

Marine Environmental Impacts of Desalination plants - Intake Water and Discharges

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THE MARINE ENVIRONMENT

- The Arabian Gulf and Red Sea are the major source of seafood, as well as two of the most precious and coveted resources— water and oil
- Within the Gulf, there are different types of sensitive habitats in which plants and animals live such as



Mangroves



Seagrasses



Coral reefs



Salt Marshes

- These rich and diverse ecosystems are experiencing physical and chemical stresses mainly due to man-made activities such as:
 - ✓ Industrial development,
 - ✓ Desalination plants and
 - ✓ Oil exploration



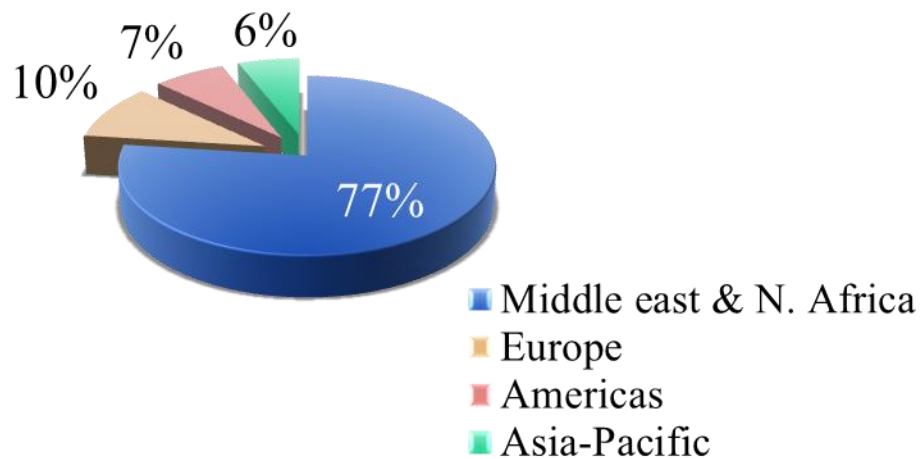
DESALINATION – FACTS & FIGURES

- Worldwide, only 1% of drinking water is produced by desalination, supplied by more than 12,500 plants in more than 120 countries amounting to 24.5 million m³/day (ETAP, 2008).
- The market volume has soared from \$ 2.5 billion in 2002 to \$ 3.8 billion in 2005 with a growth rate of over 15% per annum (Lattemann and Höpner 2008).
- The regions of the Middle East clearly dominate the demand (over 50% of the market share), followed by Asia-Pacific, America, and Europe that share about 10% of the market respectively (Lattemann and Höpner 2008).
- Of which KSA ranks first in overall capacity with approximately 23% (Lattemann and Höpner 2008).
- It is estimated that by the year 2025, the Arabian Gulf Region would demand approximately 137 billion m³/year (Lattemann and Höpner 2008).

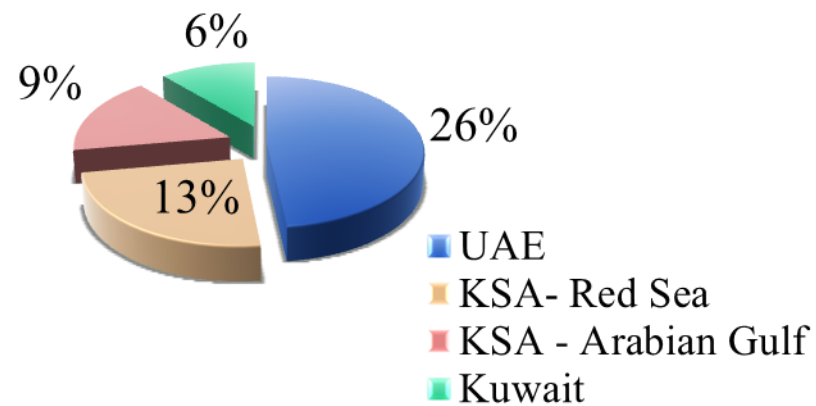


DESALINATION – Regional Distribution of Capacities

Global Contribution



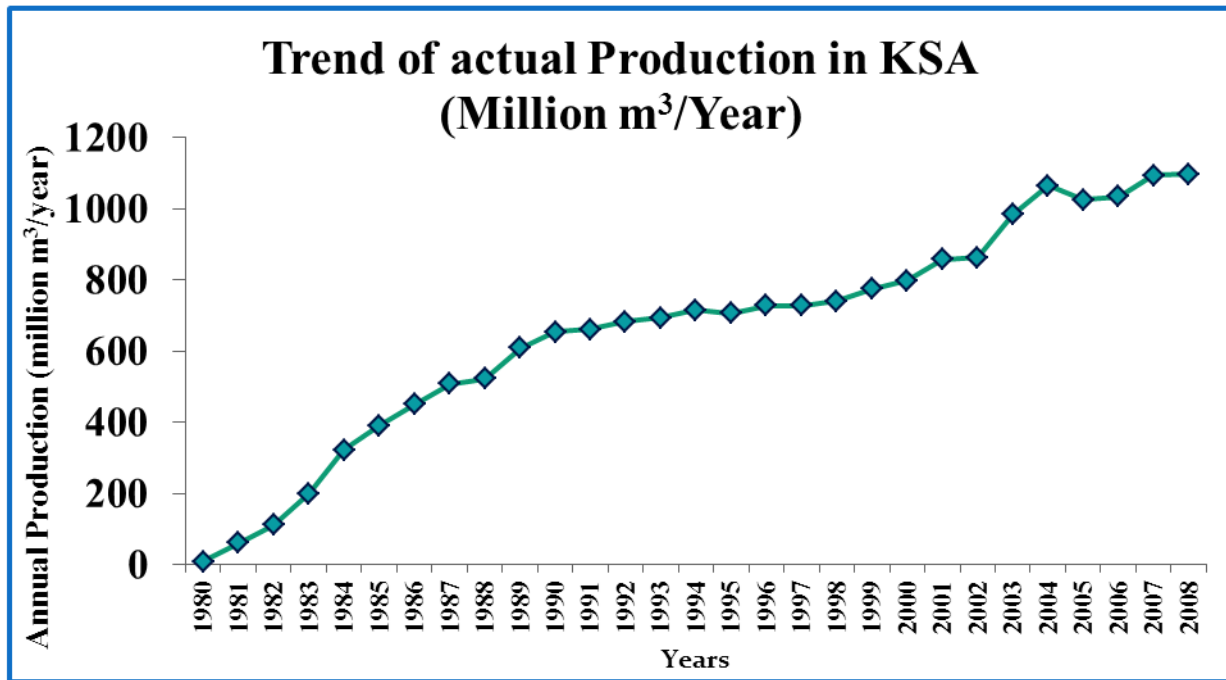
The main producers in the Gulf region



(from Lattemann and Höpner 2008)



PRODUCTION IN SAUDI ARABIA



Working plants along the West Coast:

JEDDAH, AL-SHOAIBAH, **YANBU**, AL-SHUQAIQ, HAQL, DUBA, AL-WAJH, UMMLUJ, RABIGH, AL-AZIZIYAH, AL-BIRK, FARASAN, AL-QUNFIDAH

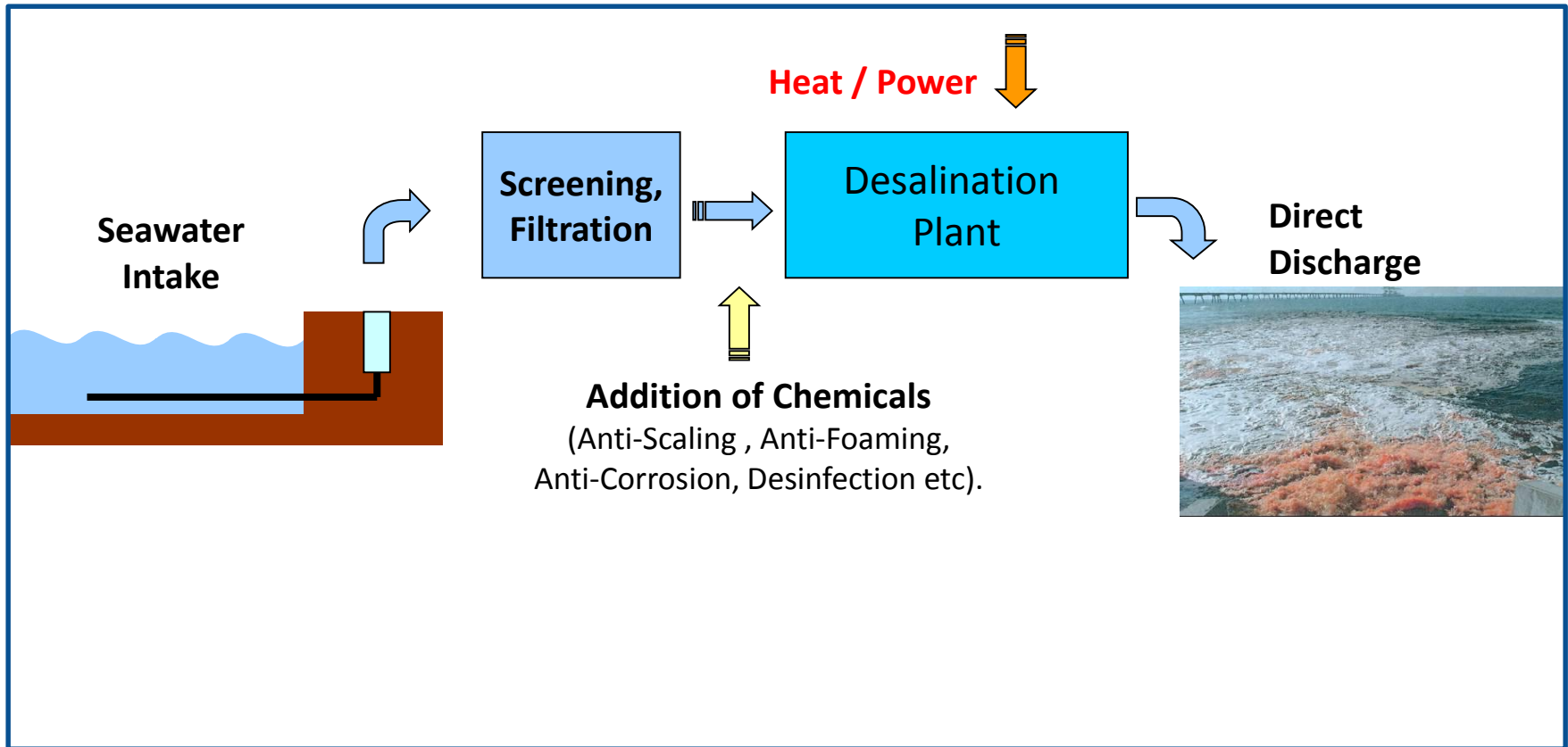
Working plants along the East Coast:

AL-KHOBAR, AL-KHAFJI AND AL-JUBAIL

Source: <http://www.swcc.gov.sa/>



THE PROCESS OF DESALINATION





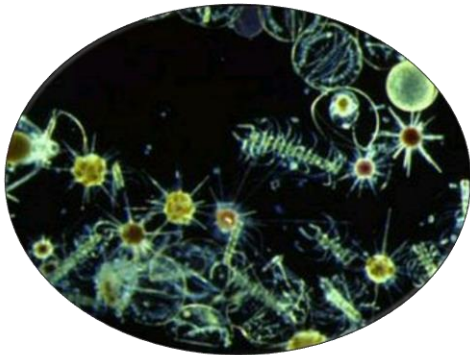
Impacts of Desalination



Impacts due to
Intake

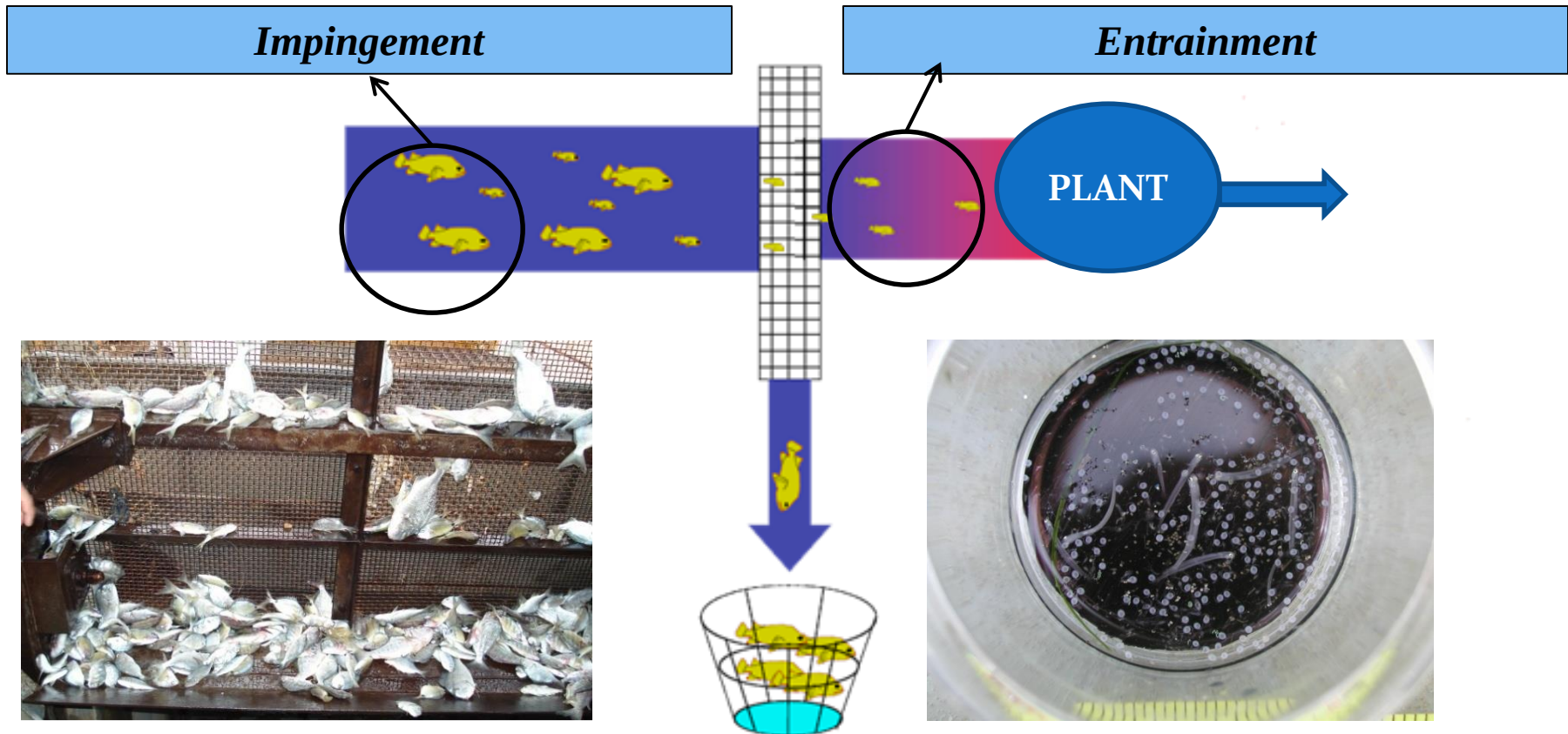
Impacts due to
Discharge

💧 The intake seawater is not mere seawater but a habitat which contains an entire ecosystem of phytoplankton, zooplankton, larval forms of invertebrates and fishes.



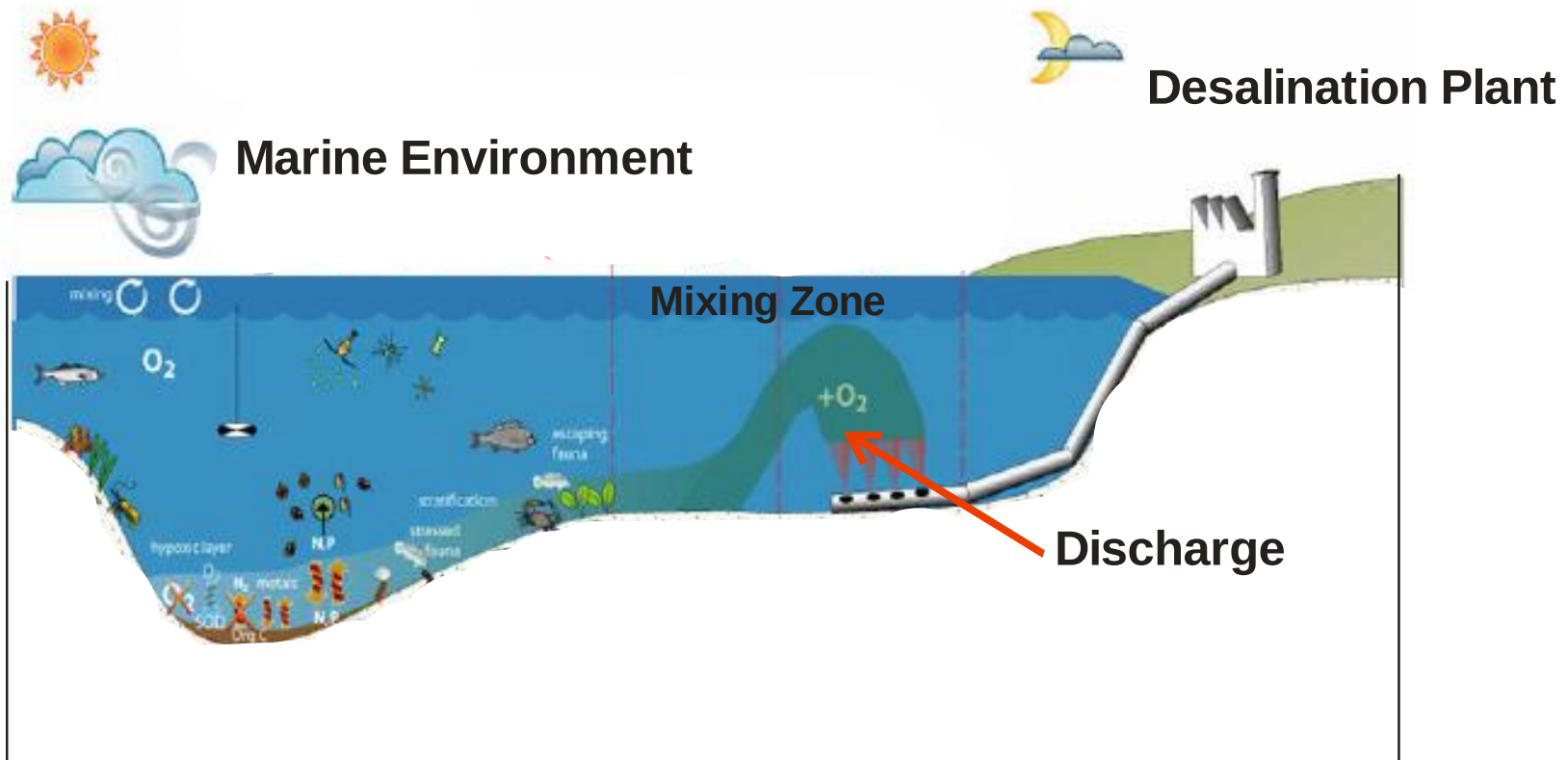
- 💧 Major impact of intake is loss of Aquatic life and biodiversity
 - 💧 Animals larger than the mesh – injury or death due to impinging effect
 - 💧 Animals smaller than the mesh – Entrained into the plant and killed by thermal and chemical alterations.
- 💧 Construction of the intake structure causes disturbance of the seabed which results in:
 - 💧 Re-suspension of sediments.
 - 💧 Release of nutrients and pollutants into the water column.

❖ Entrainment & impingement



- 💧 **Impingement** occurs when marine organisms are trapped against intake screens by the velocity and force of water flowing through them.
- 💧 **Entrainment** occurs when smaller organisms pass through an intake screen and into the process equipment.

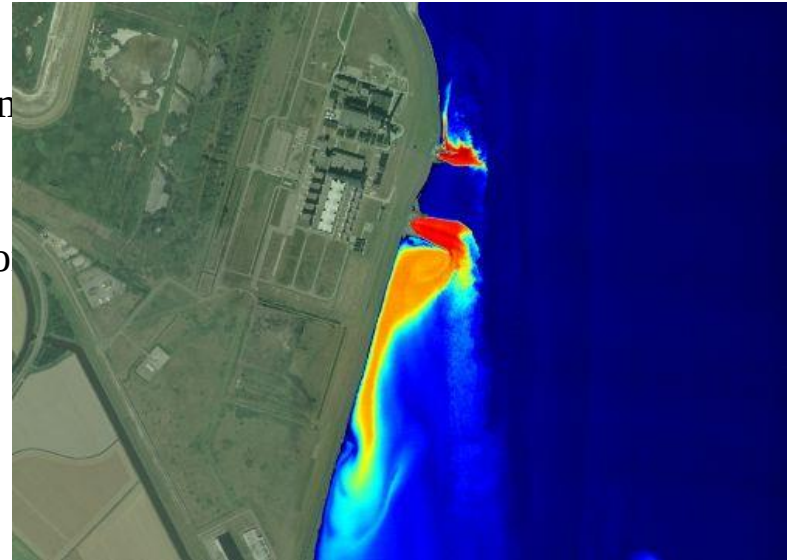
IMPACTS DUE TO DISCHARGE



- 💧 Salinity increase (Brine)
- 💧 Temperature increase
- 💧 Toxicity due to chemicals (chlorine, trace metals etc.)

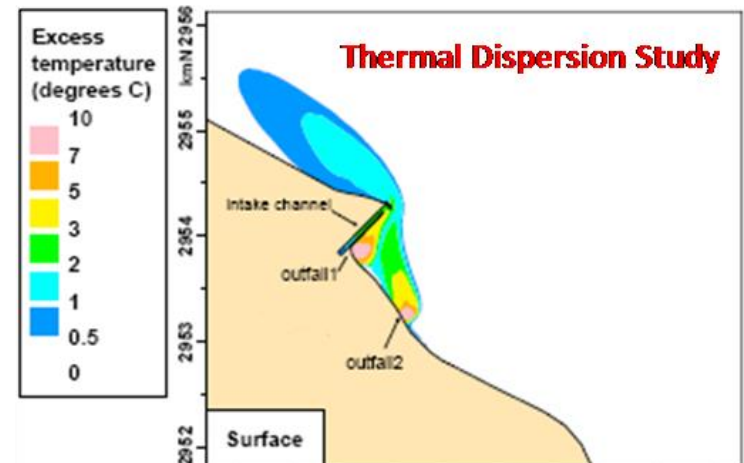
❖ Brine (high salinity)

- 💧 Dense brine water (in RO plants) sinks to the sea bottom impacting the benthic communities.
- 💧 Depleting the available dissolved oxygen near the bottom causing hypoxic (low oxygen) conditions.



❖ Temperature

- 💧 Death due to thermal shock
- 💧 Increased proliferation of Harmful algal blooms
- 💧 Coral bleaching
- 💧 Decreased larval survival



❖ Chemicals

- 💧 Pretreatment and Post treatment
 - 💧 Avoiding biofouling
 - 💧 Suspended solids
 - 💧 Accumulation and
 - 💧 Scale deposits
- 💧 Cleaning chemicals

Examples of commonly used chemicals

- 💧 **Sodium hypochlorite**
To prevent biological growth
- 💧 **Ferric chloride**
To remove suspended matter
- 💧 **Sulfuric acid**
To adjust the pH
- 💧 **Sodium hexameta phosphate**
To prevent Scale formation
- 💧 **Sodium bisulphate**
To neutralize residual Chlorine
- 💧 **EDTA**
To remove Carbonate deposits
- 💧 **Citric acid**
To clean the membrane



Nata Sea Water Desalination Plant in Japan

(From: Younos, 2005)

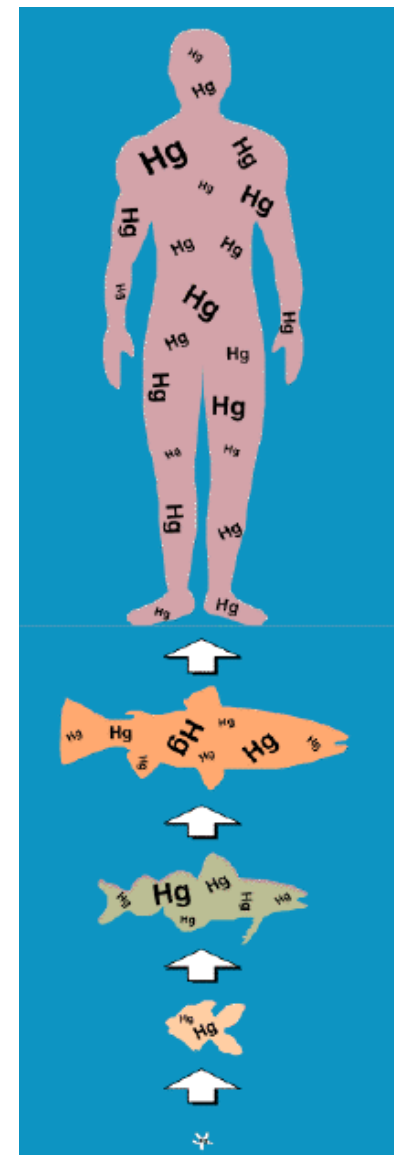
Impacts of chemicals

Chlorine

- 💧 Potent Biocide
- 💧 High reactivity with organics
- 💧 Forms Chlorinated/Halogenated byproducts
- 💧 Carcinogenic

Trace metals

- 💧 Sediments – tends to accumulate trace metals from discharges.
- 💧 Selectively accumulated by organisms to much larger concentrations that can cause toxicity- **Bioaccumulation**.
- 💧 Increases many folds along the food chain (**Biomagnification**).
- 💧 Becomes highly toxic for human consumption.



Mitigation Measures



Mitigation Measures for Intake

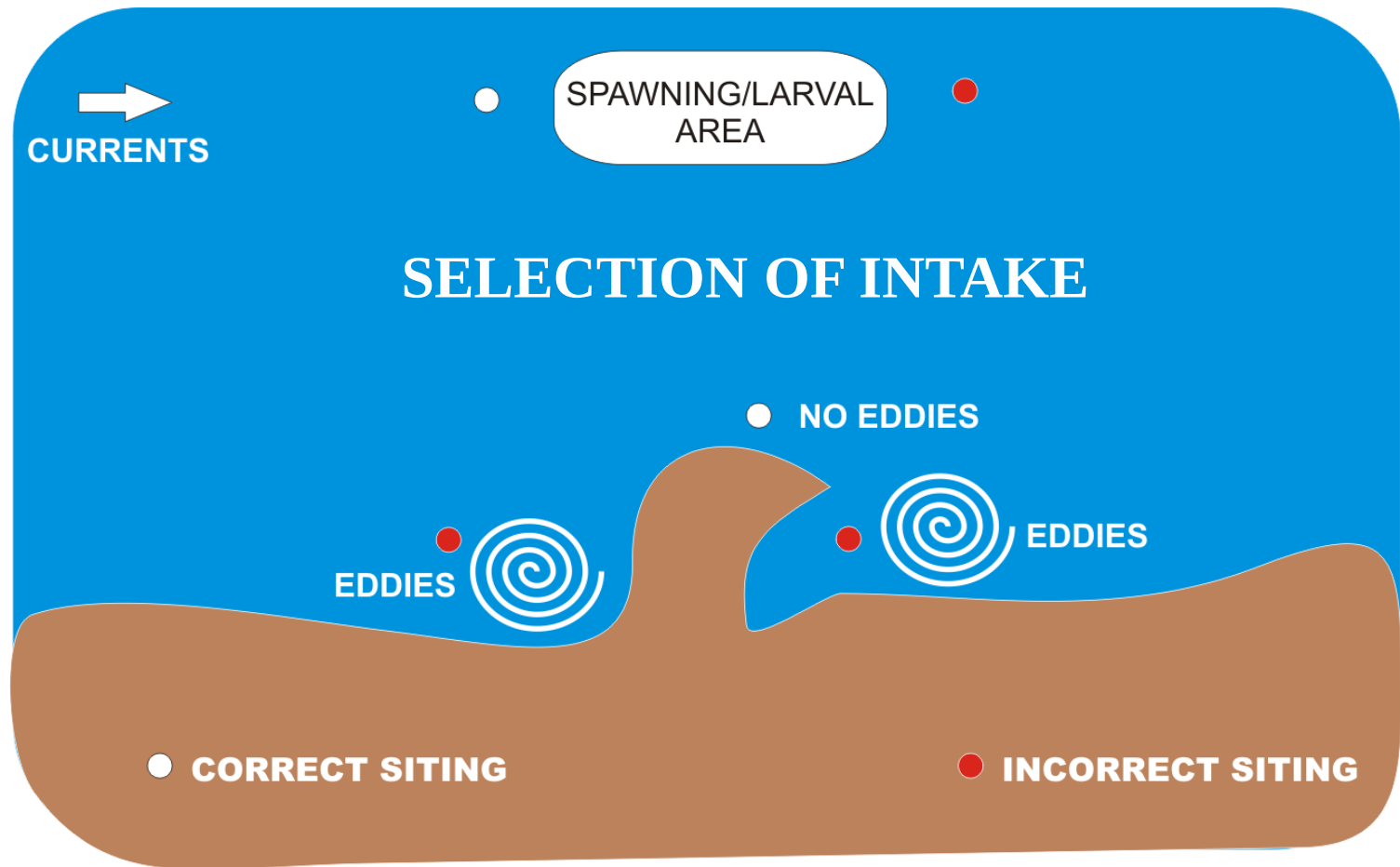


Mitigation Measures for Discharge



MITIGATION MEASURES FOR INTAKE

❖ Mitigating entrainment



💧 Proper site selection for intake reduces the aquatic loss caused due to entrainment.



❖ Mitigating impingements

Surface Intakes

- **Behavioural Technologies**
 - Light
 - Acoustic Fish Deterrents
 - Velocity Cap
- **Collection Technologies**
 - Ristroph screens
- **Exclusion Technologies**
 - Cylindrical Wedgewire screens
 - Barrier Nets

Subsurface Intakes

- Vertical Wells
- Horizontal Directional Drilling (HDD) Wells
- Infiltration galleries
- Slant wells

• Behavioural technologies

✓ Light

- 💧 Most impingement of fishes has been noted to be greater at night.
- 💧 Underwater Strobe lights elicit an avoidance response and are more effective.

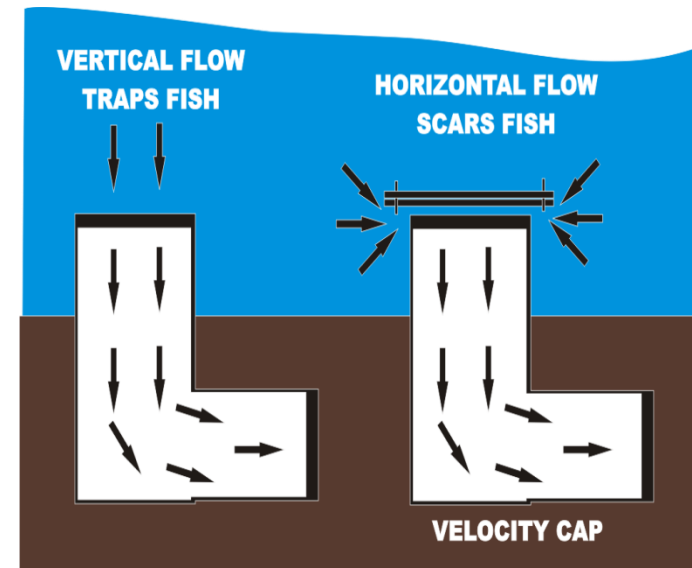


✓ Acoustic fish deterrents

- 💧 High frequency sounds (10 Hz - 3 KHz) have been most successful at repelling most pelagic fishes.

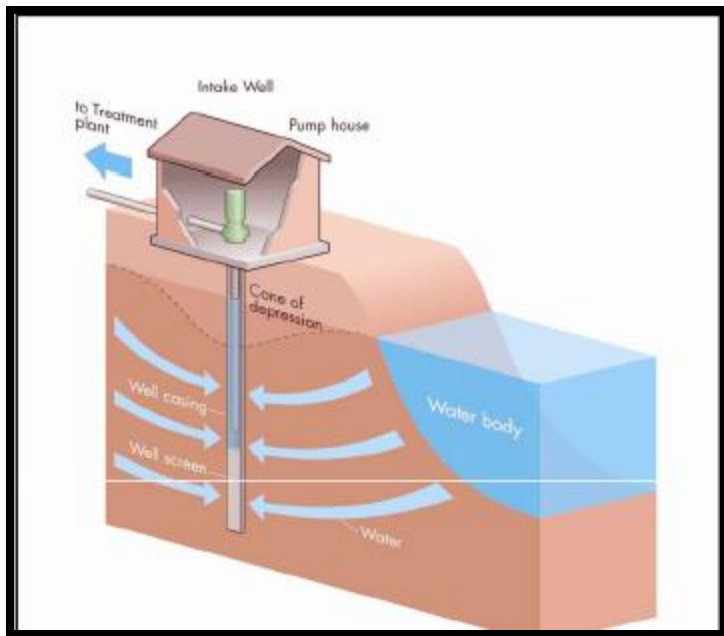
✓ Velocity cap

- 💧 Works on the principle that fish avoid rapid changes in horizontal flow and are relatively insensitive to vertical velocities.

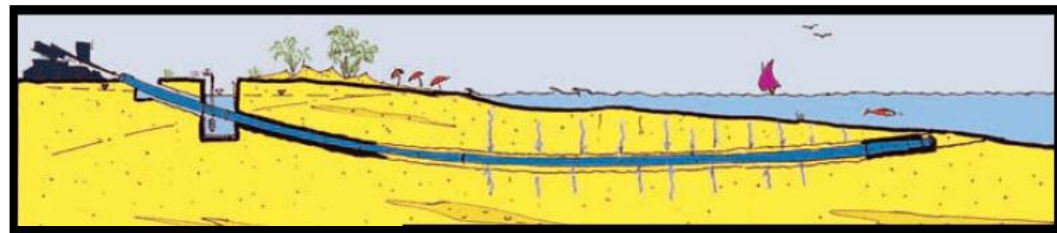


❖ Subsurface intake

• Vertical beach wells



• Horizontal directional drilling (HDD)



💧 Design includes geological structures such as porous rocks, sea mud, sand and other seabed material between the intake and the sea, limiting the intake with its water permeability.

💧 Eliminate entrainment and impingement by providing a level of pre-filtration



MITIGATION MEASURES FOR DISCHARGES

- 💧 Focus on 3 Aspects
 - 💧 Discharge Dispersion
 - 💧 Effluent Composition and
 - 💧 Environmental Impact Assessment
- 💧 Do not discharge close to sensitive habitats (Corals, seagrass etc.)
- 💧 Conduct hydrodynamic modeling study to identify discharge locations
- 💧 Select discharge locations to have best dilution and dispersion
- 💧 Use of hazardous chemicals could either be replaced or treated before discharge (For eg., Chlorine can be removed by adding Sodium bisulfite).
- 💧 Provide nozzles to discharge pipeline for to improve mixing
- 💧 Conduct Real Time monitoring of marine environment near discharge (Example: Use Real Time Monitoring Buoys).

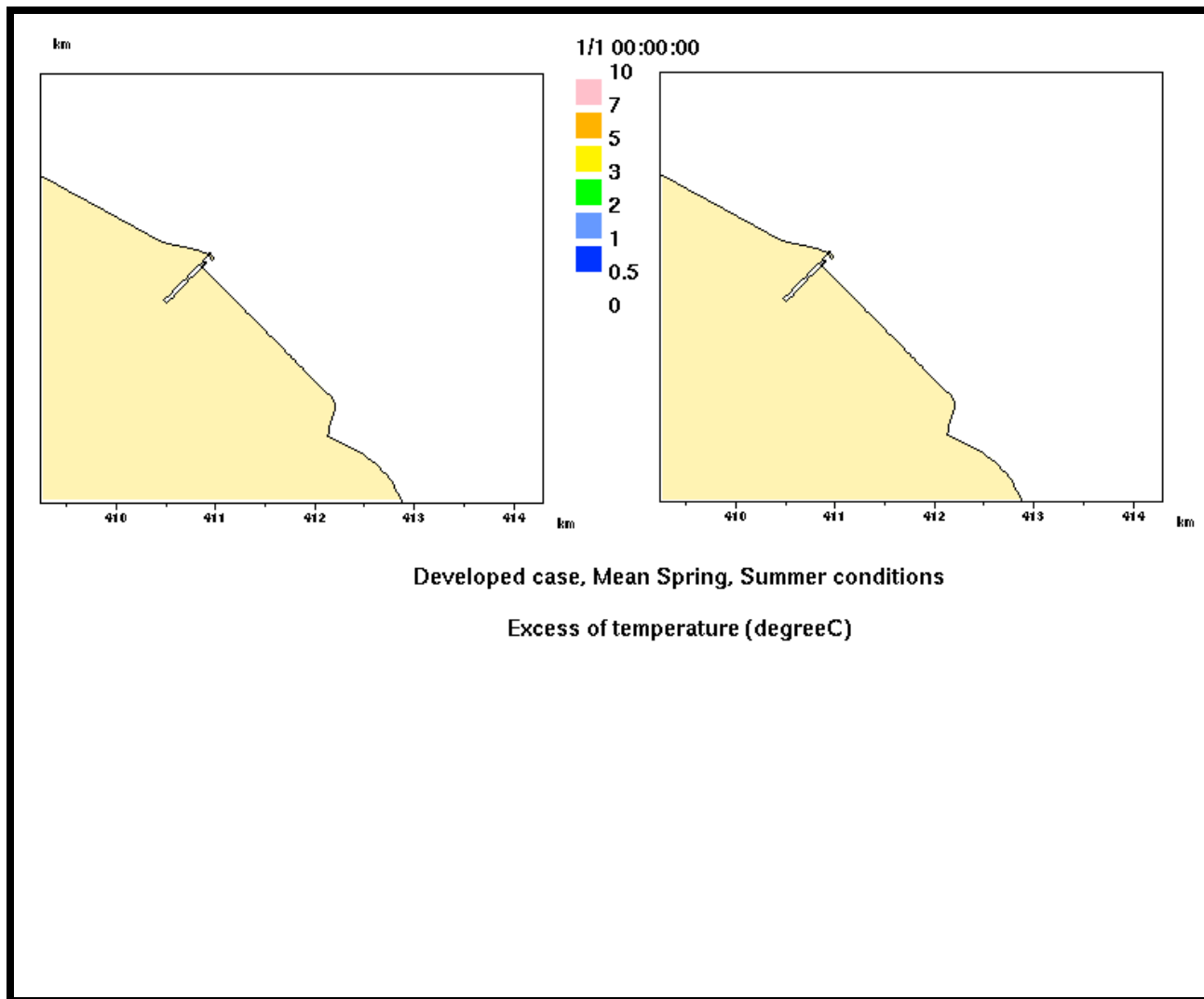


Monitoring Buoys



Continued...

❖ Modeling the temperature profile of outfall





PME AMBIENT WATER QUALITY STANDARDS

Parameter	Unit	Red Sea	Arabian Gulf
		Industrial (C3)	Industrial (C3)
Physico-chemical parameters			
Temperature	°C	Δ4	Δ4
Salinity	psu	Δ2	Δ3
TDS	mg/l	37-45,000	37-50,000
TSS	mg/l	10	10
Chemical Indicators & nutrients			
Chloride (as Cl)	mg/l	22,000	35,000
Heavy metals			
Arsenic	mg/l	0.1	0.1
Cadmium	mg/l	0.05	0.05
Chromium (total)	mg/l	0.1	0.1
Copper	mg/l	0.15	0.15
Lead	mg/l	0.2	0.2
Mercury	mg/l	0.001	0.001
Nickel	mg/l	0.2	0.2



CONCLUSIONS

- 💧 The current US EPA standard requires that the best available technology should be used in order to achieve **impingement reduction of 85-95%** and **entrainment reduction of 60-90%**.
- 💧 The design and location of the intake should be site specific, adjusted to the particularity of the local marine ecosystems.
- 💧 A desalination facility has to improve its recycling techniques using the Best Available Technology thereby preventing dangerously high concentrations in the discharge.
- 💧 The facility has to monitor regularly the pollutant concentrations of the discharge to that of the national ambient standards (PME) or environmental quality standards of various international organizations like ANZECC and NOAA.
- 💧 Good and effective management practices during intake and discharges will help produce sweet potable water and electricity with least environmental impacts.

Thank You

