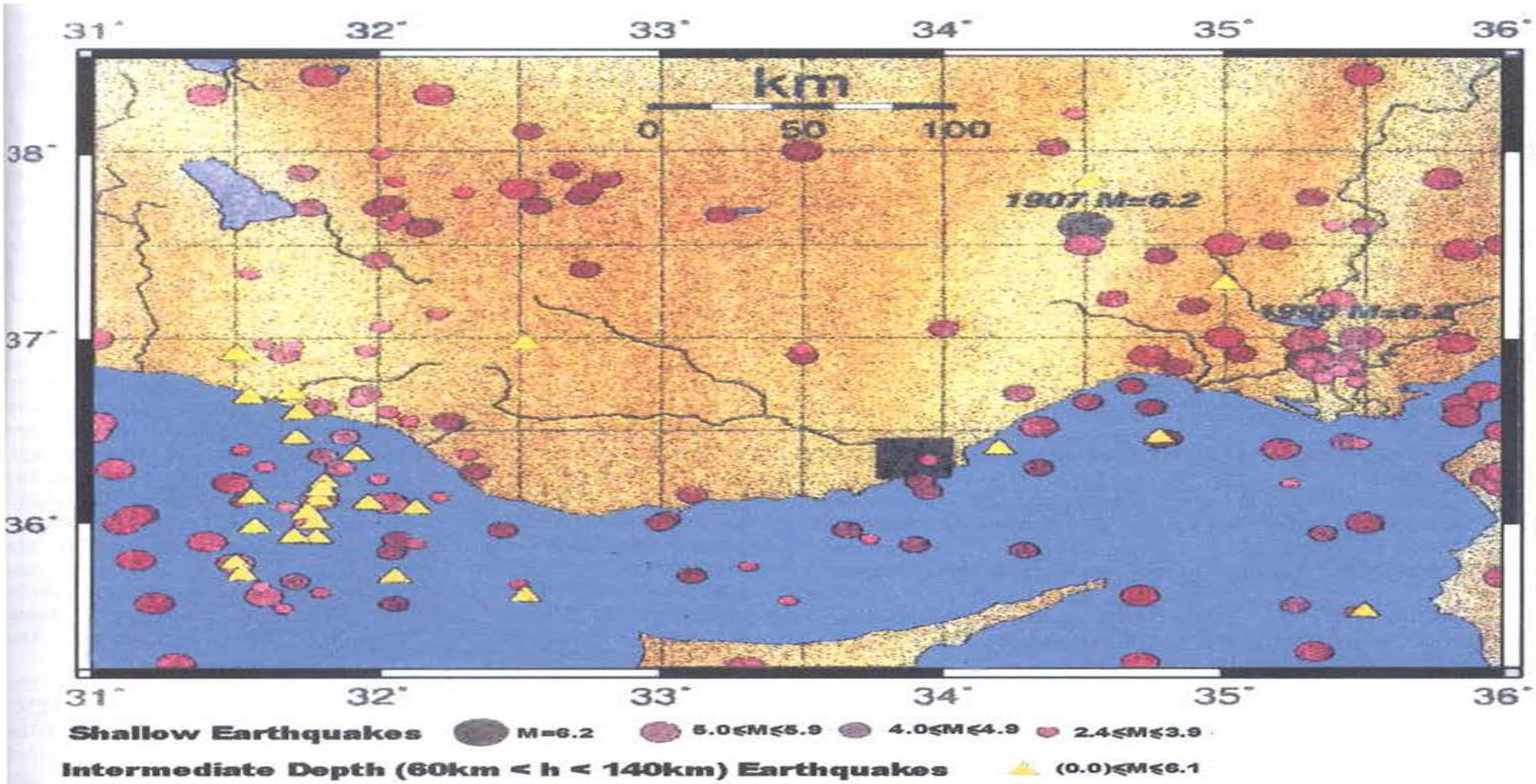
Names in ***bold*** *characters:* nuclear power plants on rivers flowing into the Mediterranean Sea.
Names in ***italic*** *characters:* nuclear power plants on rivers flowing into the Black Sea.

Population at mid-year (in thousands)

	1990	1996	2010
Cyprus	681	738	850
Greece	10161	10475	11224
Turkey	56098	62697	75567
Syria	12116	14619	21043
Lebanon	2555	3084	5674
Israel	4660	5696	7223
Egypt	53270	60603	73466



Lithospheric motions in the easternmost part of the Mediterranean (Papazachos and Papaioannou, 1999)


31°
32°
33°
34°
35°
36°
38°
37°
36°
km
0
50
100
1907 M=6.2
Shallow Earthquakes
M=6.2
5.0≤M≤5.9
4.0≤M≤4.9
2.4≤M≤3.9
Intermediate Depth (60km < h < 140km) Earthquakes
(0.0)≤M≤6.1

- **1939** : 27 December –Turkey, 8 Richter, *30.000* people died
- **1953** : 18 March - Turkey , 7.2 Richter, *1.200* people died
- **1962** : 01 September – Iran, 7.3 Richter, *14.000* people died
- **1966** : 19 August - Turkey, 6.9 Richter, *11.000* people died
- **1968** : 31 August - Turkey, 7.4 Richter, *11.600* people died
- **1970** : 28 March - Turkey, 7.4 Richter, *1.086* people died
- **1975** : 06 September - Turkey, 6.8 Richter, *2.312* people died
- **1976** : 24 November - Turkey, 6.9 Richter, *4.000* people died
- **1978** : 16 September - Iran, 7.7 Richter, *25.000* people died
- **1983** : 30 October - Turkey, 7.2 Richter, *2.000* people died

Relevant ecosystems

- The UNEP Specially Protected Areas Protocol covers a total of 123 areas, of which:
- 47 are marine
- 15 are exclusively marine and
- 32 are mixed land and sea

- The Specially Protected Areas Regional Activity Center of UNEP and with the collaboration of the World Conservation Union (IUCN) have listed 233 sites of biological and ecological value.

- These protected areas are all established under national jurisdiction, and therefore, there are few international legal instruments governing their establishment, regulation and management. The SPA Protocol to the Barcelona Convention is the principal one in the Mediterranean.

- The monk seal has been classified as "endangered" since 1966 and is today on the IUCN world list of the twelve animals that face extinction.

- The Black Sea unique water balance is contributed by:

- the high degree of isolation from the World Ocean
- the extensive drainage basin and
- the large number of incoming rivers

Agricultural characteristics

- Agricultural land accounts for 57% of the territory of the seven countries (ranging from 17% in Cyprus to 75% in Syria) .

- Forests occupies 22% of the combined territories (ranging from 3% of Syria up to 35% of Bulgaria.
- Radioactivity transfer along food chains were selected for radioactive cesium, strontium and iodine.

- The uptake of a radionuclide from the soil by plant roots varies widely, depending on:

- the plant species
- the environmental conditions
- and the soil characteristics

- Industrial food processing and domestic food preparation affects the radionuclide content (concentration or dilution) in aliments.

Tourism

- Tourism and recreation are a key element in coastal development because they force many aspects of urbanization notably the construction of hotels, restaurants, sport facilities, marinas, etc.

- In many coastal resorts, population will be multiplied several times during the holiday season.

- An indirect result from installation and operation of any nuclear power plant it could result in a negative impact in a high tourist zone of East Mediterranean area.

International legal impacts

The problems concerning pollution in border areas

can be summarized by two general principles:

- States are under a duty to prevent transborder pollution
- No State can claim a better protection against transborder pollution than the one it provides under its own laws against pollution of national origin.

Socioeconomically impact

- The coastal zone, is subject to multiple uses by human beings:

- heat capacity (it stores heat, thus alternately cooling the ambient air and warming it by evaporation, which cools the sea)

- its value as a solvent

-as a sure source of salt.

- Sometimes, specific areas in the coastal zone are declared protected areas for their peculiar characteristics: the aesthetic pleasures of the sea along the seashore (waves, surf, sailing and fishing boats, etc.) are important ingredients for tourism; Agriculture in the hinterland has also a significant impact both environmentally and economically by competing with certain fishery products.

- About 130 million people of the Mediterranean population is concentrated on the coast and it is expected to double by the year 2025. The discharge of sewage occurs in the vicinity of all the major cities of the basin and has drastically modified the ecosystem in this vicinity.
- The eastern basin of the Mediterranean Sea is practically free from such sources of radionuclides.

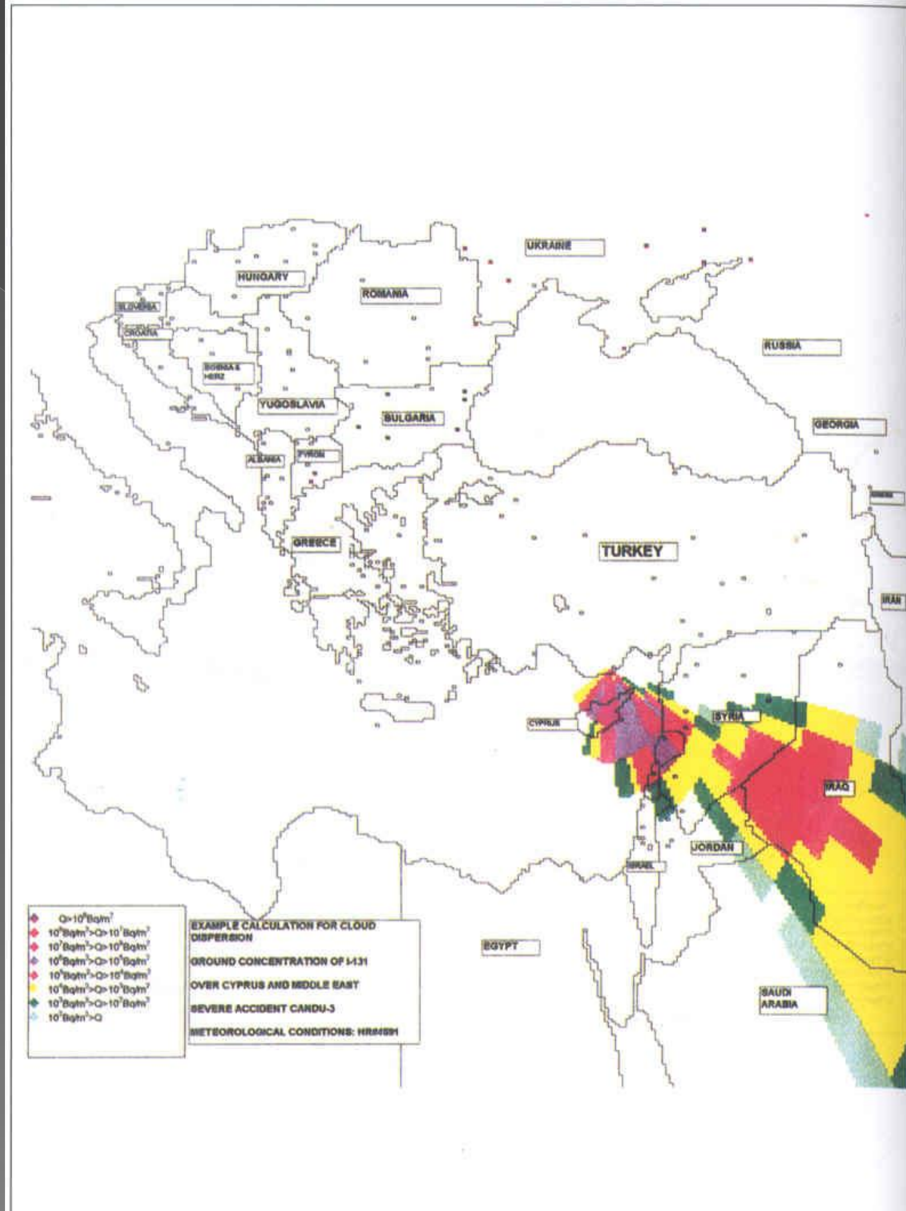
- The lesson learned from accidental situations, shows that special emphasis must be put on the latter more than on the former. In fact, the radioactive contamination with health consequences is generally restricted to limited areas close to the source.

Radiological Impact

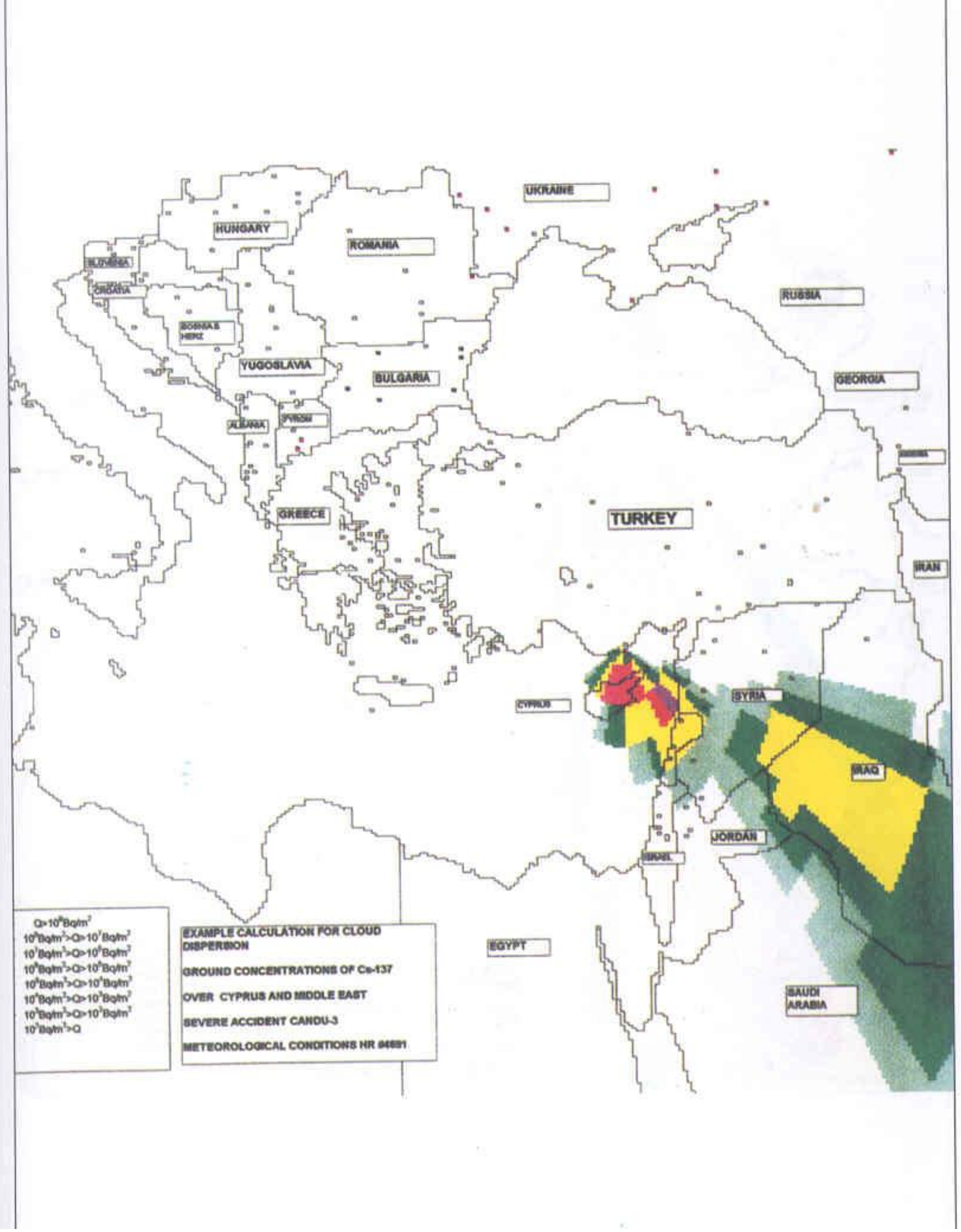
- The potential consequences of an accident in a Nuclear Power Plant to the Eastern Mediterranean countries are considered.

- The assessed consequences include health effects, environmental effects and economic effects.

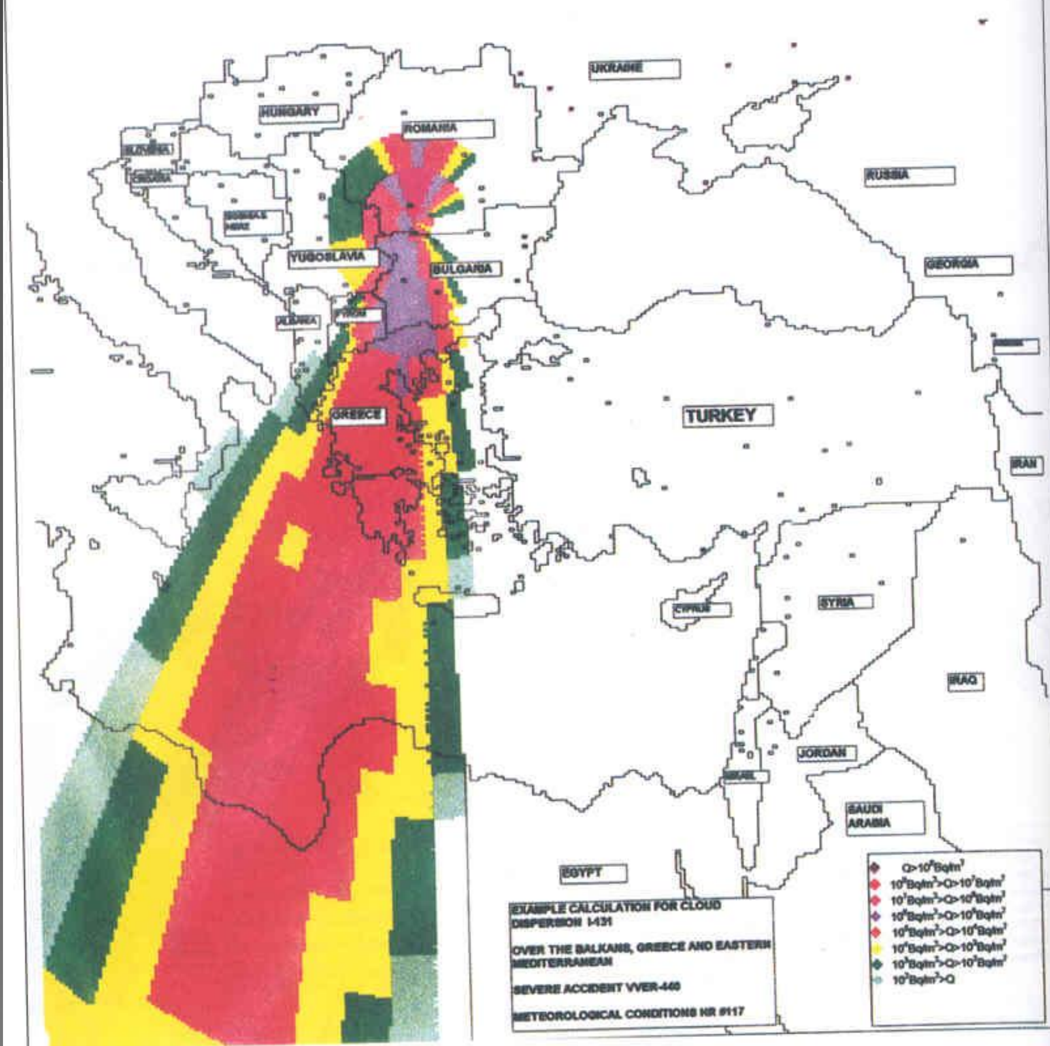
- The consequences are compared with those of the accident at Chernobyl.



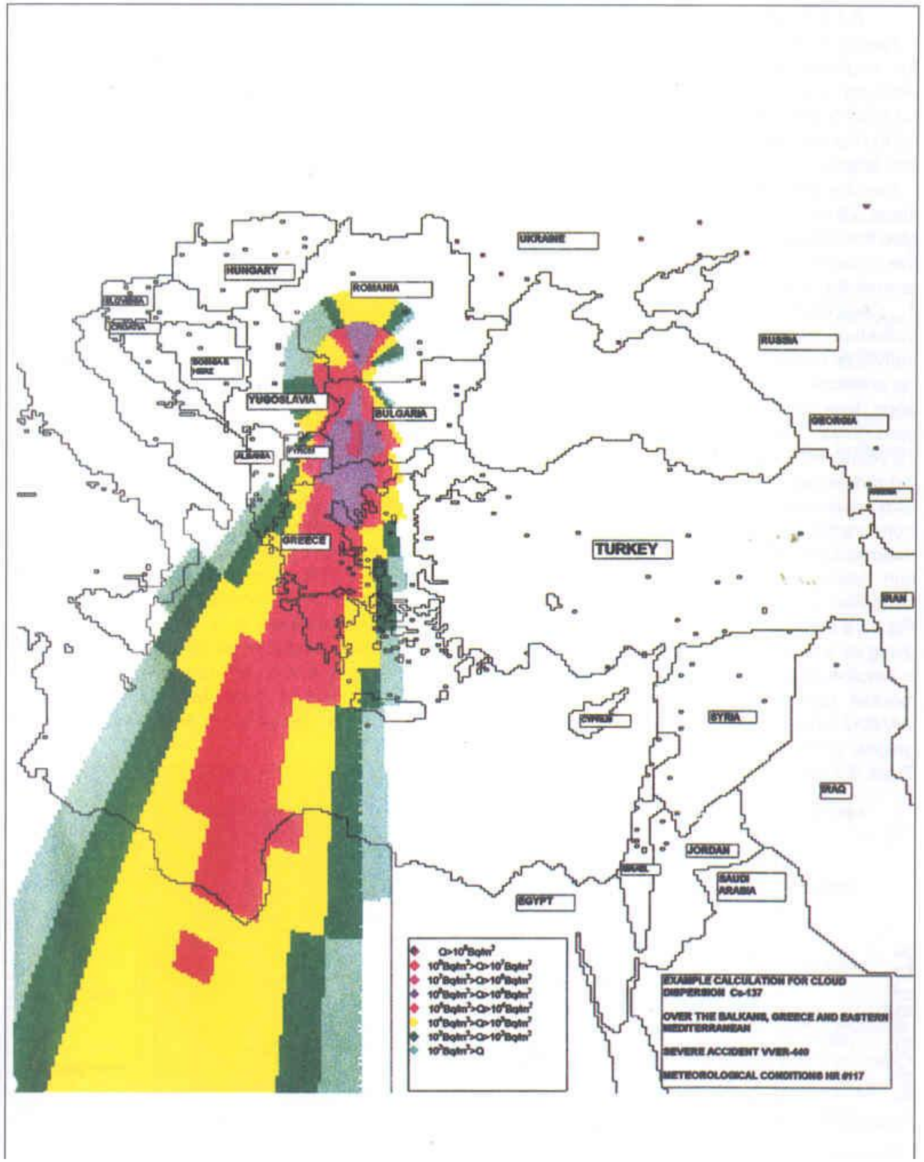
Example calculation for cloud dispersion 900 MWe plant. Meteorological conditions Hour #4691 of meteorological record. Ground deposition I-131.



Example calculation for cloud dispersion 900 MWe plant. Meteorological conditions Hour # 4691 of meteorological record. Ground deposition Cs-137.



Example calculation for cloud desperation. Accident in the Kozlodui (WWER-440). Meteorological conditions Hour #117 of meteorological record. Ground deposition I-131.



Example calculation for cloud dispersion. Accident in the Kozlodui NPP (WWER-440) Meteorological conditions Hour #117 of meteorological record. Ground deposition of Cs-137.

	^{238}U	^{226}Ra	^{232}Th	^{40}K	^{228}Ra	^{228}Th
Station 1[1]						
MV±SD	38±4	1.52±0.07	0.024±0.007	10641±793	2.91±0.6 8	0.10±0.01
Min	32	1.46	0.018	9811	2.08	0.08
Max	42	1.63	0.028	11834	3.92	0.11
Station 2[1]						
MV±SD	39±3	1.53±0.11	0.020±0.055	10651±813	3.41±0.5 5	0.11±0.02
Min	38	1.40	0.015	9875	2.96	0.07
Max	43	1.67	0.027	11847	4.32	0.13
Station 3[1]						
MV±SD	39±3	1.50±0.08	0.022±0.005	10631±741	3.22±0.6 7	0.090±0.008
Min	35	1.39	0.017	9890	2.17	0.08
Max	43	1.59	0.029	11679	4.01	0.10
Station 4[1]						
MV±SD	37±4	1.56±0.04	0.022±0.004	10689±795	3.12±0.5 1	0.082±0.019
Min	33	1.53	0.016	9895	2.67	0.06
Max	43	1.61	0.028	11789	3.97	0.11
Station 5[2]						
MV±SD		1200±1000		19000±600	600±600	
Min		<100		19000	<100	
Max		1900		20000	1100	

[1] *Florou, 1990,* [2] *Trabidou G, 1996.*

Activity concentrations of natural radionuclides in Aegean Sea

Atmospheric releases

- For weather conditions that do not allow great expansion, the total amount of the radionuclides here considered, ^{90}Sr, ^{105}Ru, ^{131}I and ^{137}Cs, would be about $3x10^{18}$ Bq (about 75% of the total release).

-For example the total deposition to ground in the island of Cyprus would be about $2x10^{17}$Bq.

- For weather conditions that allow great expansion the total amount of the radionuclides would be about $1.8x10^{18}$ Bq (about 40% of the total release).

-For example the total deposition to ground in Israel would be about $2x10^{15}$ Bq.

DISTANCE from AKKUYU (km)	AKKUYU HYPOTHETICAL ACCIDENT				CHERNOBYL	
	MAXIMUM	MEAN	WEATHER SPECIFIC			
50	2,380	11.20	4.82	(Medit.)		
150	454	2.50	33.00	(Cyprus)	2-4	(Cyprus)
250	564	1.20	1-4.5	(Lebanon-Syria)	1-100	(Lebanon-Syria)
350	82	0.60	0.05	(Syria)		
450	221	0.50	0.01	(Syria)		
550	113	0.30	0.002-3	(Jordan-Syria)	0.1-12	(Israel)
					1	(Rodos-Greece)
650	63	0.20	0.002-4	(Iraq)		
750	91	0.20	0.002-3	(Iraq)	10-20	(Turkey-Marmara)
					1-3	(Egypt)
850	27	0.12	0.002-3	(Iraq)	10-200	(Turkey-Eastern Black Sea)
950	21	0.1	0.002-2	(Iraq)	4	(Greece-Central, South)
1050	16	0.08	0.002-1	(Iraq)	10	(Greece North)
1150	16	0.06	0.002-0.6	(Iraq)		
1250	40	0.05	0.002-06	(Iraq)		

Ground concentration of Cs-137 in kBq/m^2

Marine releases

- An instantaneous spill of 100 tons of water containing an initial concentration of radionuclides of 800 MBq/kg. Since the probability of such a spill is very small, it may be taken as a worst case scenario.
- Two seasons of the year have been considered Summer and Winter, since the background, buoyancy- driven, flow varies somewhat during the year.
- Most of the radionuclides tends to collect close to the thermocline at a depth of 30 meters.

-For example after 20 days the maximum concentration is 19.2 Bq/kg while throughout most of the cloud it is between 3 and 6 Bq/kg.

Most of the pollutant concentrates within 10 meters of the thermocline with typical concentrations of about 5 Bq/kg.

ROUTE	***^{137}Cs (PBq)***	***$^{239.240}$Pu (TBq)***	***Reference***
Total input up to 1986	12.0	190	UNEP.1992; *Holm et al.. 1988*
Fallout from Chernobyl	2.5*	0.02	Papucci et al.. 1996. *Whitehead et al.. 1988*
Atmospheric input. 1986-1996	0.3	7.5	*Papucci et al.. 1996*
Marcoule reprocessing plant. up to 1995	0.03	0.3	*Papucci et al.. 1996. Charmasson et al.. 1994*
Black Sea. 1986-1996	0.3	-	*Egorov et al.. 1994*
Exchanges with Atlantic Ocean. 1986-1996	-	-6.3	*Mitchell et al..* paper in preparation
Total. up to 1986	15.1	191.5	

Inputs of ^{137}Cs and $^{239, 240}$ Pu into the Mediterranean marine environment up to 1996 through different routes.

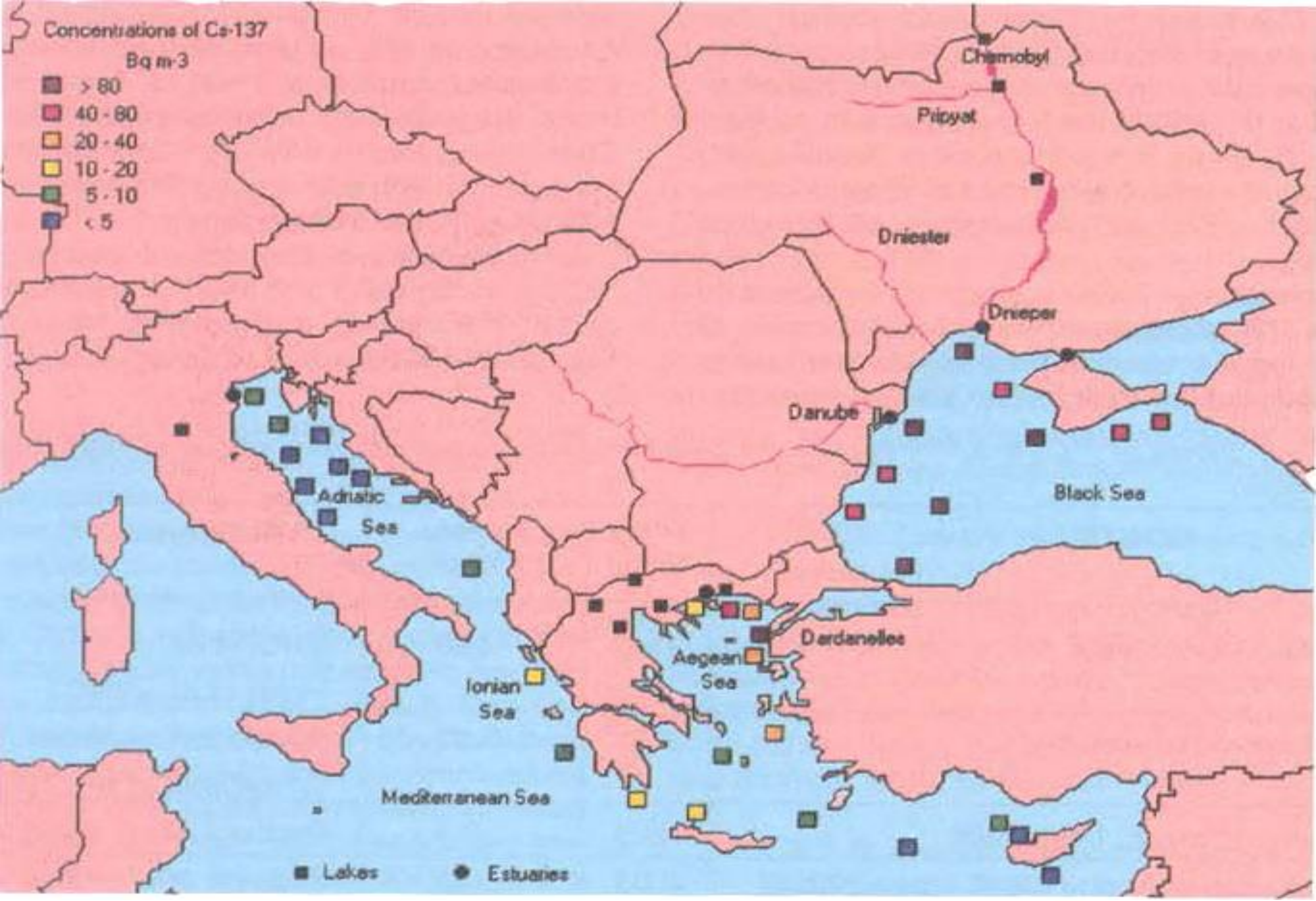


Figure 2.1 Cs-^{137} levels in the areas of interest during 1992-94 (Adriatic Sea 1990

Sea water Cs-137 levels in the Eastern Mediterranean during 1997-1999

Activity concentrations of natural radionuclides in sea water worldwide (mBq l^{-1})

Nuclide	Concentration $x10^{-6}$ (mBq l^{-1})	Reference	Region
^{238}U	47 44.4	Bojanowski et al. 1982 Miyake et al. 1970	Mediterranean Sea North Pacific Ocean
^{226}Ra	1.48-1.67 1.20	Broecker & Cromwell, 1967, Szabo, 1967, Bojanowski et. al. 1982	Atlantic Ocean Indian Ocean Mediterranean Sea
^{232}Th	(3.7-288.6)x10^{-4}	Miyake et al. 1970, Moore et Sacket, 1964, Somayajulu & Goldberg, 1966	North Sea Atlantic Ocean
^{40}K	11840	Eisenbud, 1973	North Sea
^{228}Ra	(3.7-37)x10^{-2}	Kaufman 1967	Baltic Sea
^{228}Th	0.007-0.12	Miyake et al. 1970, Moore et Sacket, 1964, Bojanowski et al. 1982	North Pacific Ocean Mediterranean Sea

Pathway	Percentage	Collective dose (man Sv)
Fish	91	24
Molluscs	4.6	0.12
External exposure	2.7	0.072
Crustaceans	1.3	0.034

The Radioactivity Impact to Fish

- Comparative studies were carried out in two cultured fresh-water fish, Cyprinus caprio and Anguilla anguilla, to determine their tolerance in the uptake of ^{137}Cs (3000 Bq/l).

- The histological studies were concentrated in muscular tissues livers, kidneys and gills. The symptoms observed include hyperemia, hydropsy, anaemia and degeneration of liver and kidney tissues.

- Food is a major route by which environmental radiocontaminants reach man. Even with strict controls and containment, releases of radioactive fission products from nuclear power plants are likely to occur.

- Animal products may become contaminated basically in two ways, directly or indirectly. Directly, this happens through drinking water, inhaltion or when originating from aquatic organisms via gills and integuments. Indirectly it takes place through consuming contaminated food.
- Cesium 137 was selected for study due to its abundance in fission products, its relatively long half-life as radionuclide and its facile incorporation into food, bone, body fluids and tissue.
- Cyprinus caprio and Anguilla anguilla were selected for study, due to their different anatomy and physiological function. In addition, carp is a bottom feeder while the eel ranges throughout the water.

2. MATERIALS AND METHODS

- The experiment was conducted in fresh-water fish A.-anguilla and C.caprio cultured in small water tanks artificially contaminated with radioactive ^{137}Cs. The fish A.-anguilla were collected from artificial ponds two days before the experiment started. The fish C.caprio were collected from a local lake. They were kept in a 200L tap water dechlorinated by active carbon. The fish acclimatized well to the aquarium conditions, behave well and no diseases occurred. The dimensions of the water tanks used were 79cm in length, 35cm in width, 50cm in height.
- The fish were sacrificed every one or two weeks, weighed, their length was measured, and the overall conditions of the fish were compared with the control.

3. RESULTS AN DISCUSSION

- The results indicated that the amount of ^{137}Cs was more in the muscular tissues of carp than the eel.

TABLE 1:

Uptake of 137Cs in cultured fresh water fish: Cyprinus caprio and Anguilla anguilla

Time of killing days	Concentration of ^{137}Cs (Bq/Kg) in muscular tissue		
	Carp		Eel
	(1500 Bq/1)	3000 Bq/1)	(3000 Bq/1)
15	980	1.150	1.170
30	2.980	6.437	1.000
45	3.550	8.023	2.500
60	-	10.460	4.000
90	4.985	12.141	4.400
120	10.850	18.959	4.900

- Due to the absence of large scales, an eel can breath through its skin as will as through the gills. The proportion of breathing carried our through the gills is about 40 per cent and that through the skin about 60 per cent. This means that less water is taken up by the eel in comparison to carp.

- The accumulation of ^{137}Cs in both species is related to their physiology and anatomy.

- The histological studies revealed that eel is more resistant to ^{137}Cs exposure, than carp. Long time exposure to ^{137}Cs caused allergic and toxic effects to both species.

A.

B.

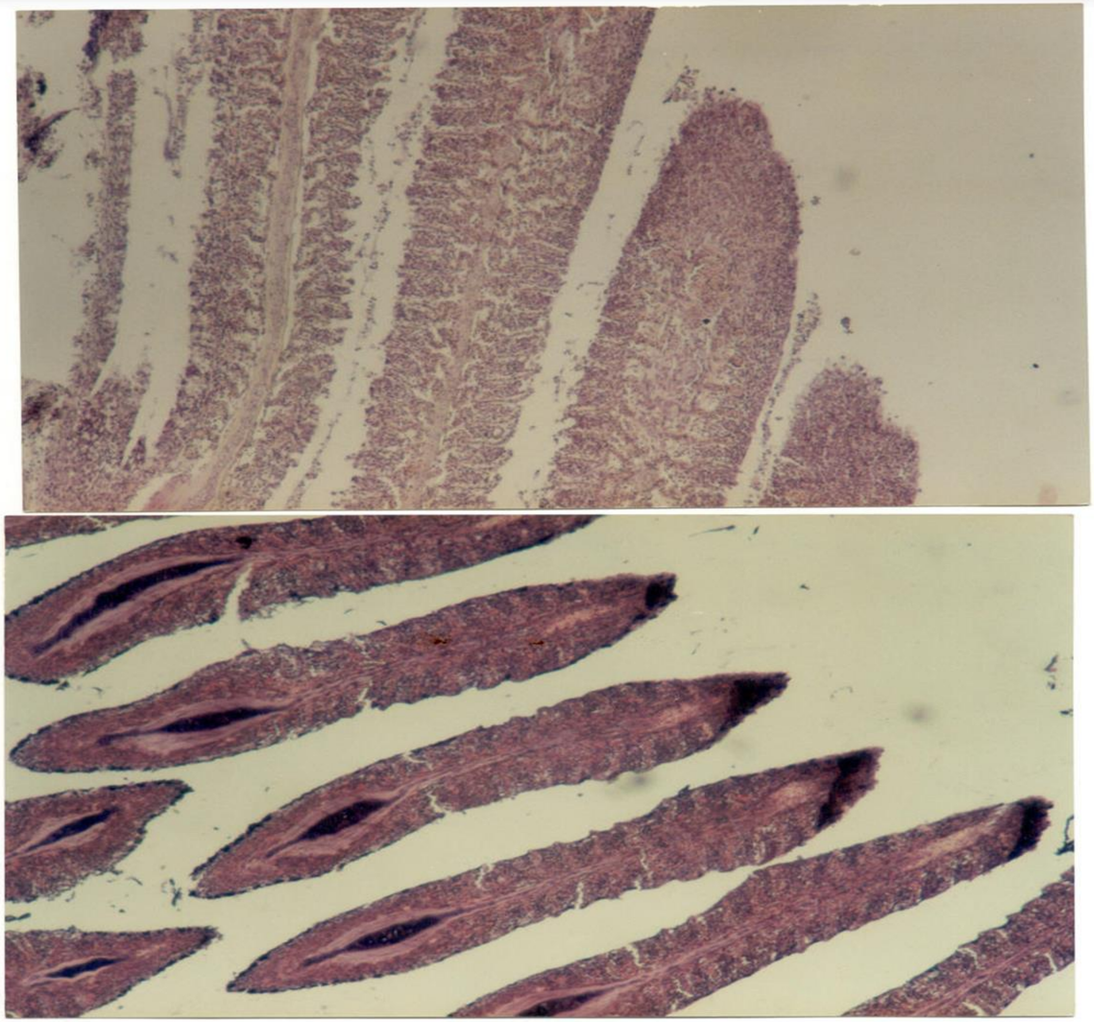
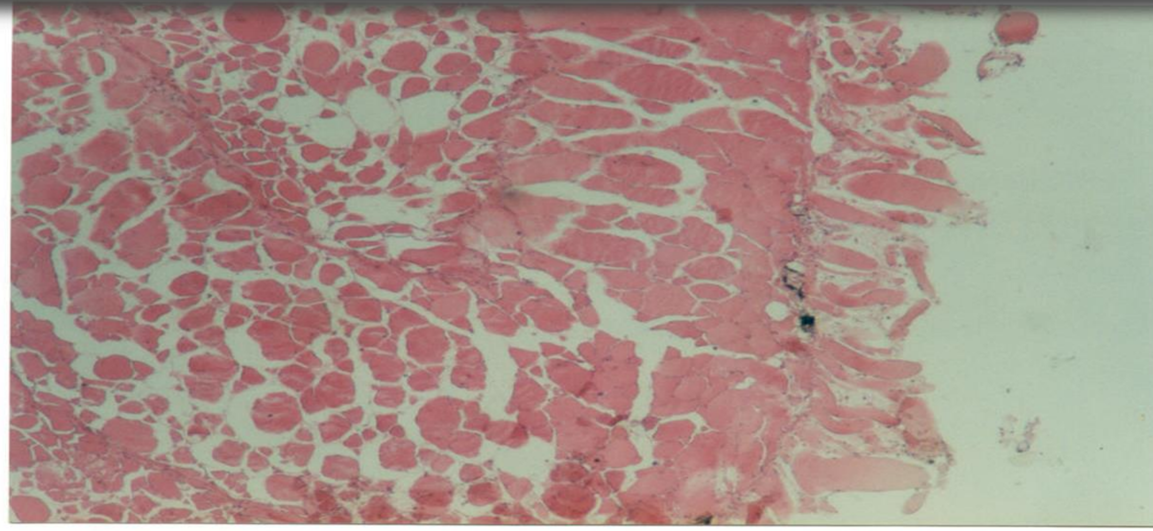


Fig.1. Remarkable epithelial hyperplasia and fusion of some secondary lamellae in the gills. Final stage. A. Carp (x250). B. Eel (x100).

A.



B.

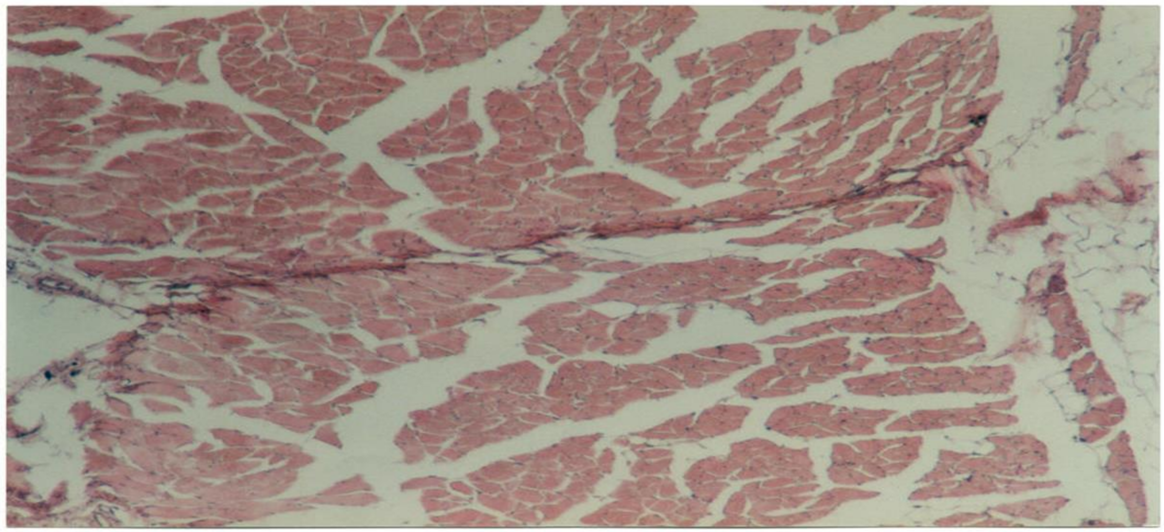


Fig.2. Degeneration of muscles fibers. Final stage.
A. Carp (x100), B. Eel (x100).

A.

B.

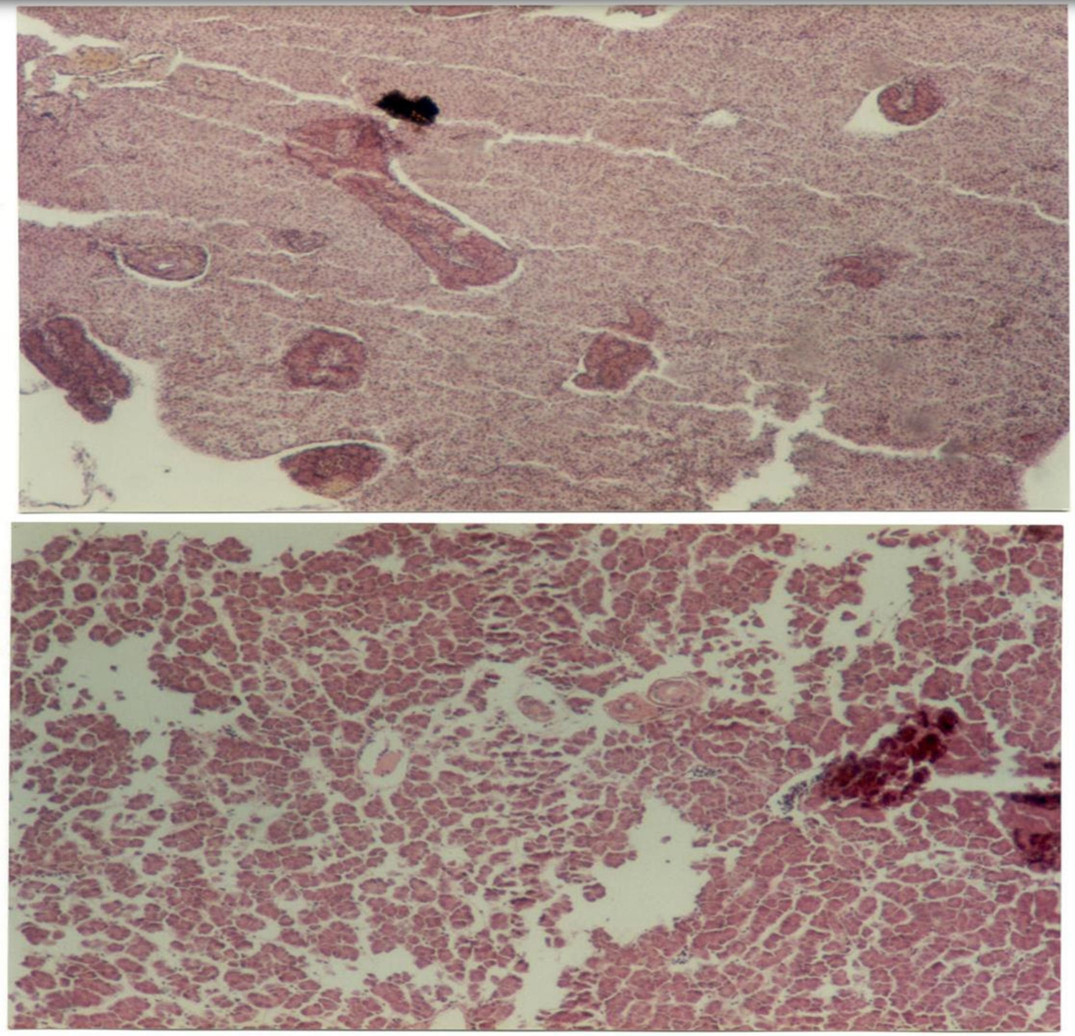


Fig.3. Degeneration of hepatic cells. Final stage. A. Carp (x100), B. Eel (x100).

A.

B.

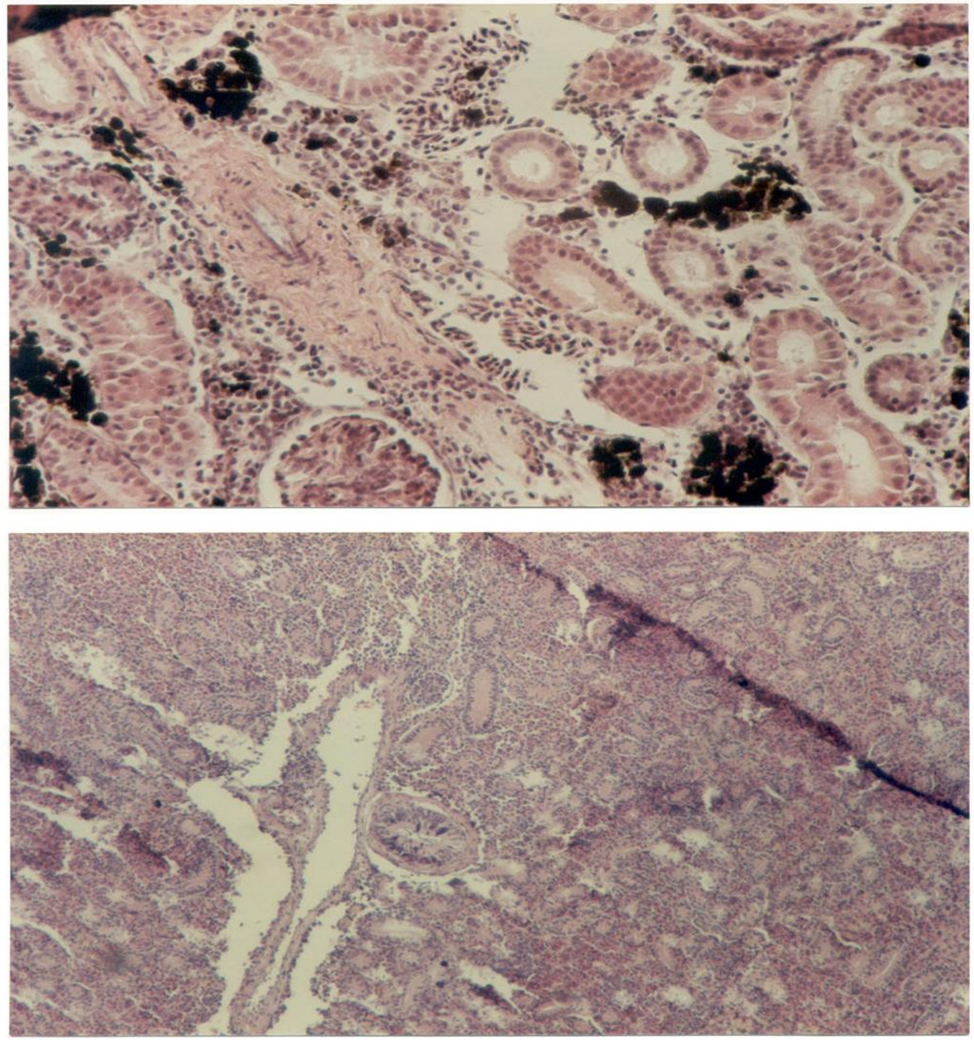


Fig.4. Degeneration of Kidney parenchymal cells and hydeopsy of re nal tubules. Final stage.
A. Carp (x100), B. Eel (x100).

4. CONCLUSIONS

The presence of 137Cs, causes allergic and toxic effects. The ability of both species to concentrate 137Cs to a high degree make them valuable as biological indicators of radioactivity. The present work intensifies the necessity to look after more aquatic species investigating their sensitivity to 137Cs in order to plan an emergency action, in case of a nuclear accident and subsequent release of radionuclides in the environment.

In particular:

1) In the Mediterranean region the radioactivity releases are estimated to be about 5TBq/a and less than 1GBq/a respectively in terms of the Cs^{137} discharge.

2) Atmospheric, rivers and strait-exchange inputs Cs^{137} into the Mediterranean Sea by 1985 are estimated to be respectively. 10±2PBq, 0.4±0.1PBq and 1.6PBq which add up to the total input of 12±2PBq in 1985 for the entire Mediterranean Sea.

3) The total Mediterranean inventory of Cs^{137} (in 1985) was 11±1PBq (3.5 mBq/l for the water).

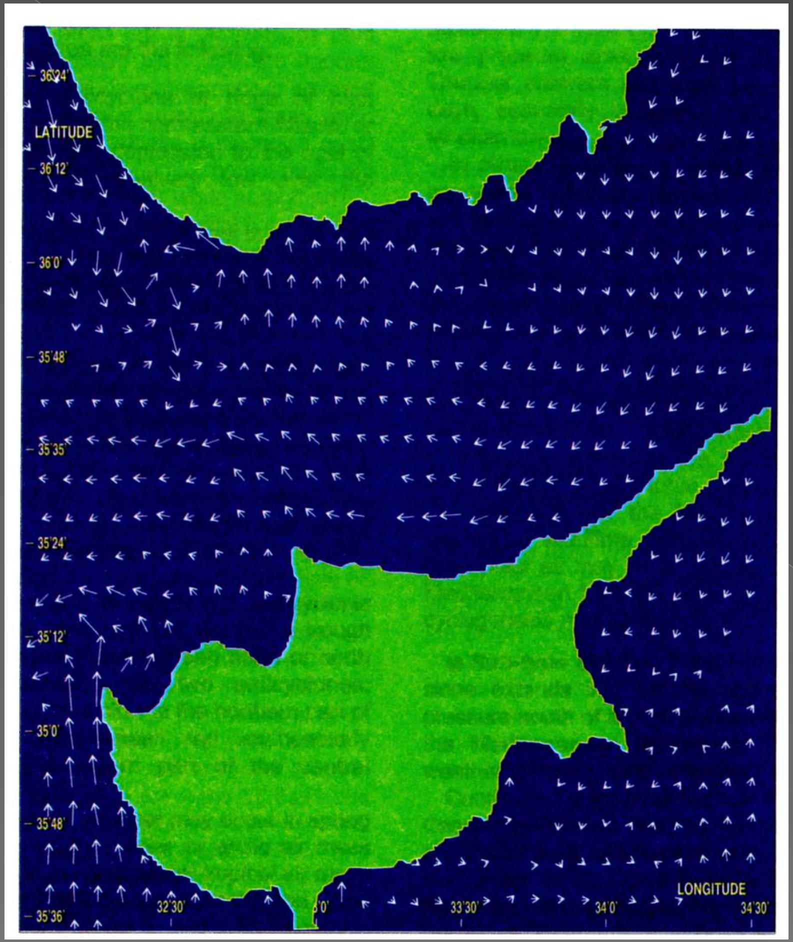
4) The average values for sediment and biological concentration factor vary between 1 to 10^5.

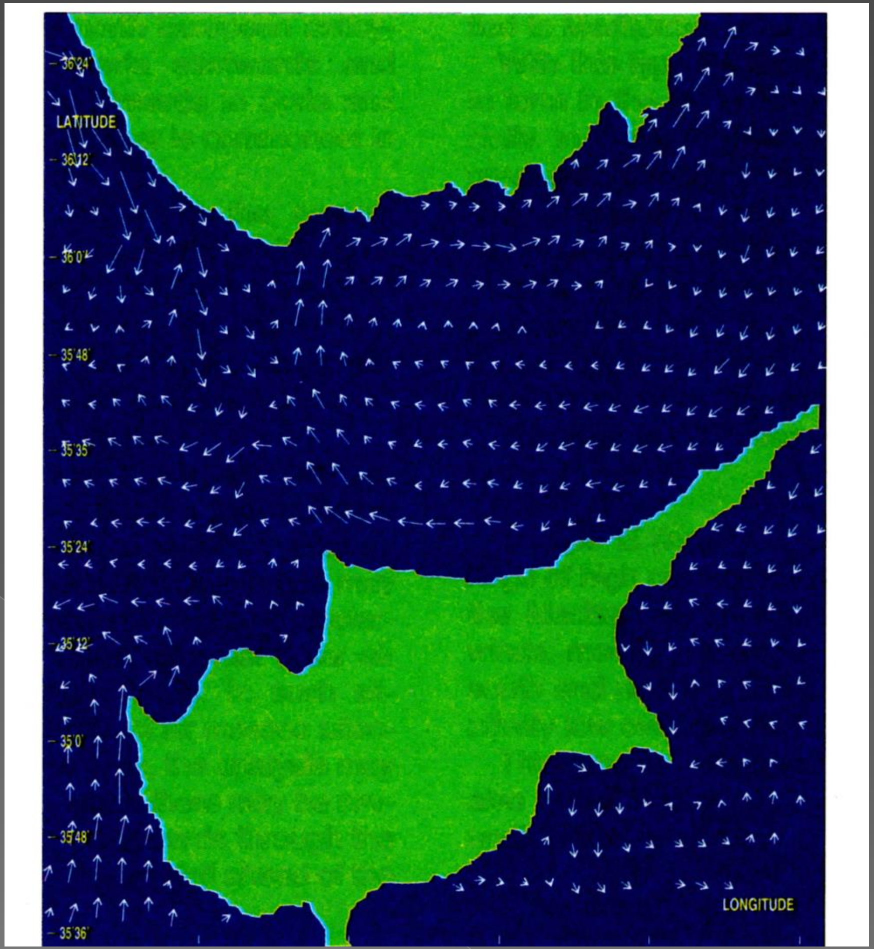
5) Chernobyl fallout increases the Cs^{137} deposition about 25-40% in addition to the existing quantity from 1986.

6) Significant increases in the Cs^{137} levels in the coastal sediment of France, by a factor of 2 to 4 (on the existing Cs^{137} from 1985) has been observed.

7) The impact of artificial radionuclides on the living marine organisms in Mediterranean are negligible. The radiation risk for man may correspond of severe harm in 10^5.

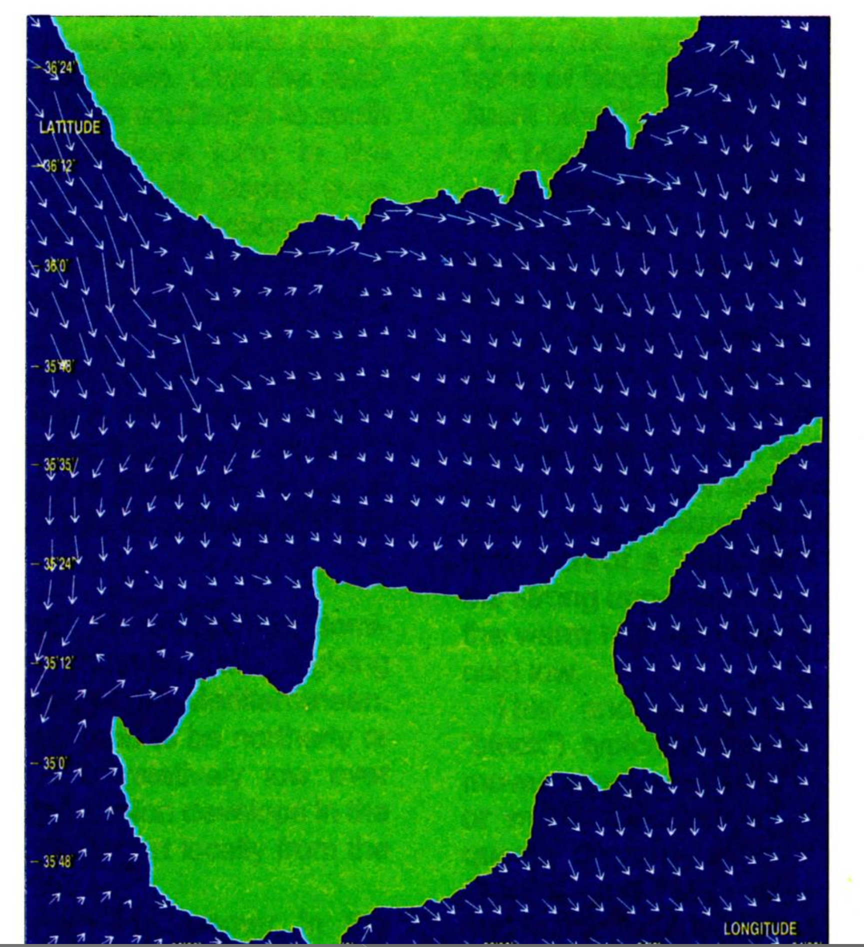
8) The risk from the sea- food consumption, due to radioactivity, estimated to be about 5 cases of severe harm in 10^7.





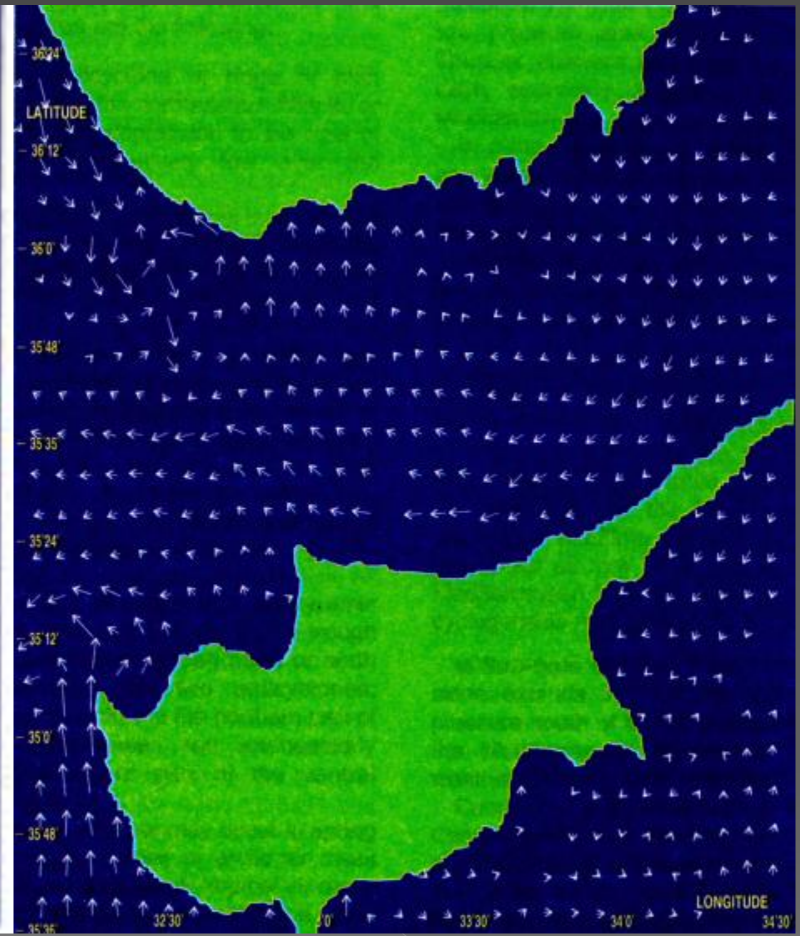
(Left) - Mean current at a depth of 5 meters under the surface in Summer, excluding the effect of winds

(Right) - Mean current at a depth of 5 meters under the surface in Winter, excluding the effect of winds



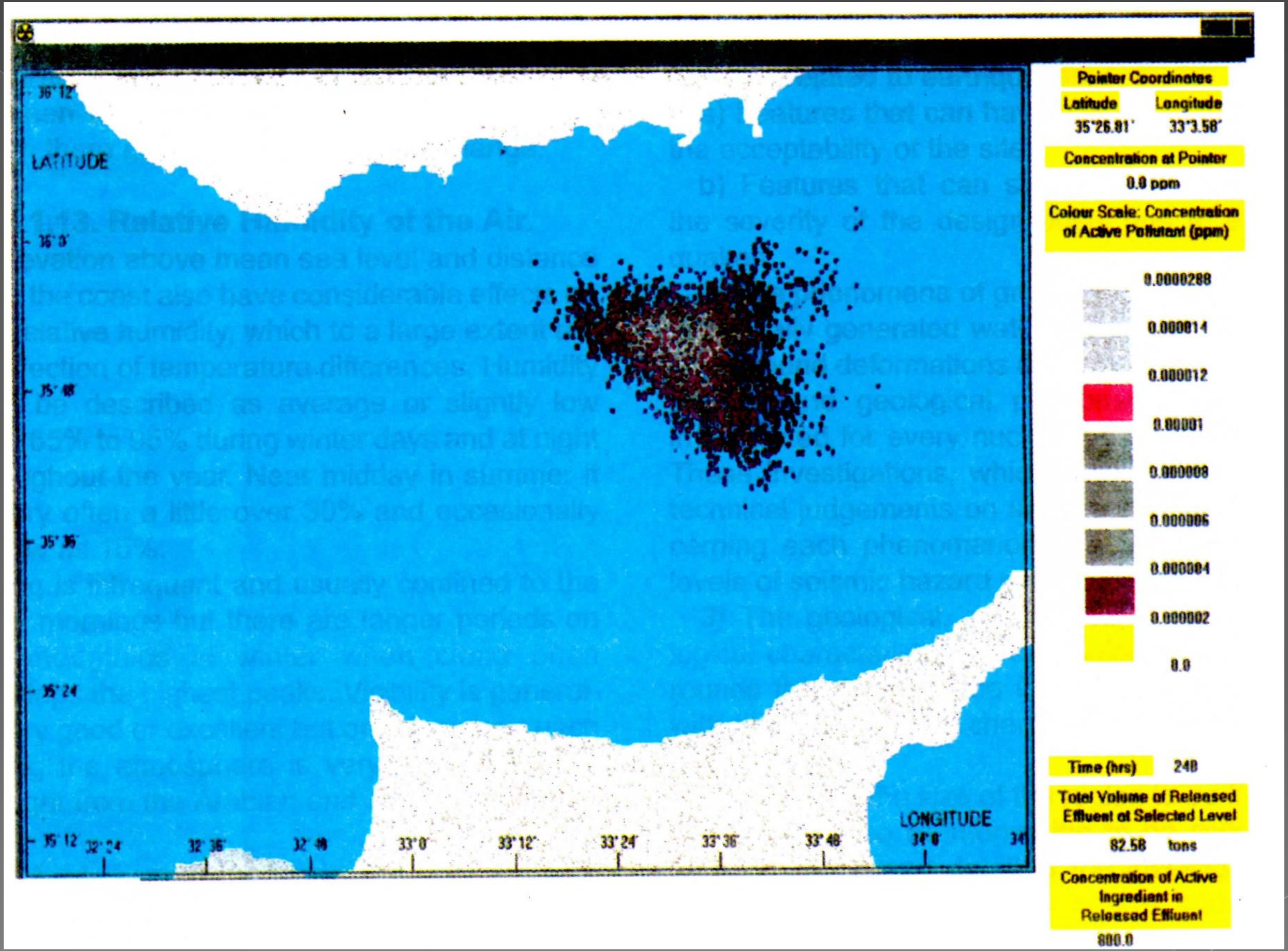
(Left) - Right) - Mean current at a depth of 5 meters under the surface in Summer, with a Westerly wind of 10 meters per second

(Right) - Mean current at a depth of 5 meters under the surface in Winter, with a Westerly wind of 10 meters per second

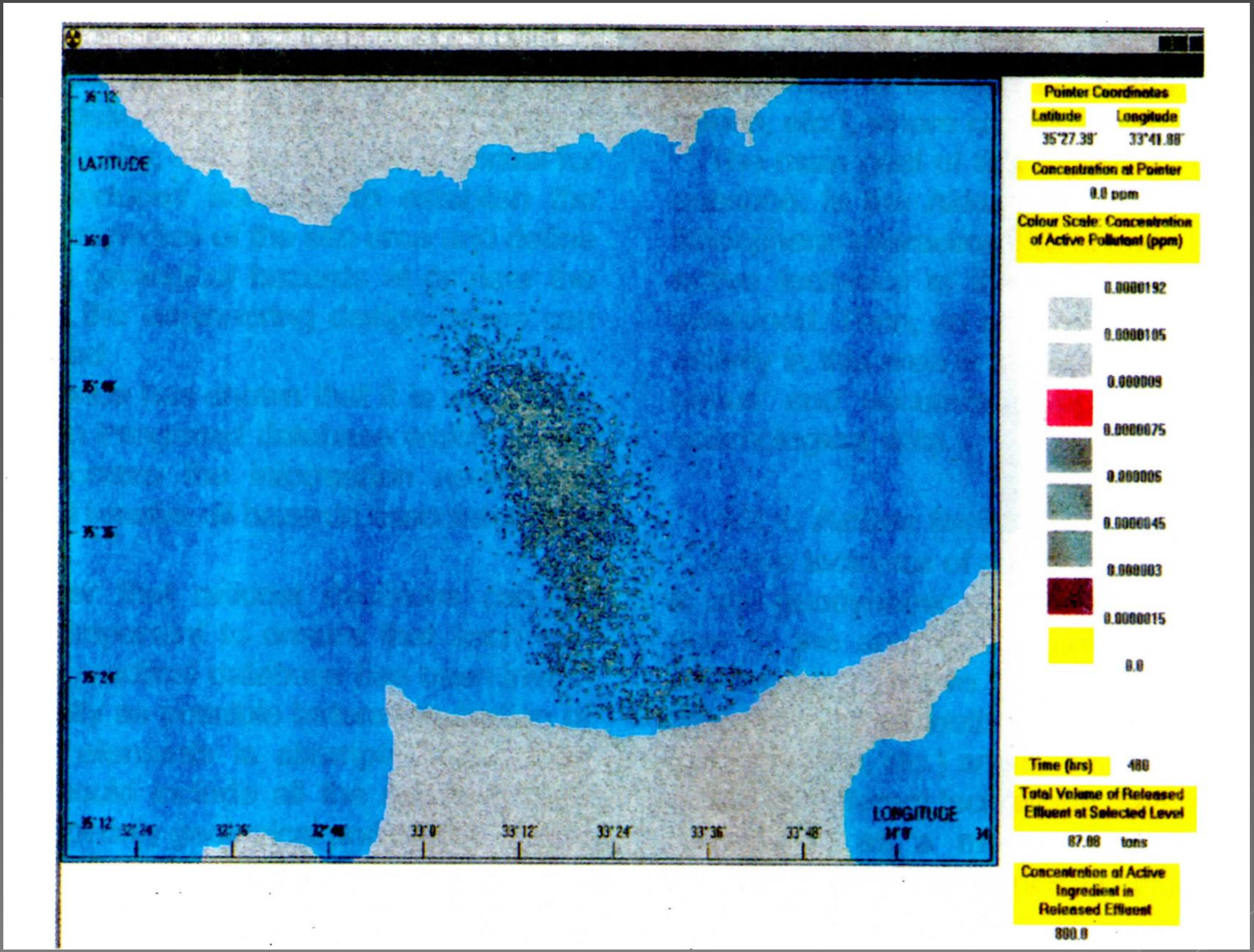


(Left) - Mean current at a depth of 5 meters under the surface in Winter, with a Westerly wind of 10 meters per second

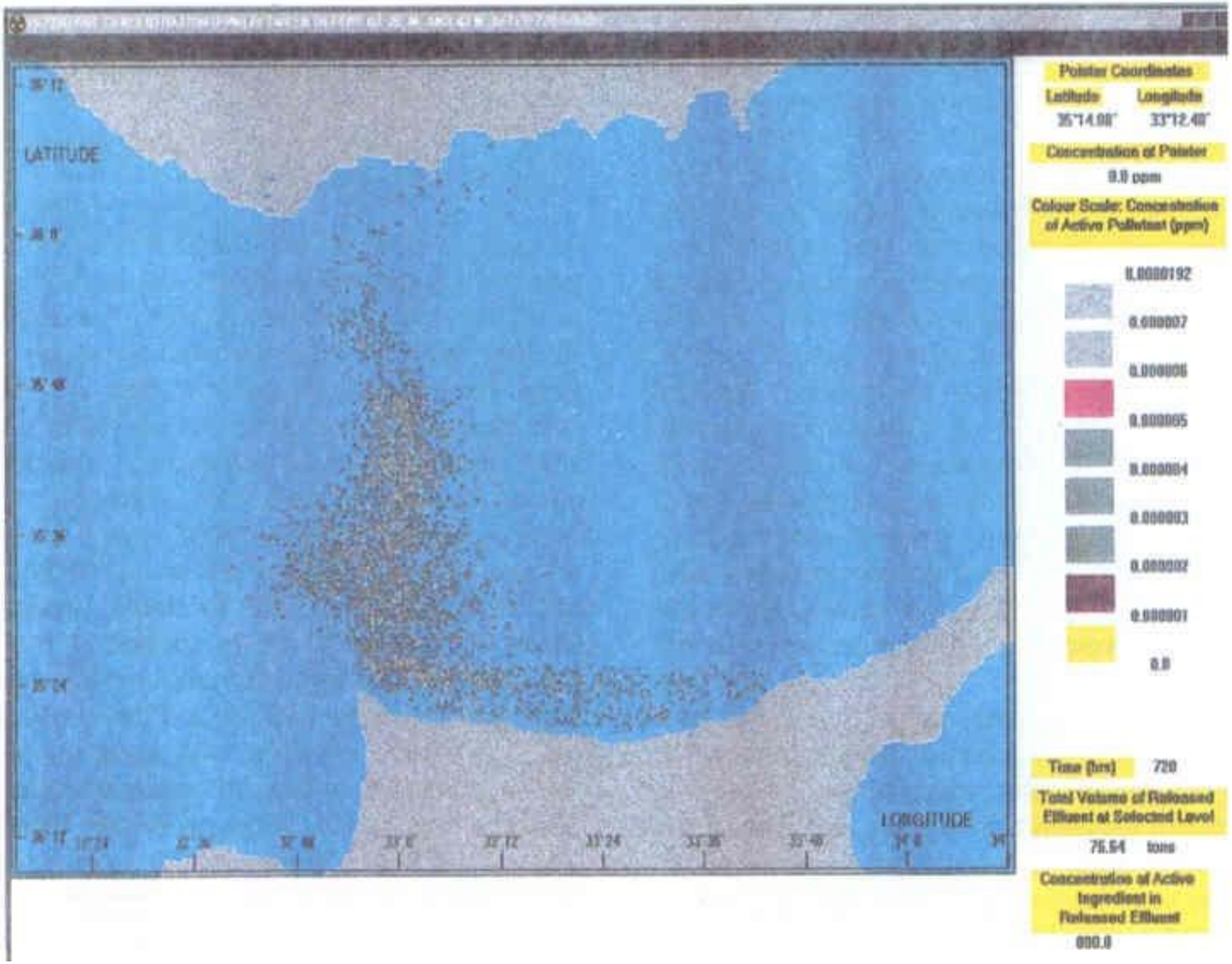
(Right) - Mean current at a depth of 5 meters under the surface in Summer, with a Notherly wind of 10 meters per second



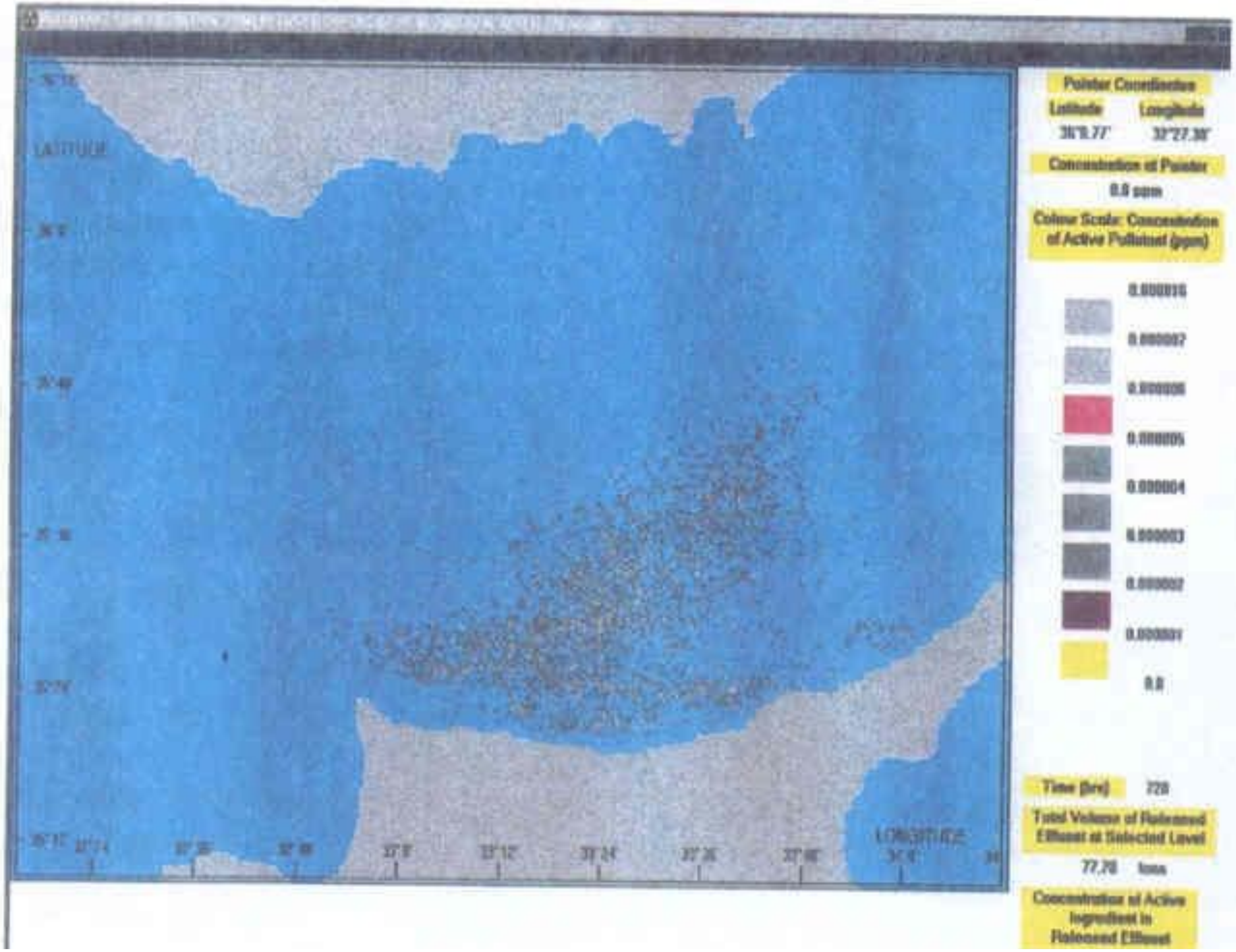
- Position of the pollutant cloud 10 days after the spill in the case of a Westerly wind of 10 meters per second in Summer



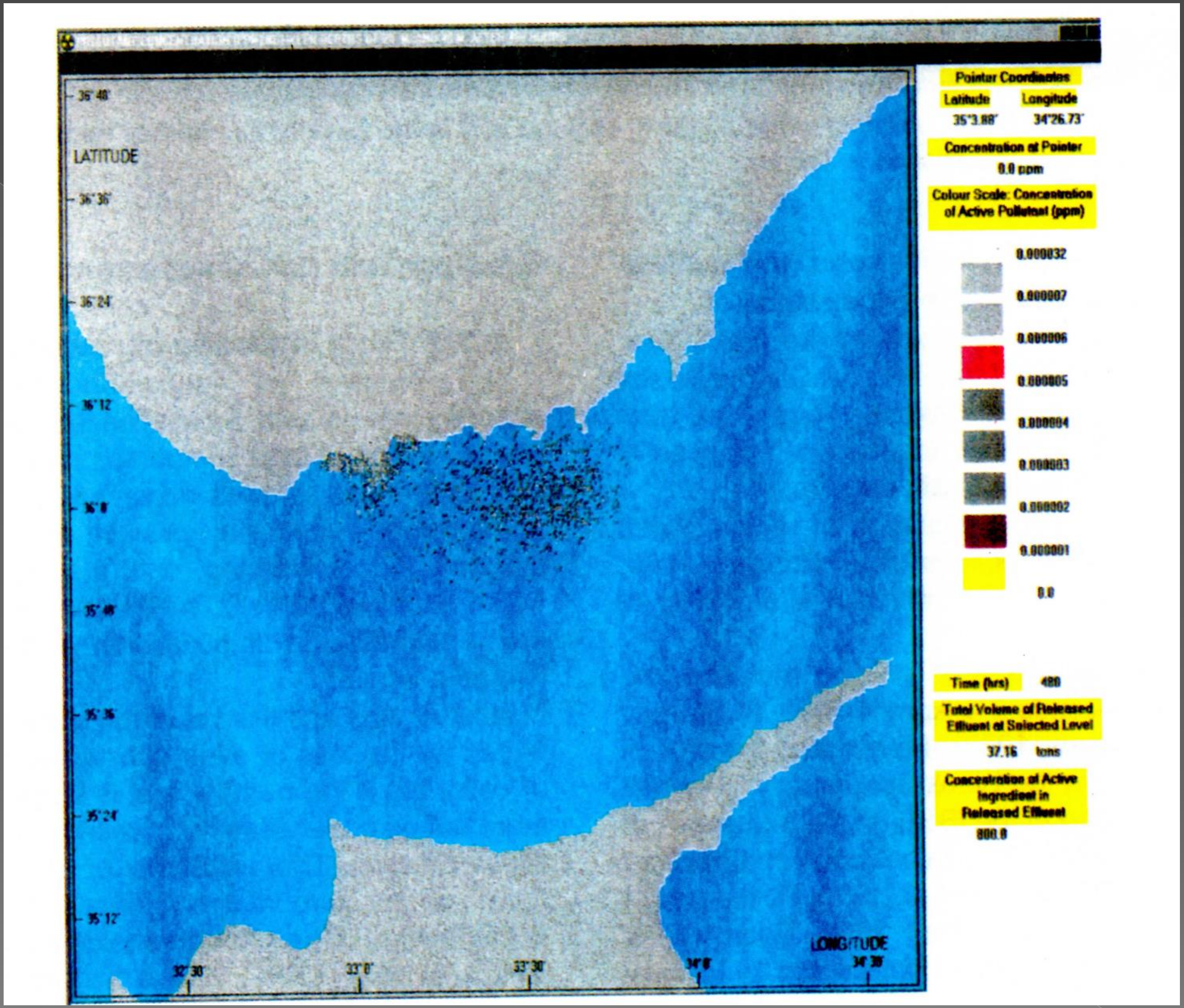
Position of the pollutant cloud 20 days after the spill in the case of a Westerly wind of 10 meters per second in Summer.



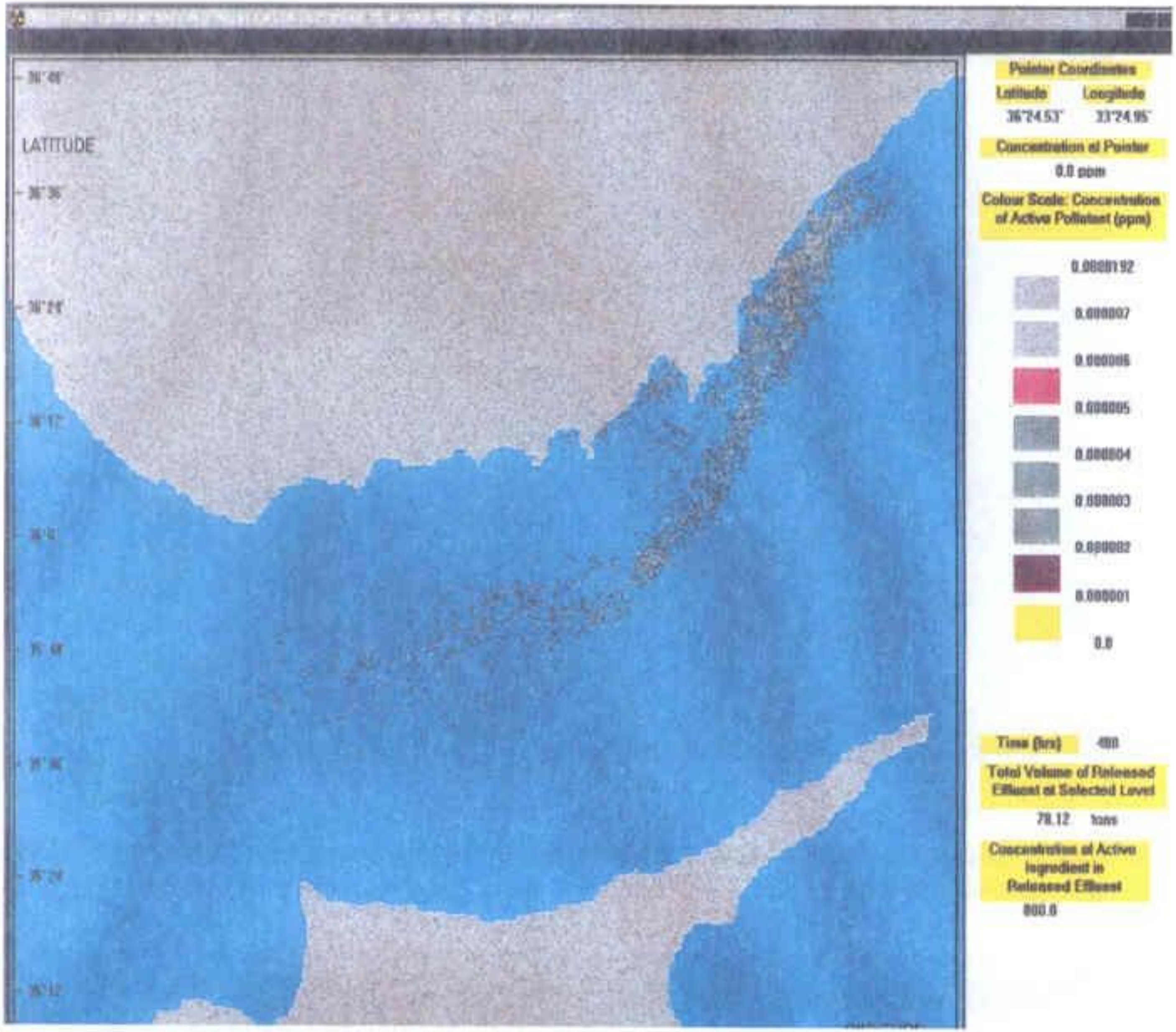
Position of the pollutant cloud 30 days after the spill in the case of a Westerly wind of 10 meters per second in Summer.



Position of the pollutant cloud 30 days after the spill in the case of a Westerly wind of 10 meters per second in Winter.



- Position of the pollutant cloud 30 days after the spill in the case of a Westerly wind of 10 meters per second in Winter.



Position of the pollutant cloud 20 days after the spill in the case of a Northerly wind of 10 meters per second in Winter.

Significant radionuclide	Released in 1986 (x 10^{15} Bq)	Remaining in 1996 (x 10^{15} Bq)	Remaining in 2056 (x 10^{15} Bq)
I-131	1200-1700	0	0
Sr-90	8	6	1.5
Cs-134	44-48	1.6	0
Cs-137	74-85	68	17
Pu-238	0.03	0.03	0.02
Pu-239	0.03	0.03	0.03
Pu-240	0.044	0.044	0.03
Pu-241	5.9	3.6	0.2
Am-241[+]	0.005	0.08	0.2

+The activity of Am-241 in 1996 has increased since 1986, as it is a daughter product of Pu-241

Residual radioactive material in the global environment as a result of the Chernobyl accident in April 1986

MARINE NUCLEAR ACCIDENTS

- **Incidents and emergencies in atomic submarine fleet of USSR / RUSSIA have been many during the 50 years operational period of NPS: twelve nuclear and more 100 radiation emergencies have taken place.**
- **Many incidents and emergencies occurred also to atomic submarine fleets of USA, UK and France**

ACCIDENTS in the last years

Submarine	Nationality	Date	Type of Accident
Tireless	British	12 May 2000	Reactor Coolant Leak
Kursk	Russian	12 August, 2000	Explosion
USS *Greeneville* (SSN-772)	American	9 February, 2001	Collision
USS *Dolphin* (AGSS-555)	American	21 May 2002	Flooding
HMS *Trafalgar* (S107)	British	06 November 2002	Submerged Grounding
USS *Oklahoma City* (SSN-723)	American	13 November 2002	Collision
No. 361	Chinese	2 May 2003	Unknown
HMCS *Chicoutimi* (SSK 879)	Canadian	05 October 2004	Fire
K-223	Russian	14 November 2004	Explosion
USS *San Francisco* (SSN 711)	American	08 January 2005	Grounding

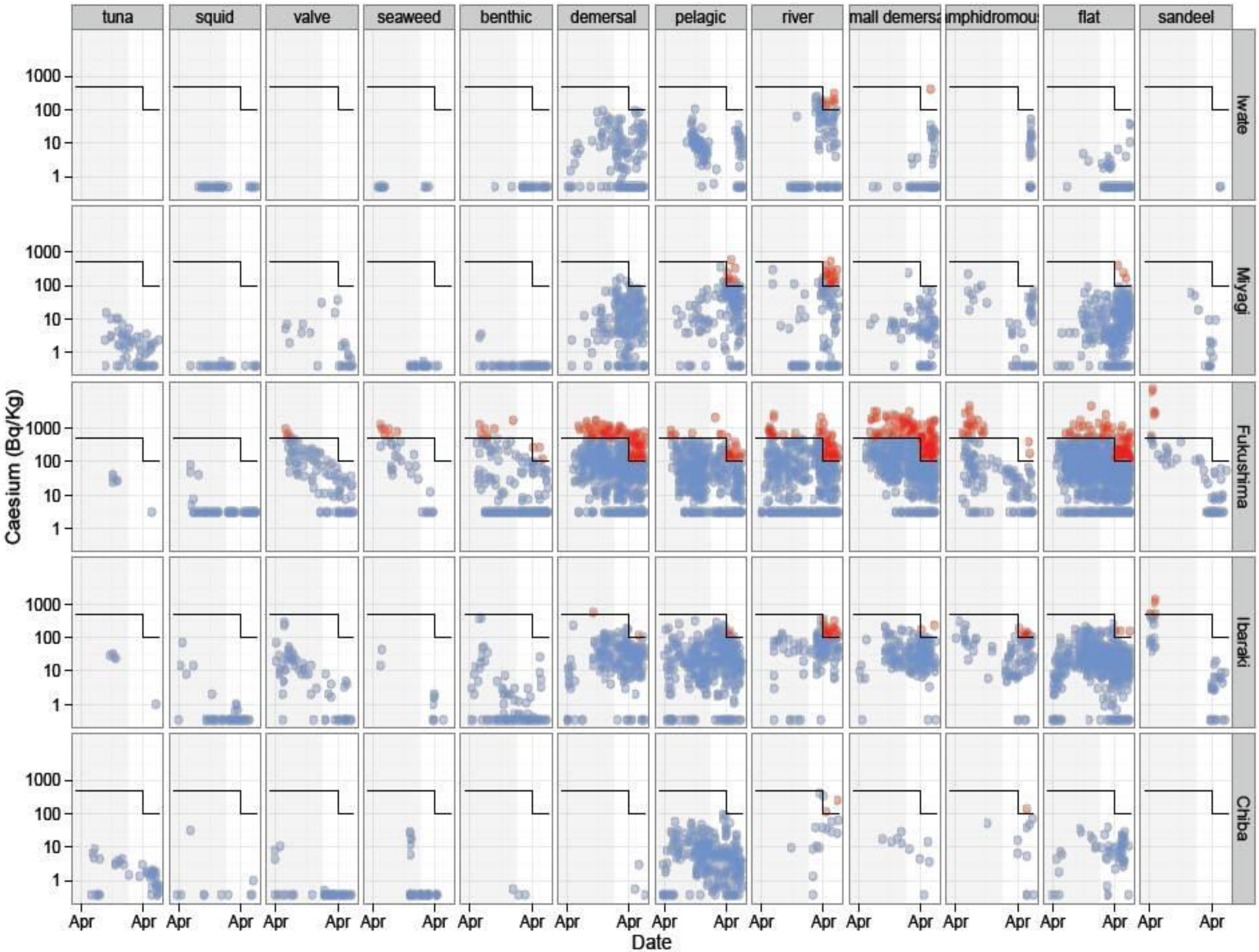
USS S.Francisco – January 2005

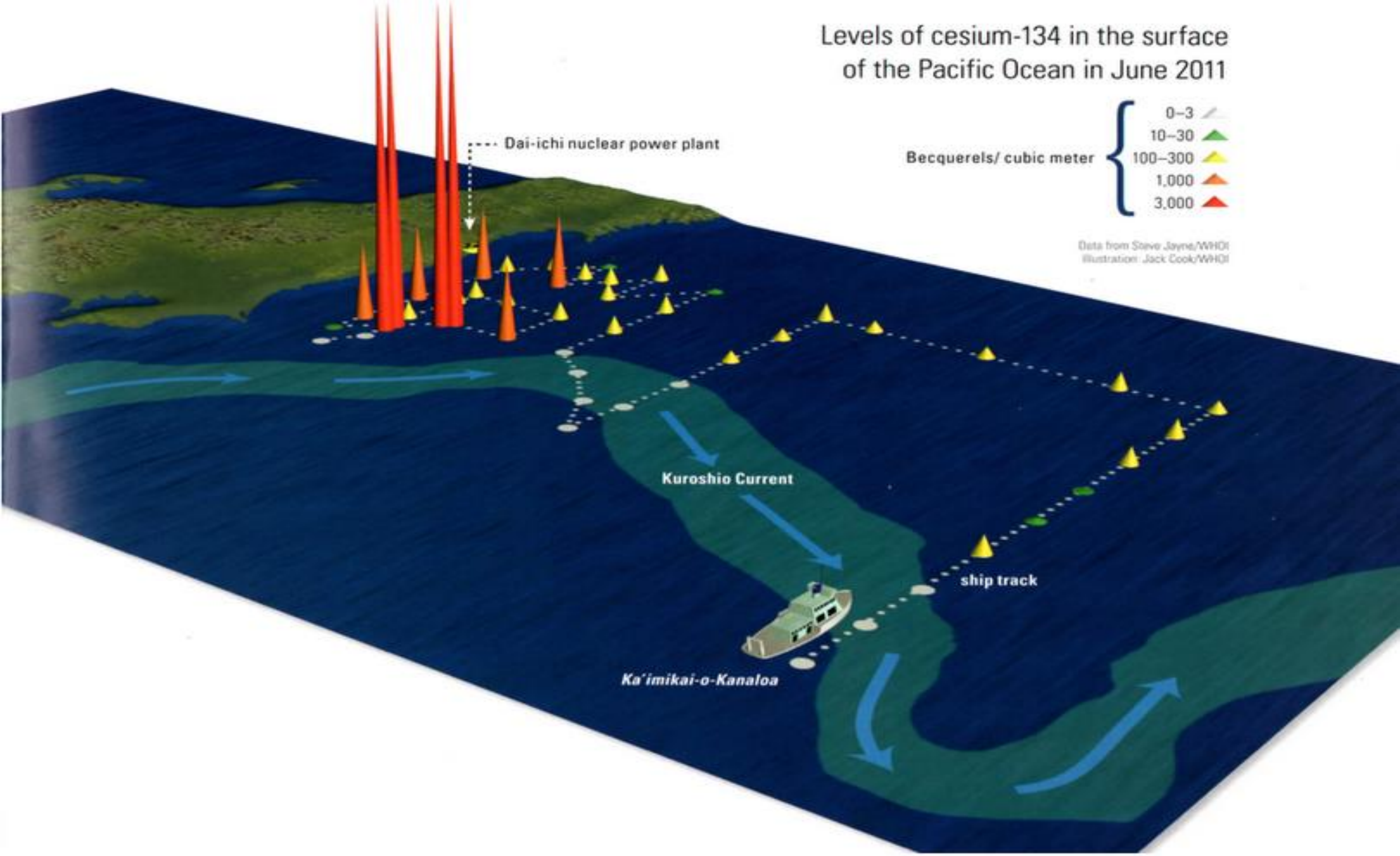

GREENLAND
K-123
Komsomolets
K-19
Cochino
Kursk
EUROPE
NORTH AMERICA
Squalus
Thresher
S-4
Scorpion
K-219
Chopper
AFRICA

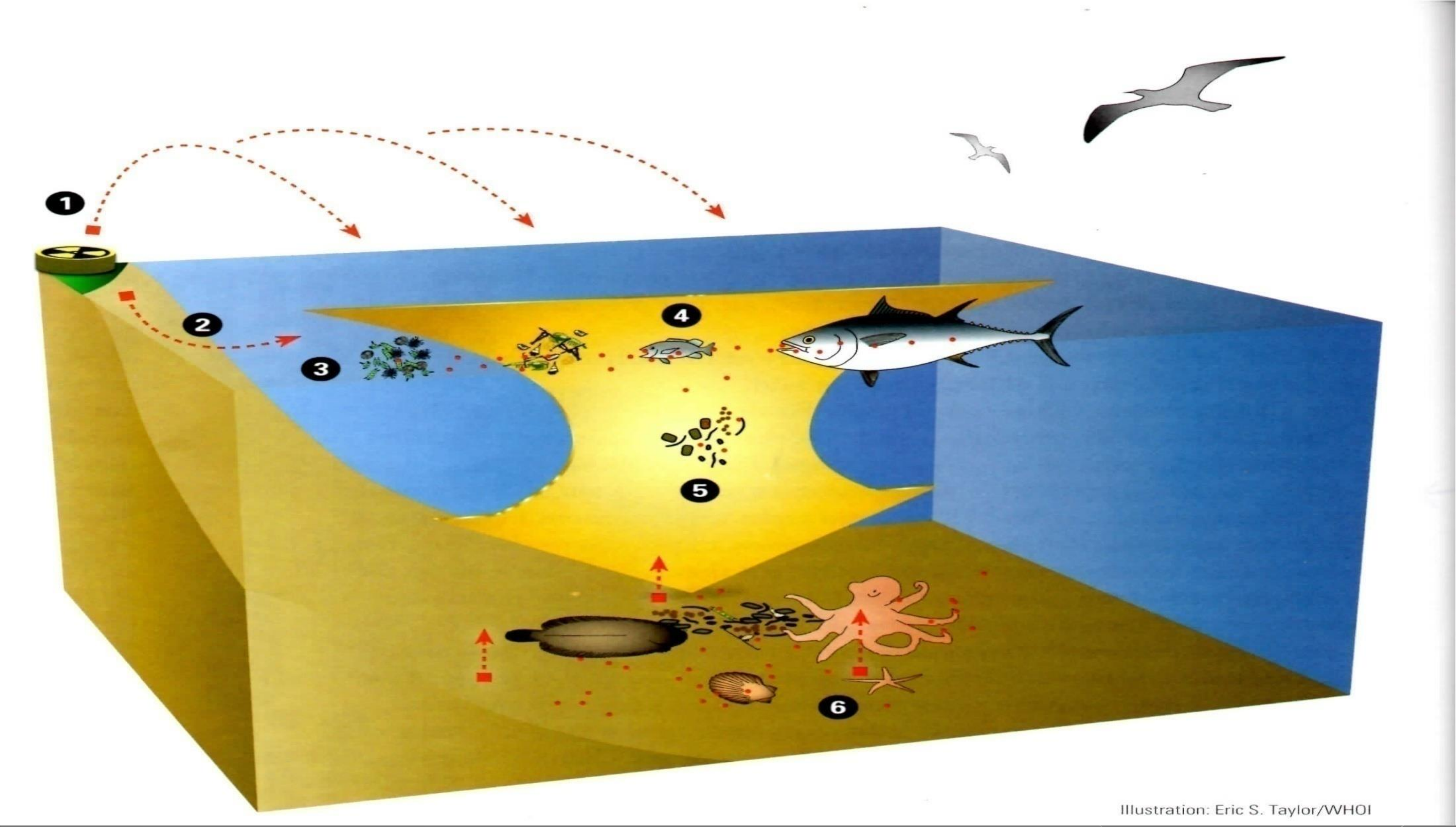

Alaska
24/03/1989
"Exxon Valdez"
40.000 t. arg.
Griland
21/01/1960
Drop of American
B52 with four
Irland
08/01/1979
"Bentegeuse"
Britain
15/02/1996
"Sea Empress"
70.000 t. arg.
"Braer"
85.000 t. arg.
Magxi
10.000 t.
radioactives wastes
Norway
07/04/1989
"Komsomolets"
Soviet Nuclear
submarine
Sweden
20/03/1970
"Othello"
60.000-100.000
t. arg.
Mourmansk
Dissolution of
old Soviet
nuclear
submarines
Sea kara
Nuclear reactor
of Soviet
iceboat "Lenin"
Kamstatka
06/1983
Unknown
Soviet
submarine
with nuclear
arms
Black Sea
Soviet martial boat
with nuclear
arms
Italy
10/01/1970
Unknown Soviet
submarine
11/04/1991
"Haven"
144.000 t. arg.
Hawai
11/04/1968
Unknown Soviet
nuclear submarine
Pacific
Depletion of nuclear
waste outside from
the coasts of California
Cape Kod
10/04/1963
American submarine
SSN593 with nuclear arms
Vermoudes
4/010/1986
Unknown soviet
submarine with
nuclear arms
Trinidad &
Tobago
19/07/1979
"Altantic Empress"
"Aegean Captain"
287.000 t. arg
Atlantic
13 regions
with radioactives
Azores
21/05/1968
American submarine
SSN589 with nuclear
Maroco
"Khank-5"
70.000 t. arg.
Spain
12/05/1976
"Urqiola"
100.000 t. arg.
31/12/1978
"Andros Patria"
60.000 t. arg.
03/12/1992
"Aegean Sea"
70.000 t. arg.
"Prestige"
64.000 t. firings
France
12/12/1999
"Erika"
21/01/2006
"Ece"
10.000 t.
phosphories
Persian Bay
19/12/1972
"Sea Star"
100.000 t.
arg.
India
Dissolution of boats
without precautions
South Africa
21/09/1972
"Texanita"
"Oswego Guardian"
100.000 t. arg.
05/08/1983
"Castillo de Belver"
255.000 t. arg.
Baglantes
Dissolution of boats
without
precautions
Malakka
07/06/1975
"Showa Maru"
237.000 t. arg.
Figi
11/04/1970
Nuclear reactor
from the famous
"Apollon 13"
Nuclear
Pollution
Pollution
of petroleum
other
pollution

Fukushima - impact on marine environment – outcome of second EU-Japan meeting

Area	Seawater (Bq/L)	Sediments (Bq/kg)
Near nuclear plant discharge ports	1-10	20-3000
Near nuclear plant - Iwasawa coast (15km south of nuclear plant)	0.1-1	
Coastal area within 30km of Miyagi, Fukushima and Ibaraki prefectures (including river outlets)	0.002-0.1	10-400
Offshore area - within about 30 to 90km from the coastline	background -0.1	10-300
Outer sea area - within about 90 to 280km and 280km or forther from the coastline	background - 0.01	no data
Background	0.0011-0.0018	0.8-1.4


tuna
squid
valve
seaweed
benthic
demersal
pelagic
river
mall demersa
mphidromou
flat
sandeel
Iwate
Miyagi
Fukushima
Ibaraki
Chiba
Caesium (Bq/Kg)
1000
100
10
1
Apr
Date


Levels of cesium-134 in the surface of the Pacific Ocean in June 2011
Becquerels/ cubic meter
0–3
10–30
100–300
1,000
3,000
Data from Steve Jayne/WHOI
Illustration: Jack Cook/WHOI
Dai-ichi nuclear power plant
Kuroshio Current
ship track
Ka'imikai-o-Kanaloa



Phytoplankton accumulated roughly 10 times as much plutonium as microzooplankton, which took up 100 times more than clams. Octopi and crabs took up about half as much plutonium as clams, but about 100 times more than bottom-dwelling fish.

(AP Photo/Yomiuri Shimbun, Kaname Muto)

Risk assessment

- The health consequences conditional on an accident at a Nuclear Power Plant at distances greater than 50km refer to late effects only. Results have been evaluated for two different weather types.

- The maximum statistical individual risk for cancer mortality as a function of distance and the weather types ranges between 0.005 to 0.029 % at 50km and 0.0001 to 0.0002 % at 1250 km.

Such values represent the maximum increase over the natural cancer death rate which is around 25% over the whole life span of an individual.

Conclusions

- With reference to any specific location of a NPP, two main issues must be considered:

- seismotectonics and

- the direct connection with the marine ecosystem.

- From the point of view of the socioeconomically impact it must be stressed that the eastern basin of the Mediterranean is practically free from man-made sources of radionuclides.

- The effects from the socioeconomically point of view may be classified into two main groups: the direct impact due to the radioactive contamination of foodstuff and other environmental compartments and the psychological impact on the population.

- The lesson learned from accidental situations, as for the Chernobyl accident, shows that special emphasis must be put on the latter more than on the former.

- It must be emphasized that the area concerned by radioactive releases from a Nuclear Power Plant has a very great importance from the point of view of tourism. Since tourism is a primary resource of income for **Mediterranean area**, it may be assumed that this issue has been taken into account.

- As it has been stressed previously, the problem of seismicity of the region is first one and the most important, since it may trigger a number of further consequences.

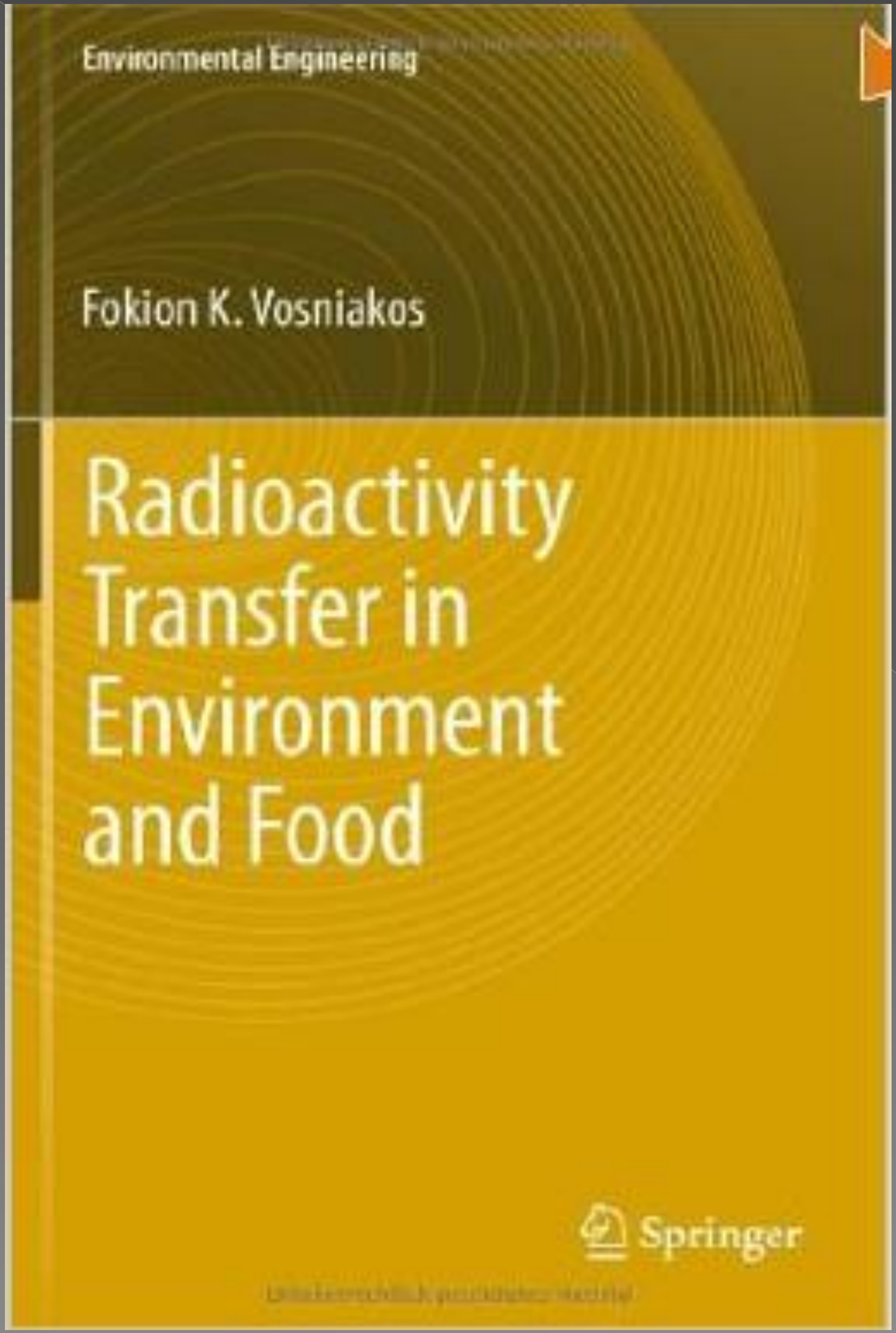
- The Eastern part of the Mediterranean Sea is characterized by the absence of nuclear plants of any kind.

- For such a reason the anthropogenic radioactive contamination of the marine compartments (sea water, sediments, fauna and plants) is due to the fallout from the experimental nuclear weapons and the Chernobyl accident .

- As it was reported a deposition of the order of 10^9 Bq/m^2 is assumed in accidental situation for the most contaminated places in the vicinity of the source.

- By taking ^{137}Cs as a reference radionuclide, the internal dose rate for aquatic animals would reach 4 Sv/a if the concentration would remain at the level reported above for one year. Since the concentration in sea water decreases rapidly, a dose rate around 10^{-1} Sv/a would probably be attained.

- When animals living in or close to the sediments are considered that the dose rate could reach values of the order of some Sv/a.



- http://www.springer.com/environment/book/978-3-642-28740-4?otherVersion=978-3642-28741-1

"How inappropriate to call this planet Earth when it is Quite clearly Ocean"

Arthur C. Clarke