مؤتمر الخليج الرابع عشر للمياه
THE 14TH GULF WATER CONFERENCE
UNDER THE THEME:
"WATER IN THE GCC...TOWARDS ECONOMIC EFFICIENCY AND FINANCIAL SUSTAINABILITY"

Arabian Gulf University

The Characterization of the Water Mass Dynamic Changes Surrounding an SWRO Desalination Plant on the East Coast of the Kingdom of Bahrain

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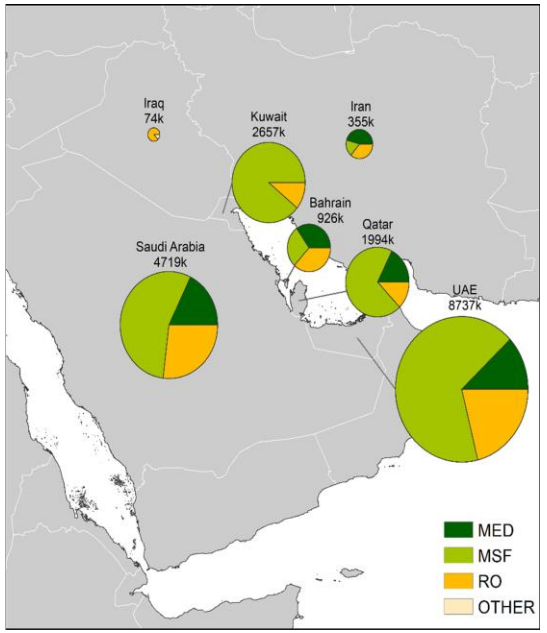
Water in the GCC: Towards Economic Efficiency and Financial Sustainability

Introduction

- The GCC countries have undergone rapid social and economic development since 1930s.
- As a result, the total population of the GCC increased by over 1200% during 1950-2015.
- It is projected to increase by a further 45% during 2015-2050.
- It is important to develop desalination to meet the rapid economic development.
- The current production of desalination plants drawing water from the Arabian Gulf is over 20 million m^3 day^{-1}.
- The production may rise to 80 million m^3 day^{-1} by 2050.
- This will generate adverse impacts to the coastal ecosystems.

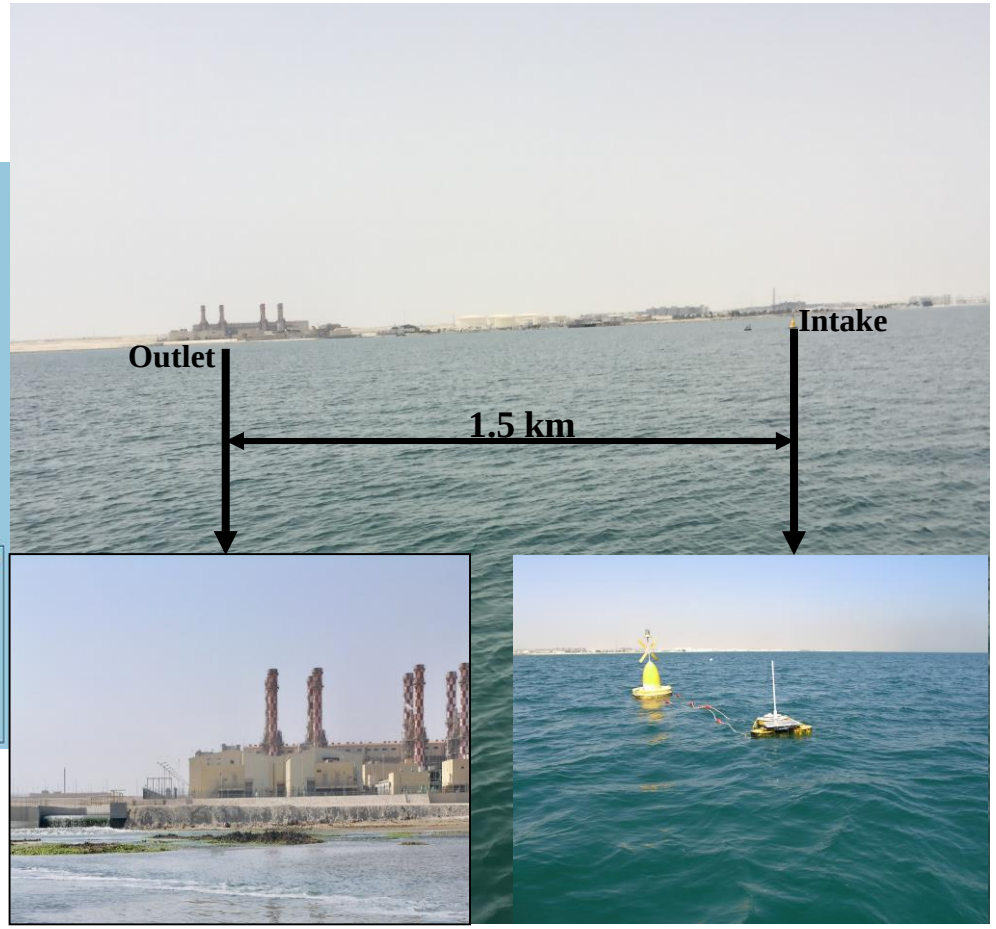


Without mitigating actions to avoid the business-as-usual scenario, by 2050, desalination in combination with climate change, will elevate coastal water temperatures across more than 50% by at least 3 ◦C, and a volume of water equivalent to more than a third of the total volume of water between 0 and 10 m deep will pass through desalination plants each year.

Methodology

Al-Dur SWRO Plant

- The present study is conducted on Al-Dur coast.
- Al-Dur SWRO DP was commissioned in February 2012.
- The plant located in the south-east coast of Bahrain.
- The daily capacity is 220,000 m^3 day^{-1}.



Methodology

Study area

The pipe intake pass through 4 submerged filtration units.

A total of 20 barrier fishing traps (Hadrah) as well as hundreds of metal wire traps (Gargoor).

Track of brine directly discharged to the coastal area.

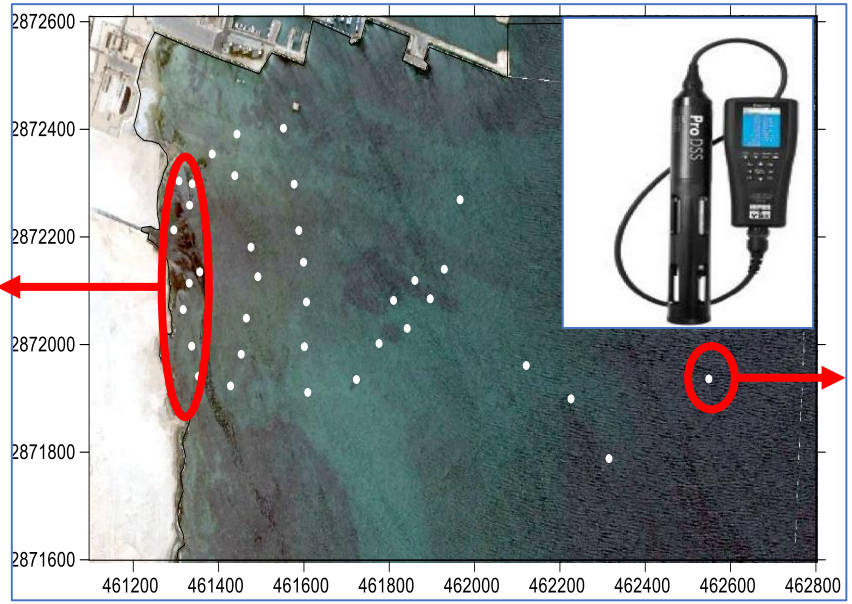
Seagrass bed nearby Al-Dur coast extends eastward to Hawar Islands.

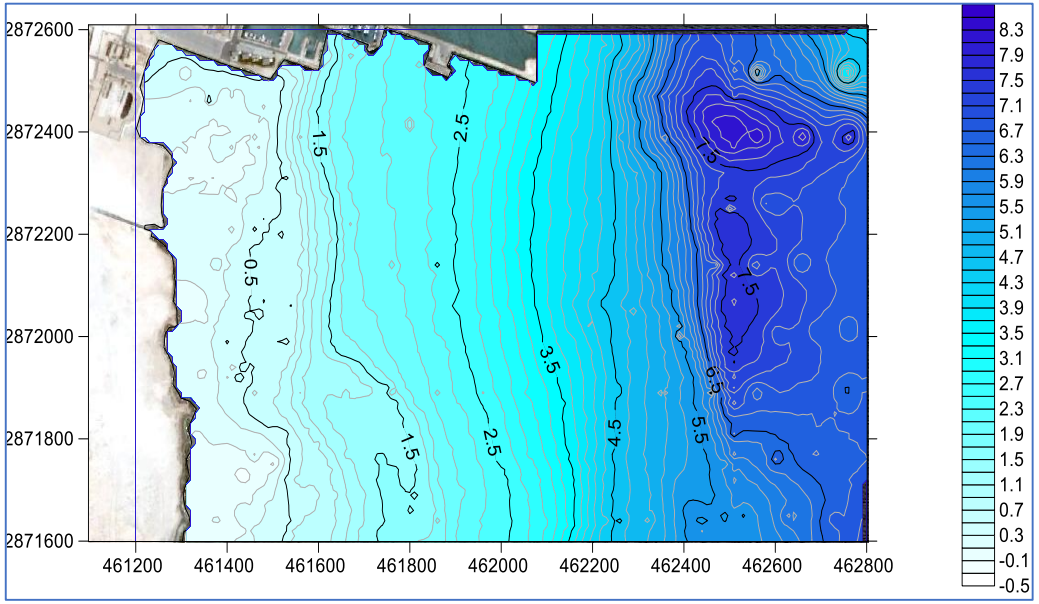
Rust of chemicals used for pipes cleaning on the coast.

Algal bloom of filamentous algae around the outlet most of the year.

Methodology

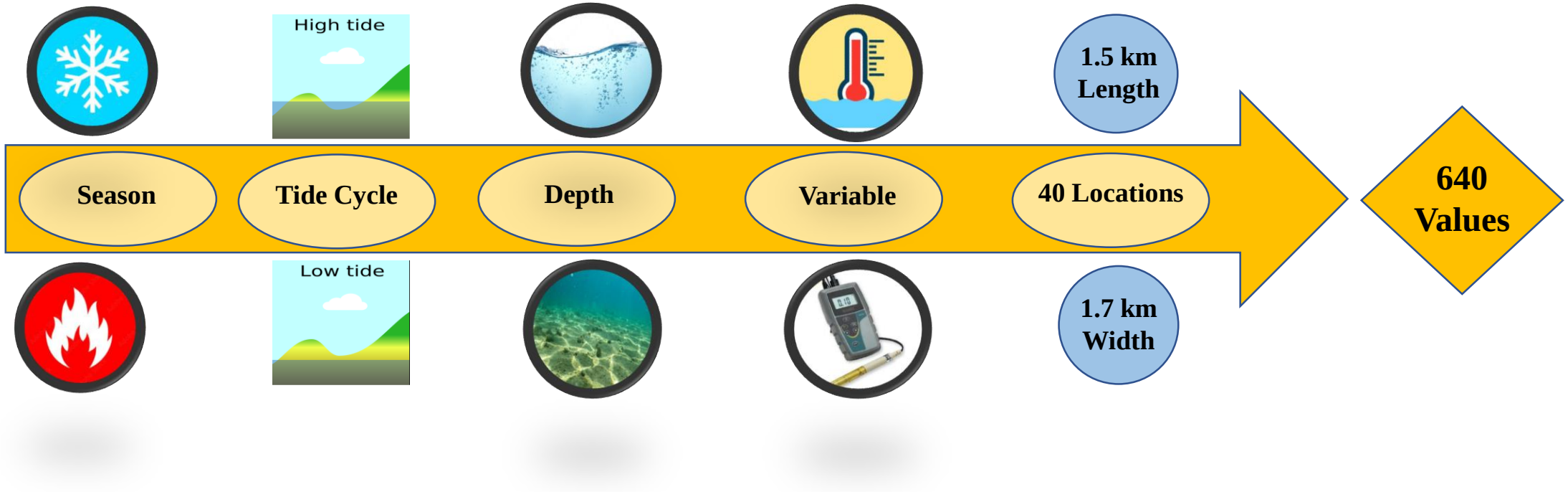
Sampling





Methodology

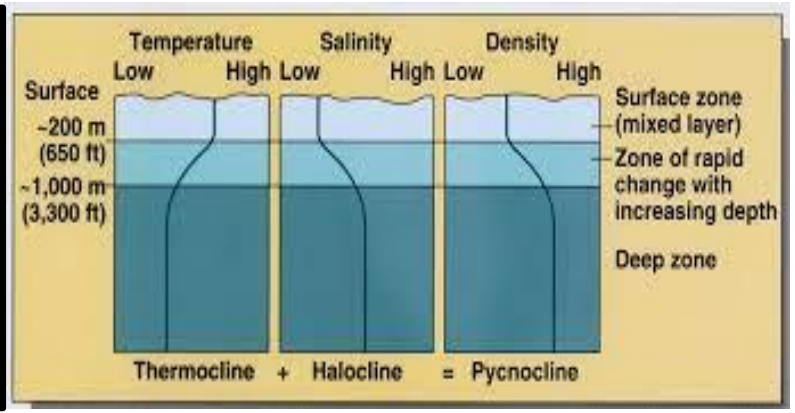
Sampling

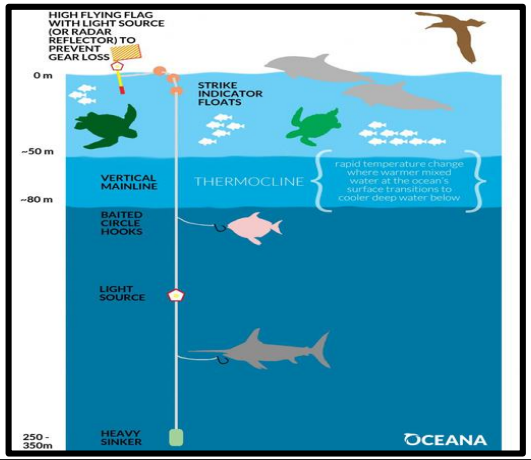


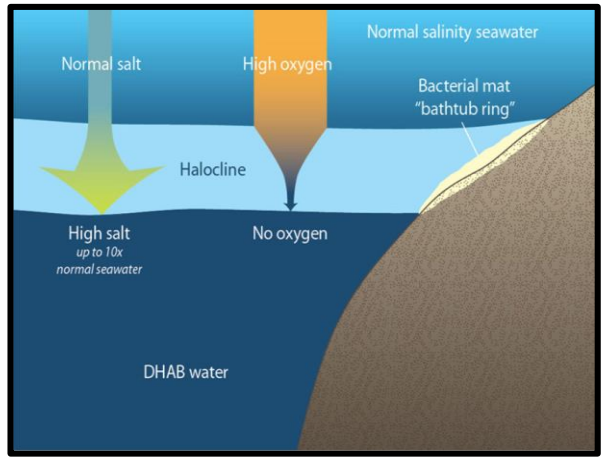
Thermal and Salinity Stratification

What are Cline?

- Layers have different properties than the surrounding water.
- Vary in temperature, salinity, density, or chemistry.
- Usually horizontal and are often vertically.
- Most common are thermoclines and haloclines.







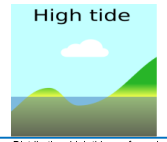
What is a Thermocline?

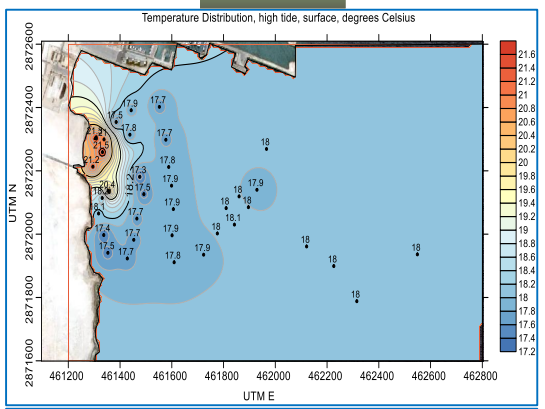
- Layers in which the temperature through the water column changes by > 3 ºC.
- Occur due to seasonal changes, currents, and weather.
- Common during warmer seasons when only the top layer of water gets heated.

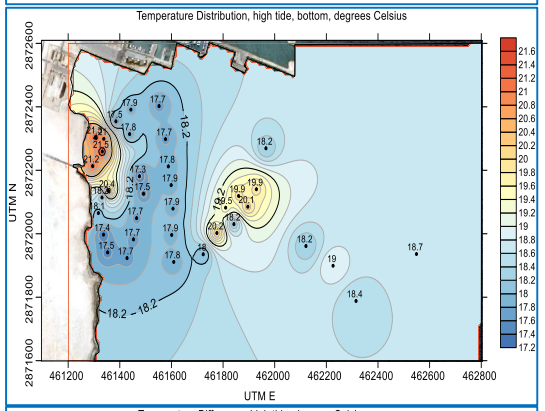
What is a Halocline?

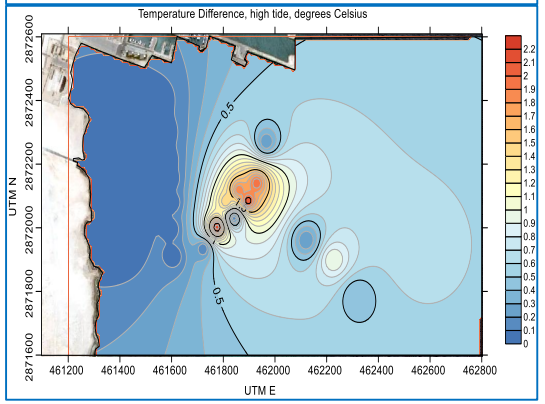
- A type of chemocline due to seasonal changes, currents, and weather.
- Salinity change through water column by 1 ‰.
- Common during warmer seasons as a result of high evaporation.

Temperature Winter





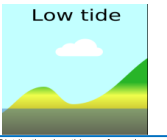


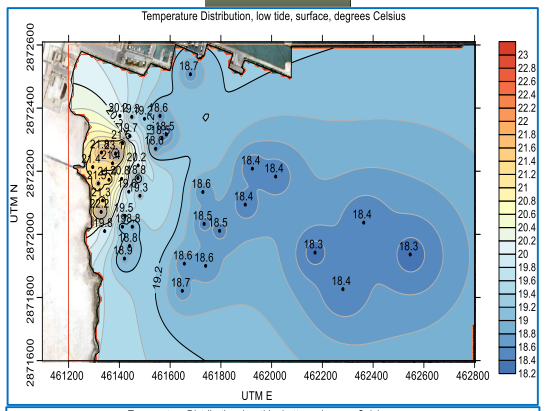


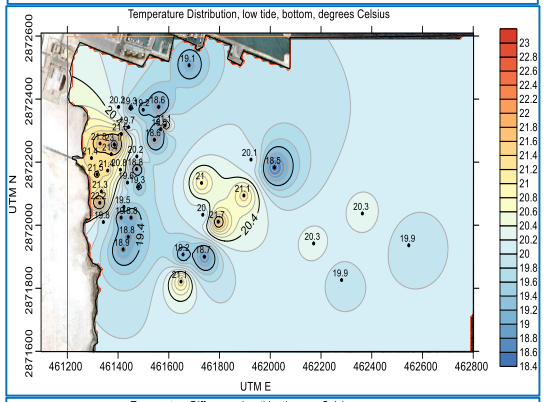
	High Tide		Low Tide	
	S	B	S	B
Min.	17.3	17.4	18.3	18.5
Max.	21.5	21.3	23.1	23.3
Average	18.3	18.6	19.5	20.1

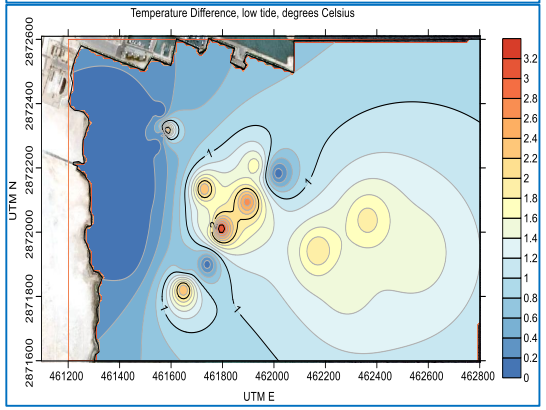
Main Findings

- Clear spatial variations following to outlet distance.
- High values at stations closest to the outlet associated with depth <1m.
- A weak thermal stratification occurred specifically at depths 3-5m.
- Other locations exhibited marginal fluctuations on a vertical basis.
- Water mass at bottom warmer than surface over the tide cycle.
- Spatial variations between high tide and low tide in bottom.
- No real spatial variations at surface over tide cycle.

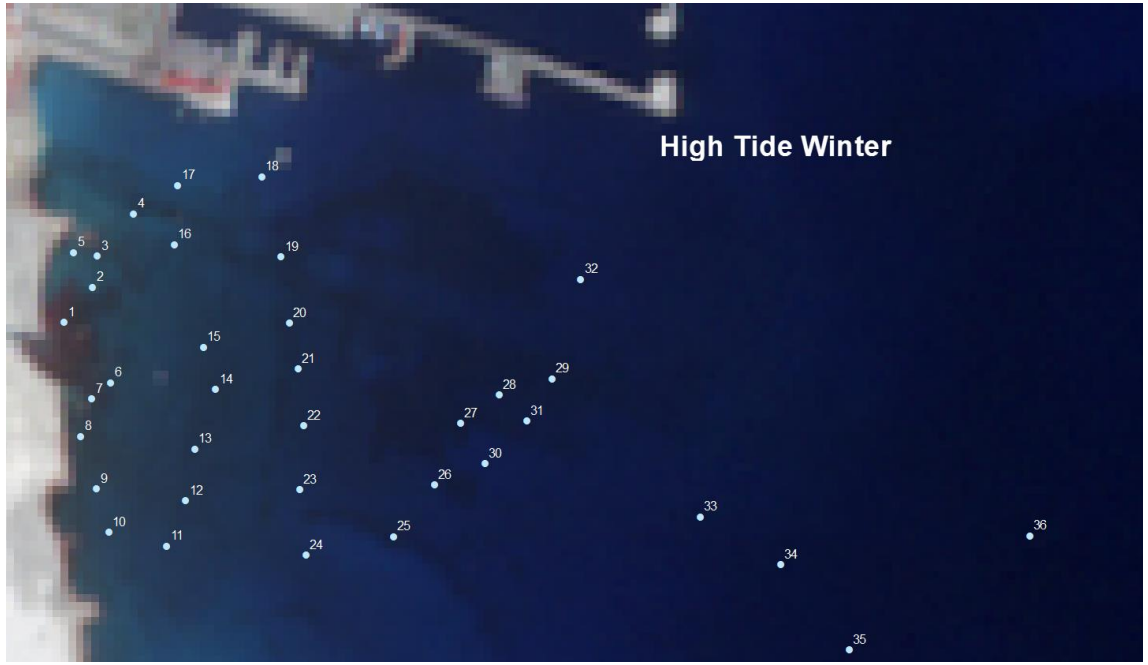






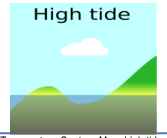


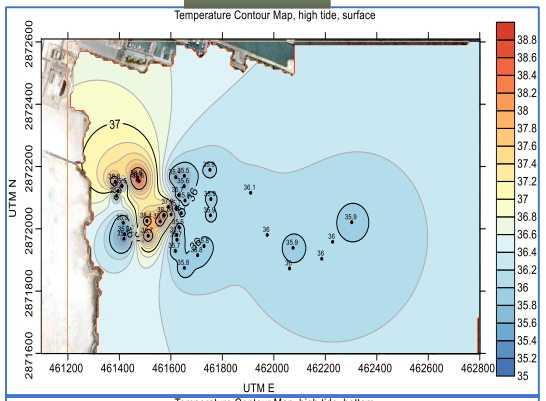
Thermocline -Winter

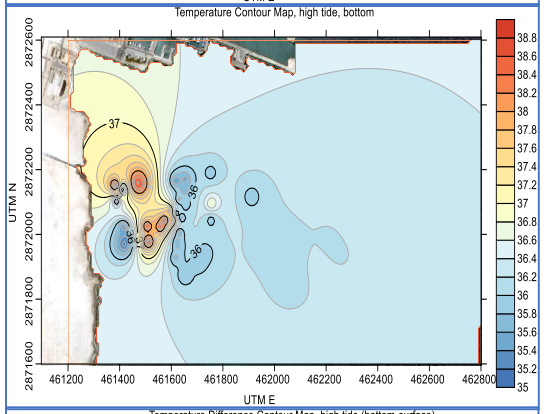


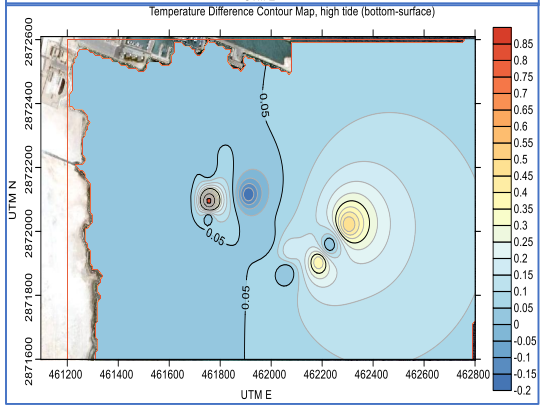
Difference > 1 ºC

Temperature Summer





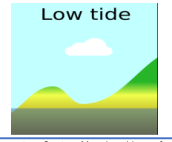


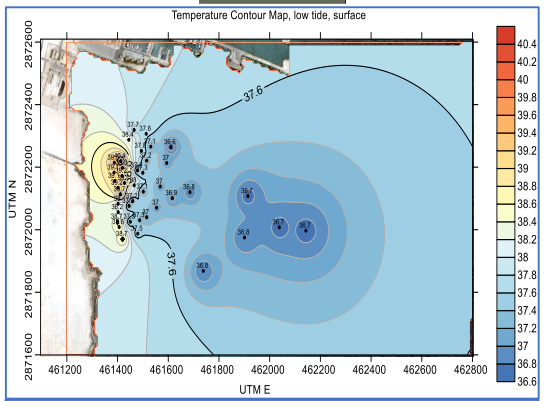


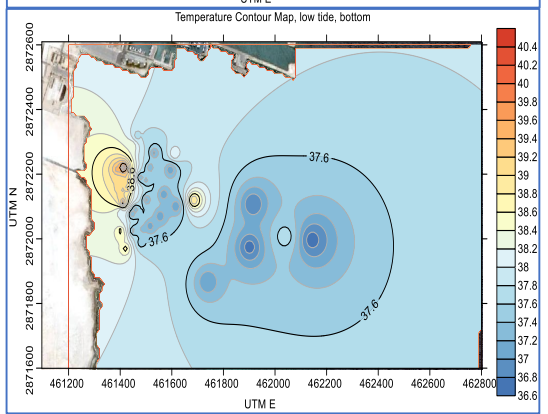
	High Tide		Low Tide	
	S	B	S	B
Min.	35.1	35.2	36.6	36.7
Max.	38.8	38.7	40.4	40.3
Average	36.5	36.5	37.9	37.9

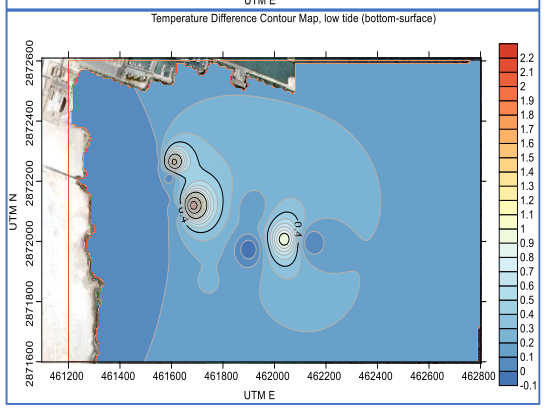
Main Findings

- Noticeable spatial variations following to outlet distance.
- High levels at stations closest to the outlet associated with depth <1m.
- Heterogeneity spatial distribution during the high tide.
- Water mass was spatially homogenized during the low tide.
- Water column seems to be thermally well mixed.
- Bottom layer relatively warmer than surface during high and low tide.
- Slight spatial variations noticed between high tide and low tide cycle.

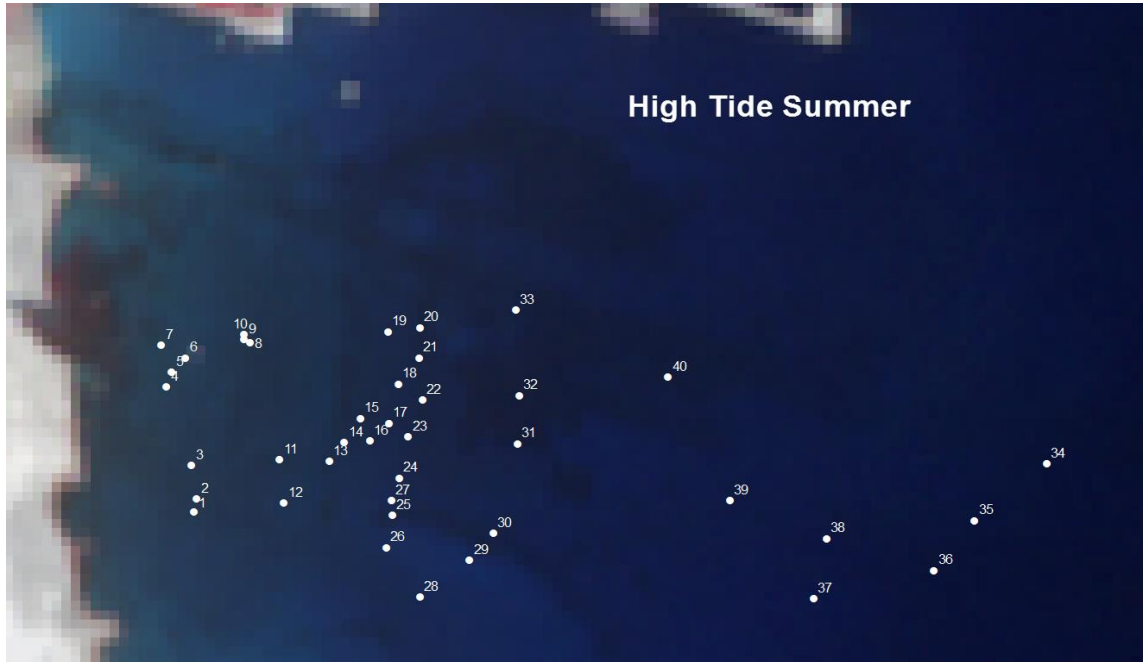


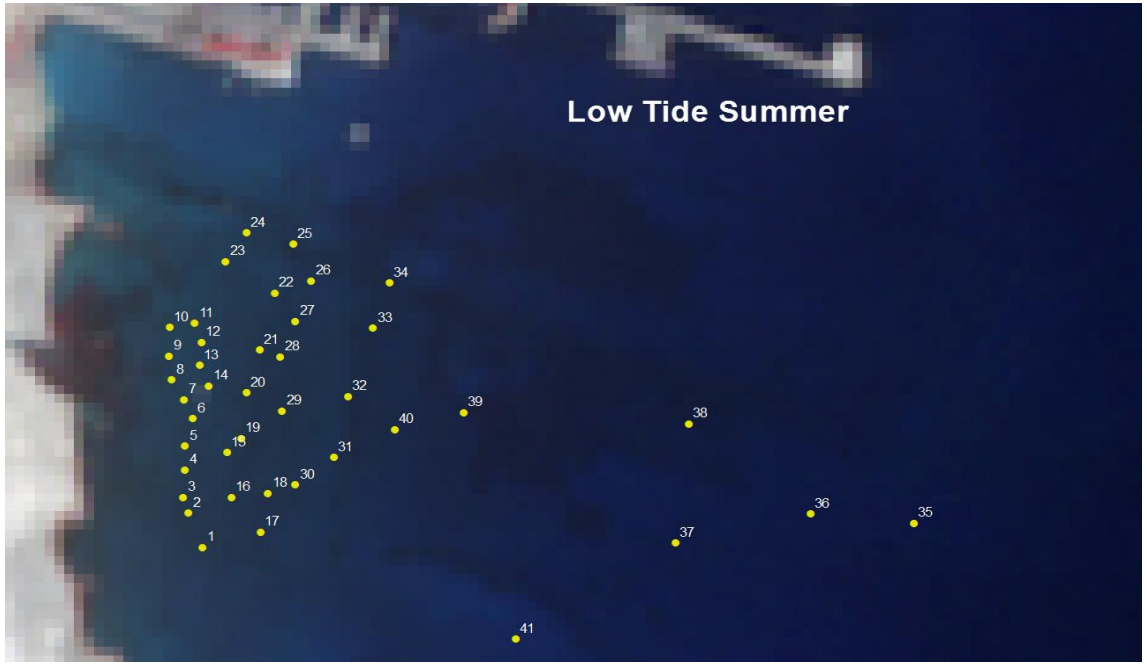




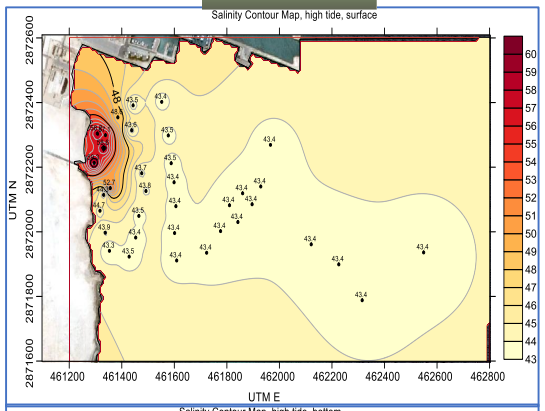


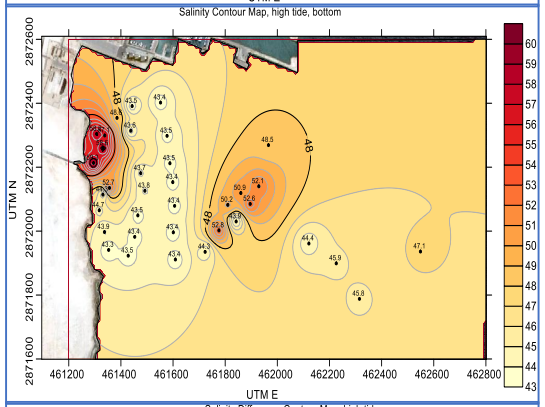
Thermocline - Summer

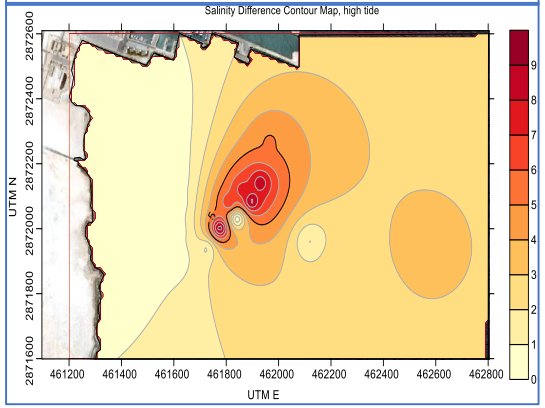




Salinity Winter



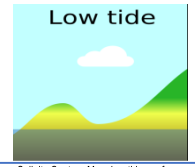


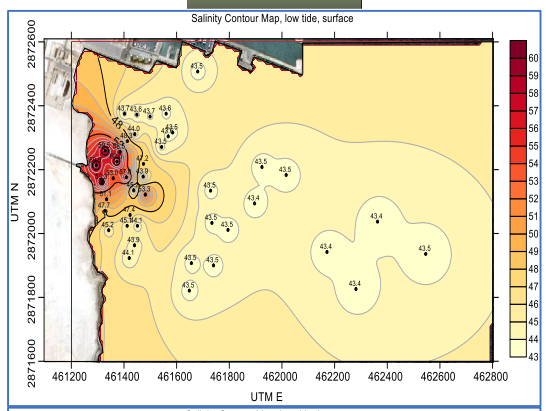


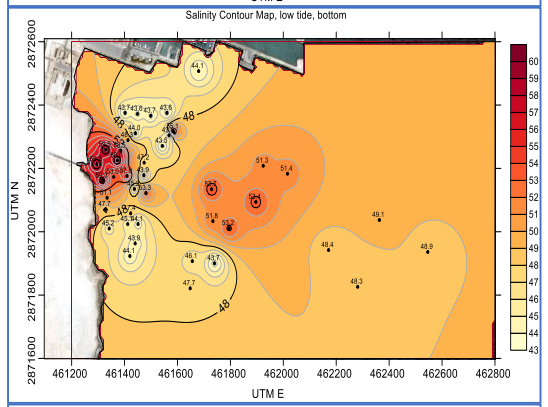
	High Tide		Low Tide	
	S	B	S	B
Min.	43.3	43.4	43.4	43.6
Max.	59.3	59.5	60.0	60.0
Average	45.6	47.3	46.9	49.2

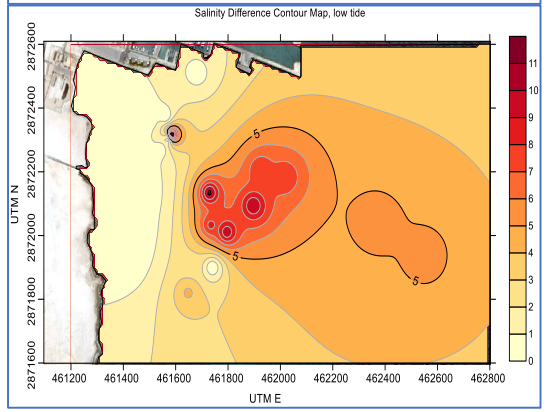
Main Findings

- Levels at bottom are relatively higher than surface.
- A slight tendence to high concentration during low tide cycle.
- A clear variations based on a distance from the desalination outlet.
- Halocline was observed at most sampling locations at depth > 3m.
- Higher gradient throughout the water column depths 5-6m.

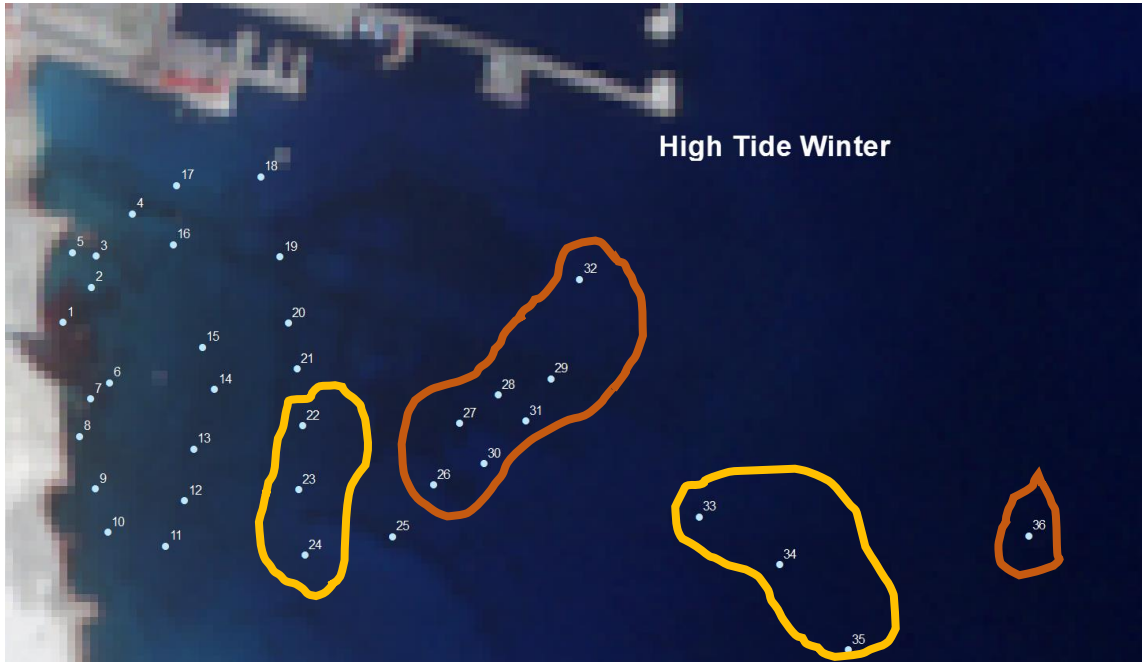








Halocline - Winter



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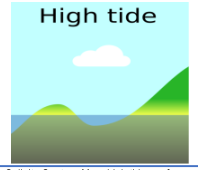
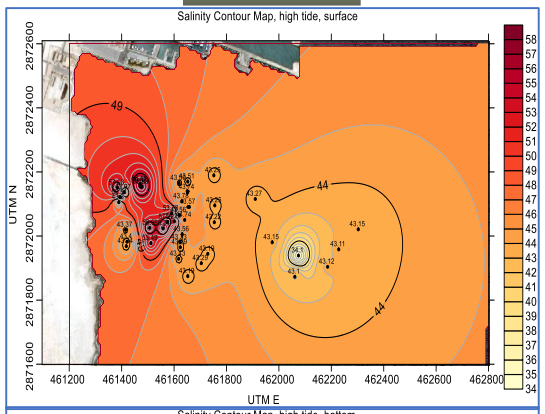
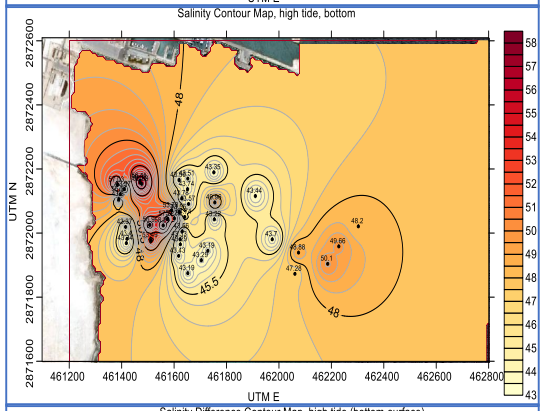
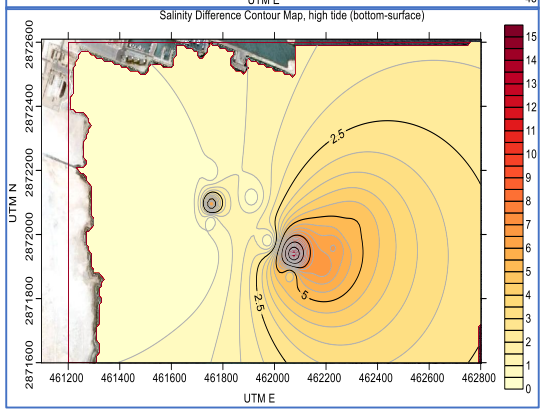
Salinity Summer





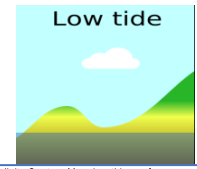


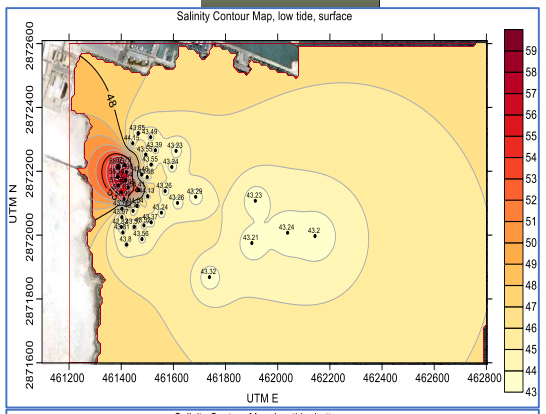


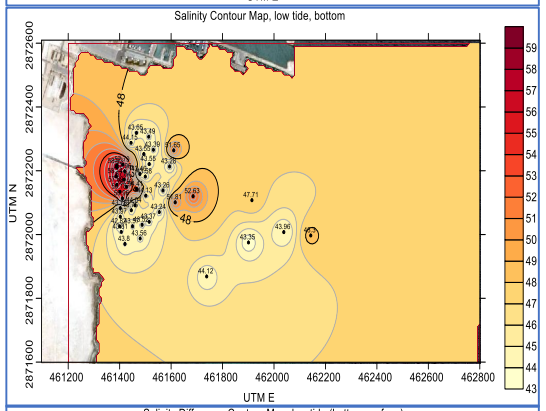
	High Tide		Low Tide	
	S	B	S	B
Min.	34.1	43.2	42.6	42.8
Max.	58.2	58.3	58.7	58.9
Average	46.7	47.8	46.9	47.8

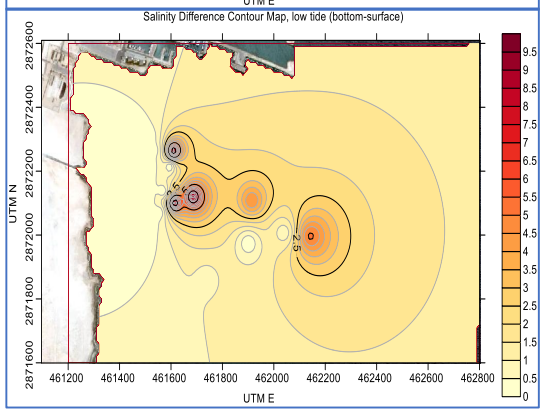
Main Findings

- Water mass at bottom hypersaline in comparison with surface.
- Low tide cycle characterized by noticeable increase.
- Water mass more homogenized during the low tide.
- A clear variations based on a distance from the desalination outlet.
- Halocline formation was observed within locations at depth > 3 m.

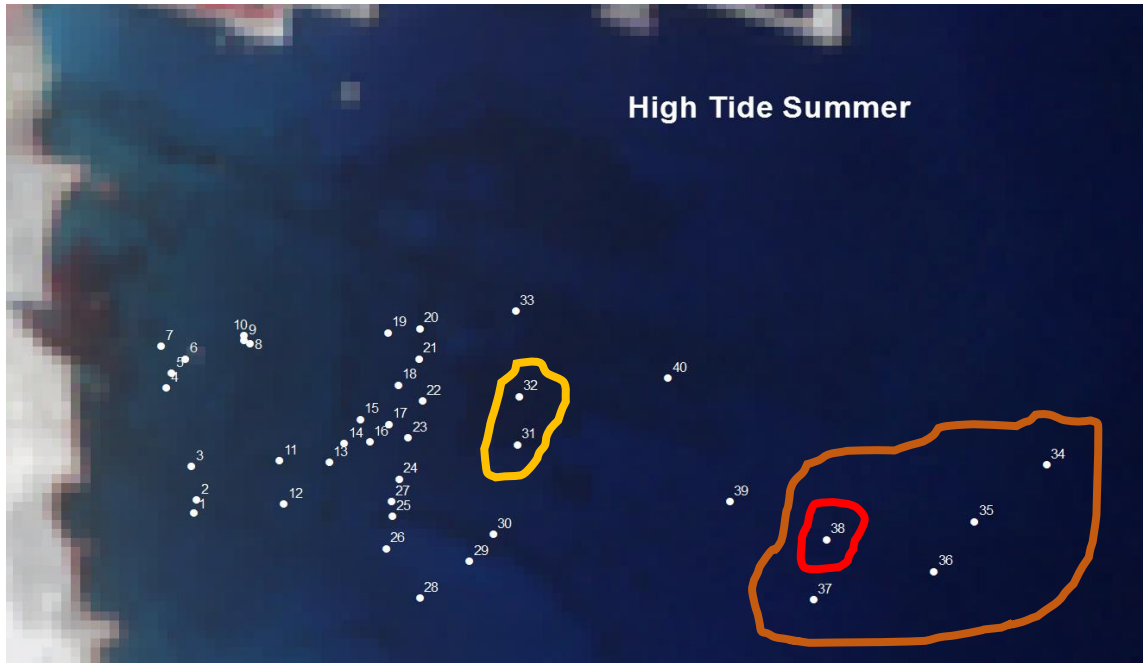


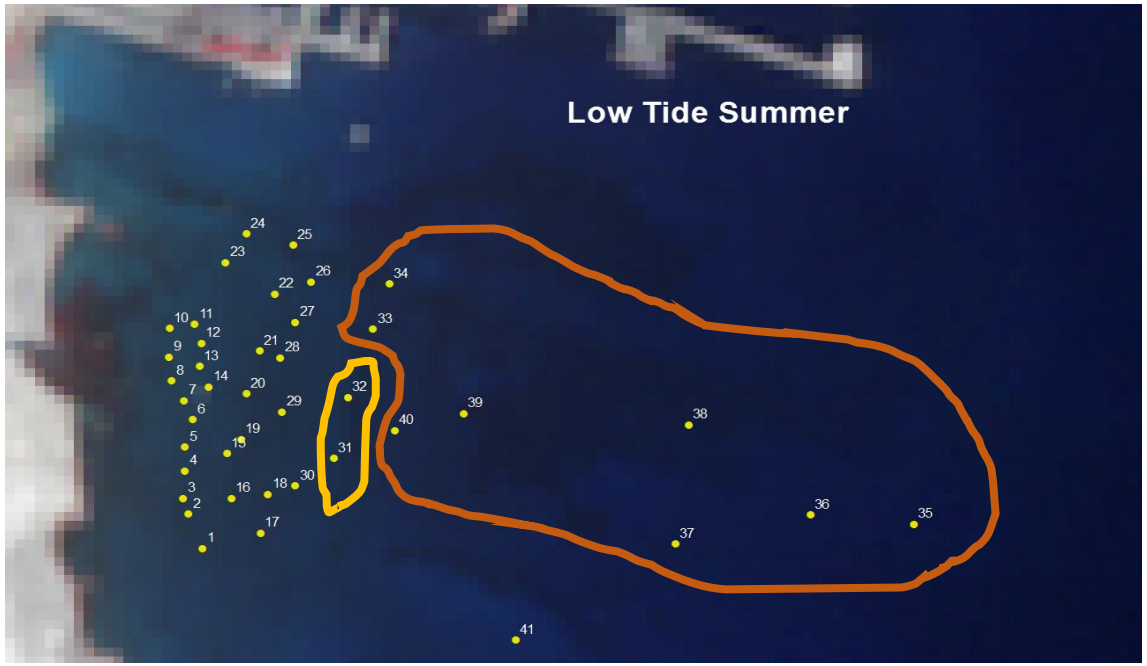






Halocline - Summer





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Difference > 10 ‰

Conclusions and Recommendations

- The coastal ecosystems and associated biota are exposed to a real impact due to desalination plants.
- The impact's extent was varied concerning physical and chemical dynamic changes considering the tide cycle.
- Hypersaline water mass was observed at bottom of locations associated with depths > 3 m.
- Benthic community within the vicinity of the Al-Dur desalination outlet are under stress due to halocline and thermocline formation.
- Future scenarios of desalination development by 2050 indicate significant adverse impacts on the marine environment in combination with climate change.
- The brine discharge adjacent to seagrass beds, may potentially impact the charismatic species (dugong, turtles and dolphins) and ecosystem’s function.
- The impacts of current Al-Dur SWRO plant will be complicated by further a new desalination plant (Al-Dur2) will be operated in 2022.
- The SCE current monitoring program needs to cover further monitoring locations representing the vicinity of each desalination plant.
- A hydrodynamic modelling to be adopted to assess the dispersion of the brine impact extent in relation to the seagrass beds.