جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Marine Monitoring Surveys for Desalination Plants: A Critical Review

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Introduction

Why bother?

- As a regulatory requirement, monitoring forms part of the modern Environmental Impact Assessment (EIA) process;
- Emphasize the importance of long-term environmental considerations in the decision-making process;
- Appropriate monitoring can minimize effects of development proposals as well as these of existing operational facilities;
- *When enforced*, it will assist in the protection, productivity and capacity of natural systems and the ecological processes which maintain their functions.

Reference

http://www.tandfonline.com/doi/abs/10.1080/19443994.2012.693700

Desalination and Water Treatment

A review of environmental governance and its effects on concentrate discharge from desalination plants in the Kingdom of Saudi Arabia

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Presidency of Meteorology and Environment (PME)

Royal Commission for Jubail and Yanbu (RCJY)
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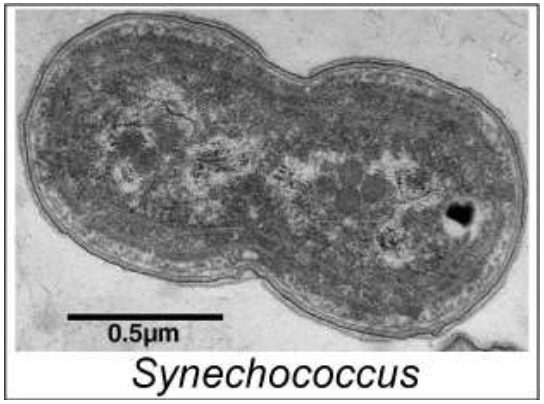
Impact on the environment

- Changes in conductivity, temperature, turbidity and the presence of chemicals may be vital parameters that influence the distribution of marine species and microbial communities;

- These ‘pollutants’ can be fatal to marine life and can cause a lasting change in species diversity and abundance in the discharge area;

- *Case-to-case basis!*



Current status of monitoring

- Shortcomings:
  - Limited in scope (i.e., salinity effects only);
  - Short-term (often with no baseline or operational monitoring);
  - Localized (i.e., no far-range or cumulative effects).

- Appropriate monitoring should (at least):
  - Account for all the complexity of potential ecosystem responses; &
  - Adequately distinguish project effects from natural processes.

Design of monitoring studies

- *Stressor base approach:*
  - Stressor: [e.g., concentrate discharge];
  - Receptor: [e.g., population diversity specific to marine microorganisms];
  - Interaction: [stress from elevated salinity].

  - This approach does not account for other stressor sources;
  - All stressor sources of a project should be known.

- *'Effects-based approach':*
  - Measures the 'accumulated environmental state' of the ecosystem.

Before-after, control-impacts (BACIPS)

- **'Stressor-based approach'**
  - Baseline and operational monitoring in the project site [Before – After]

+

- **'Effects-based' approach**
  - Identical studies in an undisturbed control site [Control – Impact]

= BACI: isolates the impact from natural variability ('background noise')

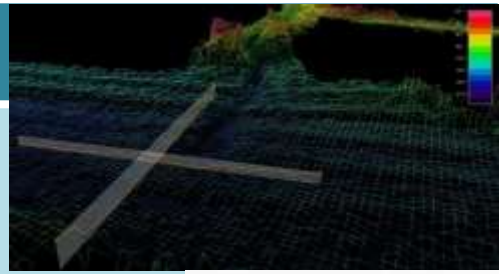
- **Appropriate monitoring design will consider:**
  - **Spatial variability** (several control sites which adequately represent the range & habitats found in the impact site; and
  - **Temporal** variability (Several 'paired sampling' dates Before and After the impact in both the Control & Impact sites).

Scope of monitoring studies

Seawater	Methods
○ **Oceanographical parameters** – S, T, DO, water currents, etc.	– Stationary buoys – AUVs – ADCPs
○ **Chemical parameters** – Major nutrients; – Priority pollutants	– Water samples
○ **Biological parameters** – Marine microbial communities	– Plankton nets; – In situ; & – Flow Cytometry

Scope of monitoring studies

Seafloor	Methods
○ **Bathymetry and topography** – Image of the seafloor with topographical features and texture of the surface is created	– Echosounder – Side-scan sonar – Sub-bottom profilers
○ **Sediment characteristics** – Texture – Pollutants	– Grab or core samplers
○ **Biological parameters** – Species lists, distribution maps, *quantitative* data (e.g. biomass) of infauna and epifauna species	– Grab or core samplers – Underwater surveys (dives, videos)



Scope of monitoring studies

Marine Life	Methods
○ **Fish**	**Quantitative survey by trawling:** – sufficient replication/coverage (mobile nature of fish species) – data is still very variable – impacts on seafloor (benthic species) – impact of sampling is large compared to impact area of a desalination plant? **=> Qualitative surveys more reasonable!**
○ **Marine reptiles (turtles, sea snakes,…)** ○ **Marine mammals** ○ **Seabirds**	**Qualitative surveys with non-invasive methods** – due to conservation interest – dives, videos, ship-based counts – qualitative data (species lists)

Case Study: KAUST SWRO Plant

- Assessing changes in the marine microbial communities at the KAUST RO outfall, using flow cytometry (FCM) as the primary analyzing tool.

- **Objective**: To develop microbial indicators for improved monitoring and regulation of discharges from desalination plants using FCM as a rapid assessment tool for fast determination of microbe abundance, diversity and viability.

- Samples are collected (diving) at a depth of 16m with 5m intervals in a radius of 25m around the discharge (sterile 15mL Greiner tubes, transported to the laboratory under cold storage and analyzed on the day of sampling).

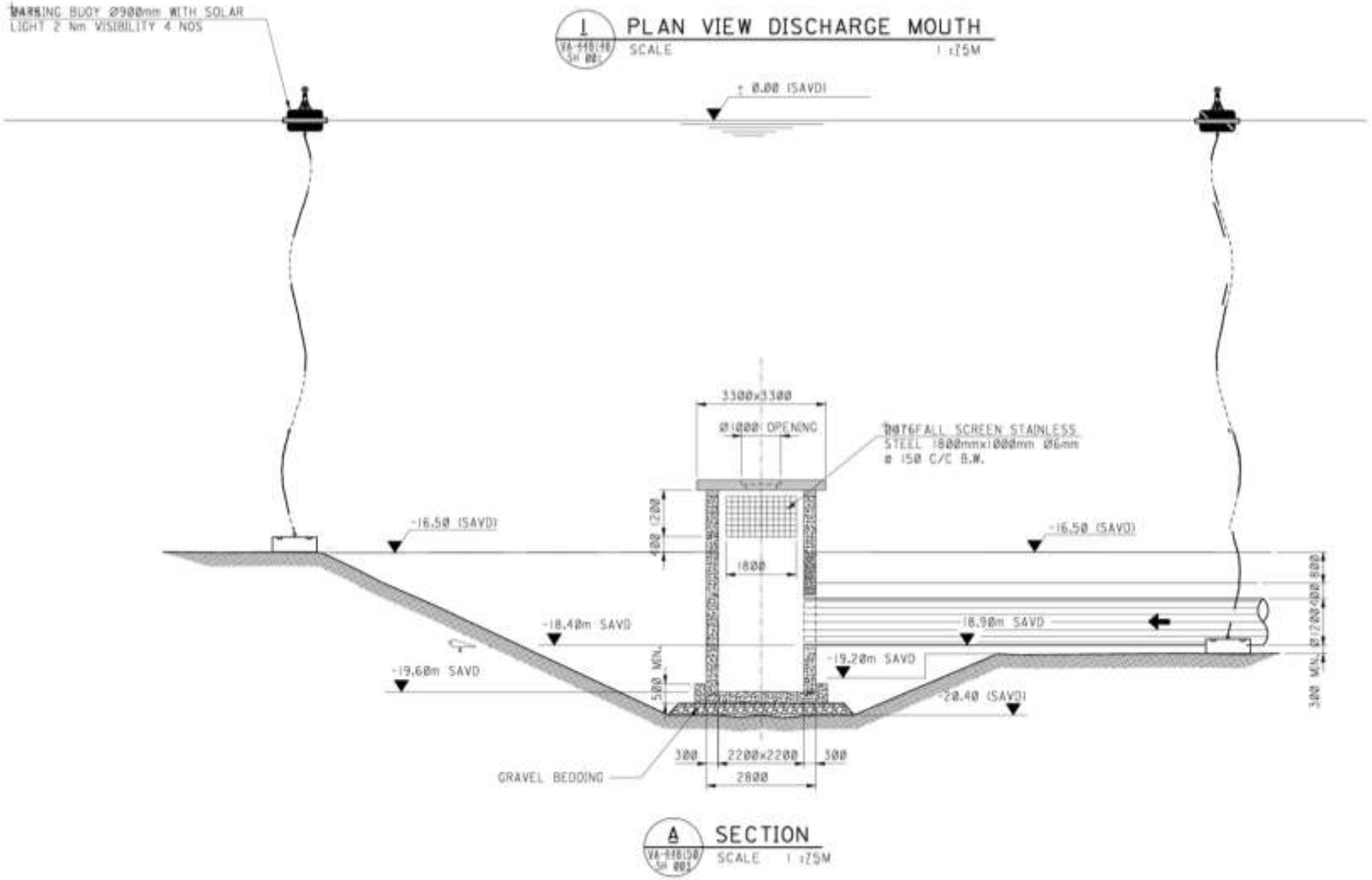
- >50 samples collected; >400 FCM measurements analyzed [1st campaign (August 2012) | 2nd campaign (October 2012)].

- Additional 3rd campaign & 'control sites' sampling is proposed for February 18th & 19th 2013.

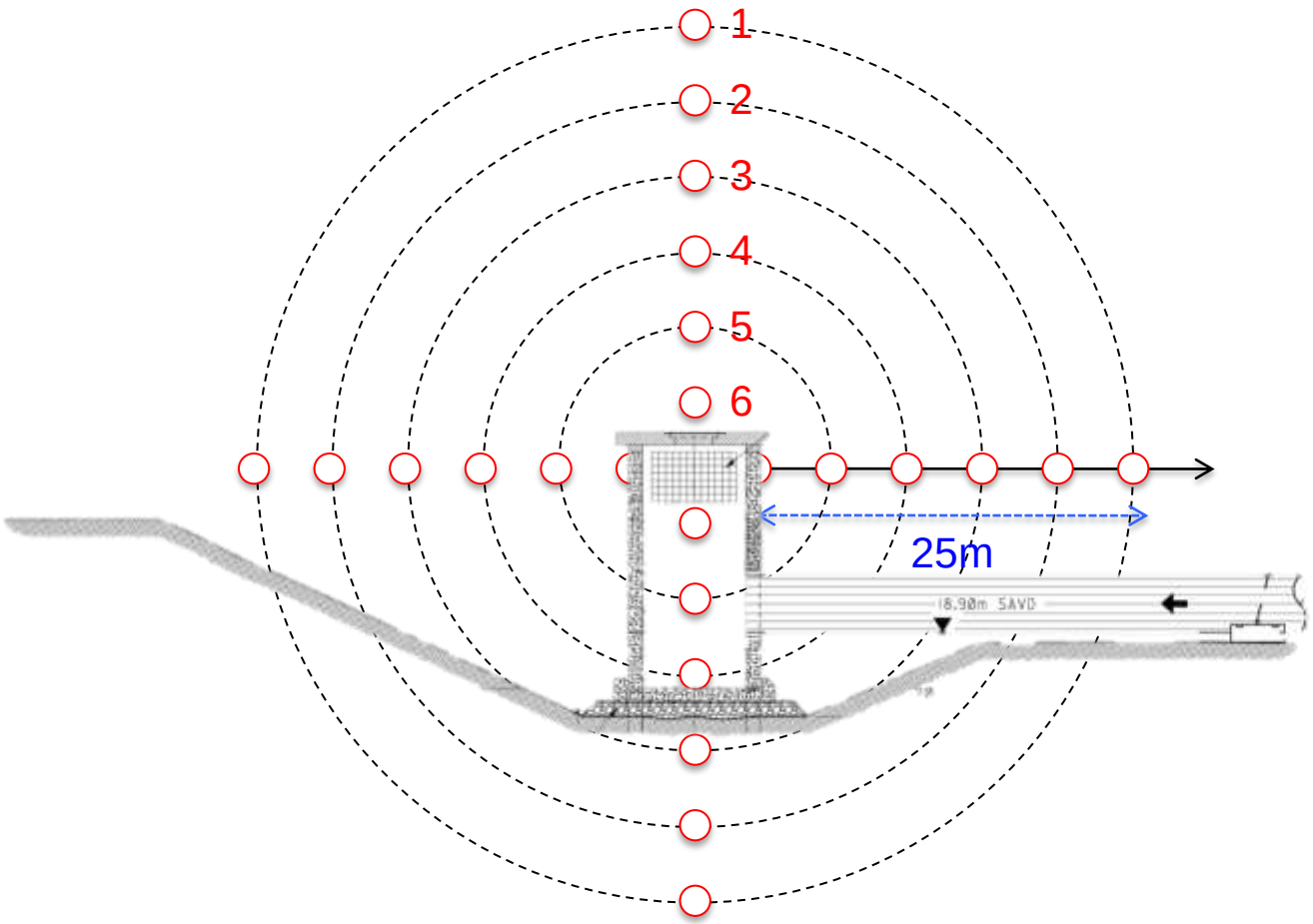
Locality


Red Sea
22 18 03, 39 06 07
Pump Station
1.5km
1.8km
22 17 54, 39 05 15
Feedwater Intake
1.3km
22 17 46, 39 04 31
Concentrate Discharge
© 2011 Google
Image © 2011 GeoEye
1183 m
Google

KAUST SWRO discharge structure



Sampling methodology



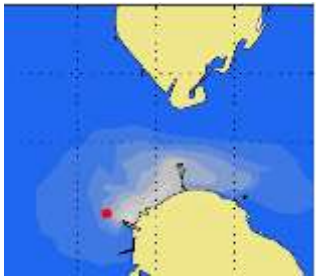
Footage

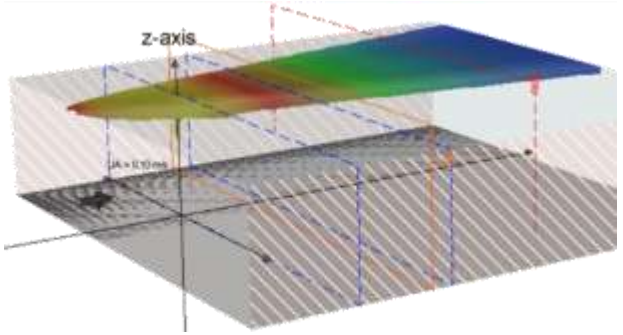
Screening tools for desalination plants in the Red Sea

Robin Morelissen (Deltares)
Dr. Sabine Lattemann (KAUST, WDRC)
Prof. Burton Jones (KAUST, Red Sea Research Centre)

- **Objective**: To develop screening tools for operational aspects (e.g., recirculation) and environmental concerns (e.g., impacts of brine disposal) of new desalination plants (or other industrial activities / developments)
- will allow for a first-order assessment of the proposed site, project design, construction, etc.
- will combine design criteria of the project with field observations, environmental knowledge and numerical modelling.
- will be developed together with and for the industry and will be available for their own, independent use (possibly web-based).

Example of web-based screening tool





Monitoring Challenges

Pre-dictive EIA process:
Predict the ***likely*** impacts

Post-dictive EIA process:
Investigate the ***actual*** impacts

- Time and cost-intensive to investigate all possible parameters;
- Non-existence of tailored desalination specific regulations; &
- Lack of robust up-to-date scientific baseline data in order to support reports on ecological effects, mitigation measures and appropriate monitoring systems.

Conclusions & Recommendations

- Accuracy of the monitoring results correlate with the effort
  - Temporal and spatial replication (BACIPS) is required to ensure sufficient statistical robustness of the monitoring analysis
- Scientific journals would reject studies which were carried out with less that good scientific practice
  - Similarly high standards should apply in EIA studies
- Explicit desalination regulation must be generated, adopted and enforced; &
- Monitoring must be based on a holistic coverage of environmental impacts as part of the decision making process, not only for locating and building new desalination plants, but also for monitoring of existing facilities.

Thank you

- Prof. Gary Amy
- Dr. Sabine Lattemann
- Dr. Frederik Hammes [Swiss Federal Institute of Aquatic Science and Technology (Eawag)]
- Dave Pallett [Coastal and Marine Services Core Lab (CMOR)]

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Through Inspiration, Discovery

Questions?

Future work

- 3rd campaign (February 2013) in order to confirm preliminary findings;

- Adenosine tri-phosphate (ATP) analysis in order to assess cell viability (combining it with the 3rd campaign);

- Detailed assessment of dynamic events influencing the quality of SWRO concentrate;

Three levels of "events":

1. Daily operation (this becomes the background or standard footprint of the system)
2. Backwashing events
3. Chlorination (dramatic event once a week)

- Benthic studies;

- Utilizing a mixing zone model to establish revised regulatory mixing zones from continuous point source discharges.