environment, forestry & fisheries
Department:
Environment, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

SALDANHA BAY SEA BASED AQUACULTURE DEVELOPMENT ZONE ANNUAL BENTHIC REDOX SURVEY AND ONCE-OFF SURVEY OF SMALL BAY

Bruce Mostert, Ken Hutchings and Barry Clark

Saldanha Bay ADZ Specialist monitoring

July 2020

Background

The Department of Environment, Forestry and Fisheries (DEFF), Branch Fisheries as the holder of the Environmental Authorisation for the Saldanha Bay ADZ has appointed an independent service provider, Anchor Research and Monitoring (AR&M), to undertake the annual redox survey of the Saldanha Bay ADZ, including a once off redox survey of the lease areas in Small Bay.

Redox Surveys

Introduction:

- Monitoring on the seabed below aquaculture installations is international best practice with the primary Environmental Quality Objectives of preventing hypoxic (low oxygen) or anoxic (no oxygen) sediment conditions by maintaining a functional invertebrate community beneath the farm installations which promotes organic matter breakdown.
- Organic matter input from faeces, pseudo-faeces, uneaten feed and fall-off of culture organisms and fouling organisms is the primary source of impact on the seabed by aquaculture.
- Decomposing organic matter uses up the available oxygen and resultant anaerobic decomposition can produce sulphide, affecting the communities living in the seabed.
- Impacts of shellfish aquaculture is usually restricted to directly below farm structures.
- Impacts of finfish aquaculture are considered more severe due to the use of artificial feeds which increases the amount of organic matter reaching the seabed.
- Impacts of finfish farming are likely to be wider reaching.

Introduction:

- Sediment organic carbon, redox potential (Eh) and total sulphides (S^{2-}) have been used in describing negative impacts below aquaculture installations.
- The chemical indicators Eh and S^{2-} have been used to classify sediments associated with fish farming (Table 1).

Table 1. Ranges of redox potential (Eh) and total sulphides (S^{2-}) in five sediment organic enrichment categories as indicated in the Sampling Plan (DAFF 2018, Cranford et al. 2006, Hargrave et al. 2008b).

	Oxygen Present		Low Oxygen		No Oxygen
	Oxic A	Oxic B	Hypoxic A	Hypoxic B	Anoxic
Geochemical:					
Redox (Eh) mV	>100	100 to -50	-50 to -100	-100 to -150	<-150
Sulfides (S^{2-}) µM	<750	750 to 1500	1500 to 3000	3000 to 6000	>6000

- The Sampling Plan indicates oxygen should not fall below the Hypoxic A category directly below both finfish cages and shellfish cultures.
- Additionally, for finfish, 30m away from the cages the oxygen must be greater than the thresholds circled in orange

Thresholds:

Shellfish

- If the oxygen falls below the Hypoxic A O category, redox values need to be compared to those measured at the reference stations.
- Non-compliance is also dependent on impact sites having a significantly lower (more negative) redox value from the levels measured at the reference stations.
- Failure to meet the thresholds in Table 1, and redox values differing significantly from reference stations will require management intervention and/or additional sampling (DAFF 2018).

Finfish:

- If the oxygen falls below the Hypoxic A O category directly below the cages, redox values need to be compared to those measured at the reference stations.
- Additionally, oxygen should not fall below the upper Hypoxic A O category 30 m away from fish cage array unless a site-specific zone of impact has been established.
- Non-compliance is also dependent on impact sites having a significantly lower redox value from the levels measured at the reference stations.
- Failure to meet the thresholds in Table 1 and redox values differing significantly from reference stations will require management intervention and/or additional sampling (DAFF 2018).

Sampling

- Sediment samples were collected from baseline sites in Big Bay, North Bay and Jutten Island using a Van Veen grab.
- A transect was attempted from the finfish site at 0 m, 30 m and 60 m stations along the main bottom current direction from the proposed finfish cage location (DAFF 2018).
- Sediment was not collected at 5 sites (out of 23 where sampling was attempted) due to rocky substrata being encountered; Big Bay – BB 7 and BB 8, North Bay – NB C 3, Jutten Island – JI 2.
- Additionally, rock was encountered at the finfish sites FF 2 (1 sample collected) and FF 3.
- Hard substrata was encountered along the finfish transect and eventually a partial transect was completed (samples collected at 0 m and 30 m but not 60 m).

Sampling

- Where possible, new sites were selected to replace the ones where sediment could not be collected (4 out of 5).
- Redox (Eh) values were measured in 2019 and 2020 as there is no suitable sulphide (S^{2-}) probe available to measure sulphide in the field.

Hach handheld redox probe and portable meter.

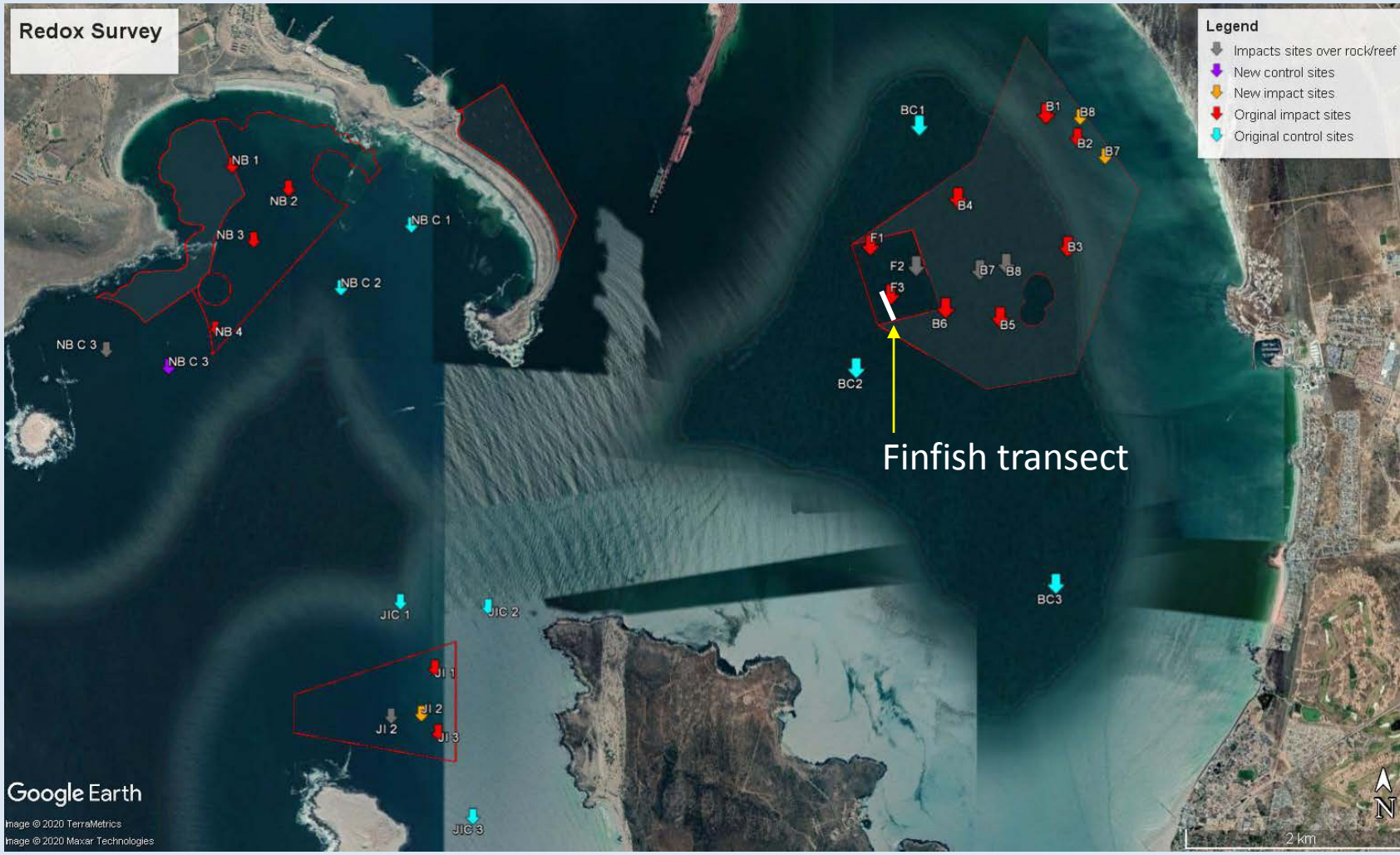
Co-ordinates of the redox survey sites from Big Bay, North Bay and Jutten Island, replaced sites are highlighted in red.

Area	Site	Latitude	Longitude	Comments
		Decimal Degrees	Decimal Degrees	
Big Bay	B 1	-33.028808	18.019161	
	B 2	-33.030550	18.022083	
	B 3	-33.039167	18.021183	
	B 4	-33.035367	18.010983	
	B 5	-33.044667	18.014917	
	B 6	-33.043950	18.009850	
	B 7	-33.031920	18.024640	New site selected - 8th May 2020
	B 8	-33.028870	18.022320	New site selected - 8th May 2020
	BC 1	-33.029733	18.007400	
	BC 2	-33.048633	18.001550	
	BC 3	-33.065414	18.020089	
	FF 1	-33.039056	18.002878	Sampled in 2020, rock in 2019 = not sampled
	FF 2	-33.040681	18.007119	Rock – not sampled
	FF 3	-33.042911	18.004736	Rock – not sampled
	FF Transect 0m	-33.042419	18.004349	
	FF Transect 30m	-33.042670	18.004450	
	FF Transect 60m	-33.042926	18.004562	Rock – not sampled
North Bay	NB 1	-33.032617	17.943633	
	NB 2	-33.034417	17.948867	
	NB 3	-33.038433	17.945633	
	NB 4	-33.045200	17.942067	
	NB C 1	-33.037283	17.960267	
	NB C 2	-33.042167	17.953733	
	NB C 3	-33.0483	17.93773	New site selected - 8th May 2020
	JI 1	-33.071767	17.96245	
	JI 2	-33.075533	17.96119	New site selected - 8th May 2020
	JI 3	-33.076783	17.96275	
	JI C 1	-33.066625	17.959244	
	JI C 2	-33.067017	17.967400	
	JI C 3	-33.083350	17.965967	

Sampling (Big Bay, North Bay, Jutten Island):

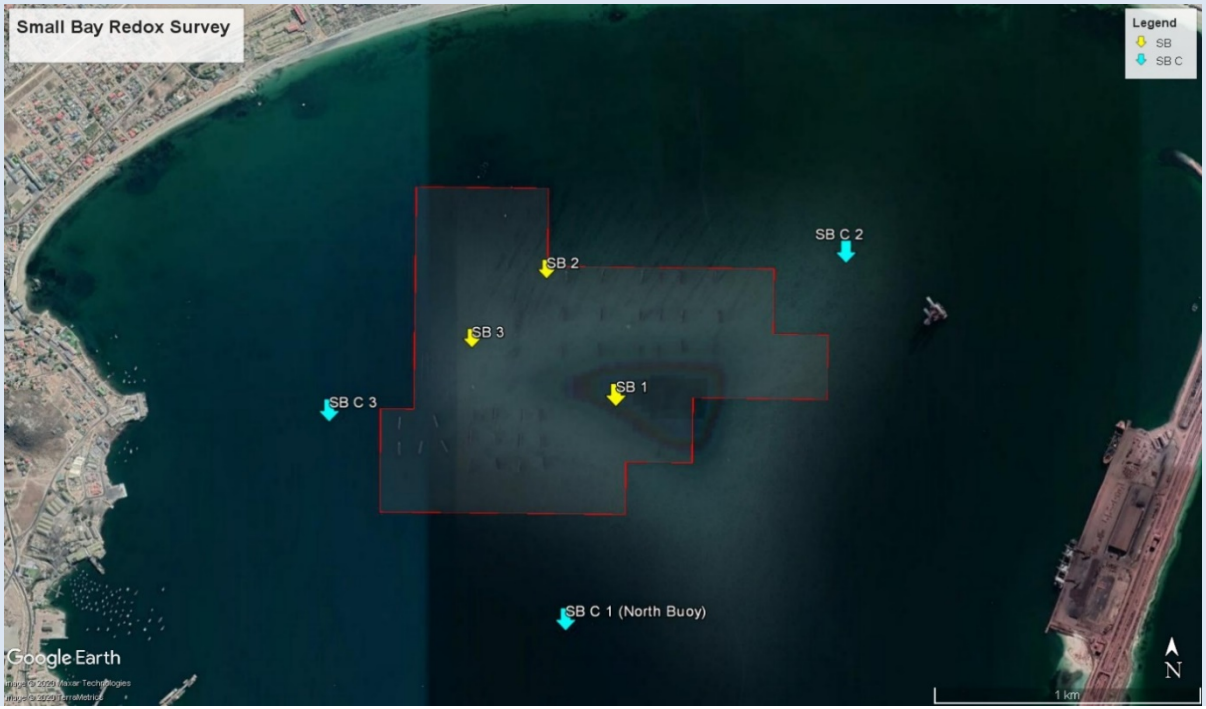
Red – impact sites, Grey – hard substrata (no sediment collected)

Blue – control sites Orange – new impact sites, Purple – new control sites



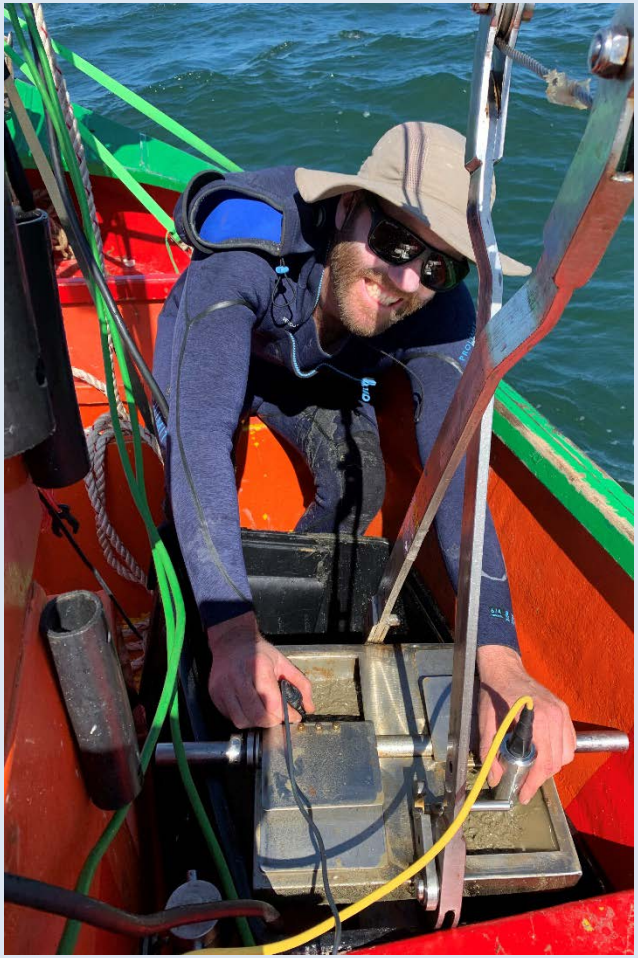
Sampling (Small Bay):

- A once off redox survey of the Small Bay was conducted on the 28th of May 2020.
- One sampling station was selected per 50 ha of lease area (equates to 3 impact sites - yellow arrows).
- Three reference stations situated a suitable distance from the lease areas (blue arrows).
- Where possible the stations selected corresponded to the DEFF's rapid synoptic survey sites (DAFF 2018).

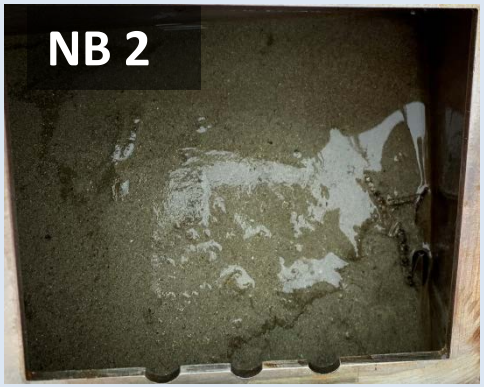


Methods:

- Three grab samples were retrieved from each site.
- Sediment was accessed through trap doors and redox potential and pH measurements were taken using a Hach handheld redox probe and portable meter.



- Readings were statistically compared to prescribed thresholds.
- Sediment was photographed and assessed for colouration and odour, e.g.:

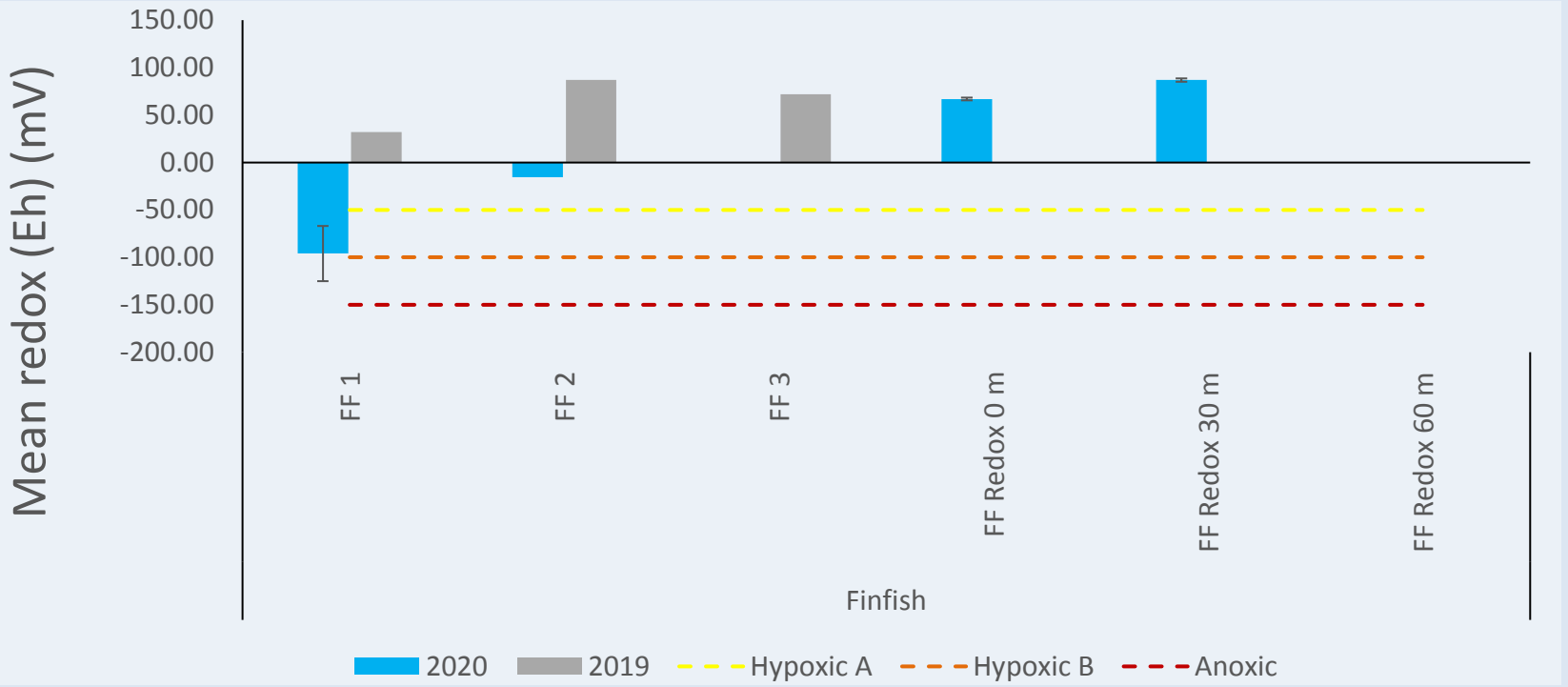


Results and Discussion:

Big Bay

Finfish:

- Baseline measurements - currently no finfish cage installations.
- Finfish transect had positive redox values (well oxygenated sediment) and did not exceed the specified thresholds; 0 m (-100 mV) and 30 m (-50 mV).
- Eh values for the Finfish lease area in 2019 were positive, while in 2020 were negative – shows differences in sediment oxygen levels between years.

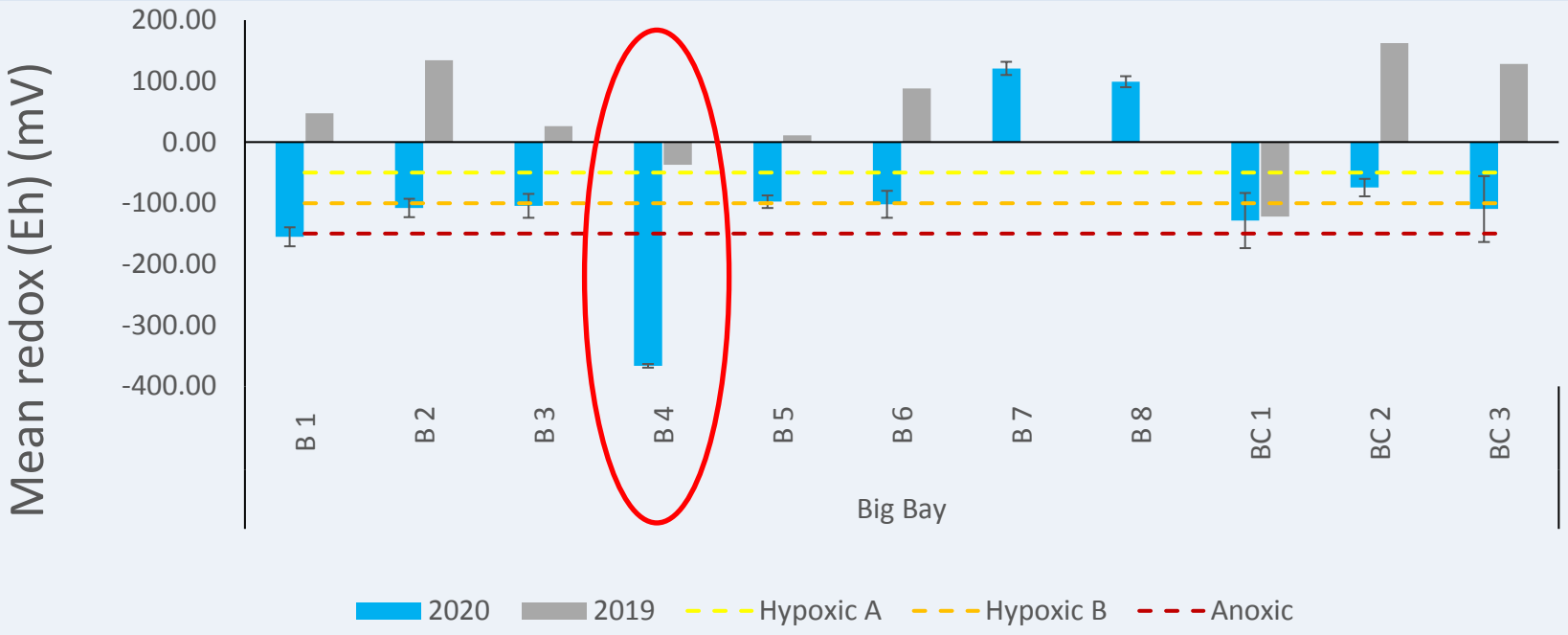


Results and Discussion:

Big Bay

Shellfish:

- B7 and B8 - positive redox values, placed in high oxygen categories (Oxic A and B respectively).
- The remaining sites recorded negative redox values mostly low oxygen category (Hypoxic B).
- Average redox value at B4 indicate anoxic conditions (no oxygen present).
- Differences in redox values between the 2019 and 2020 measurements - indicate oxygen levels in sediment differ between years as well as among sites.



Big Bay

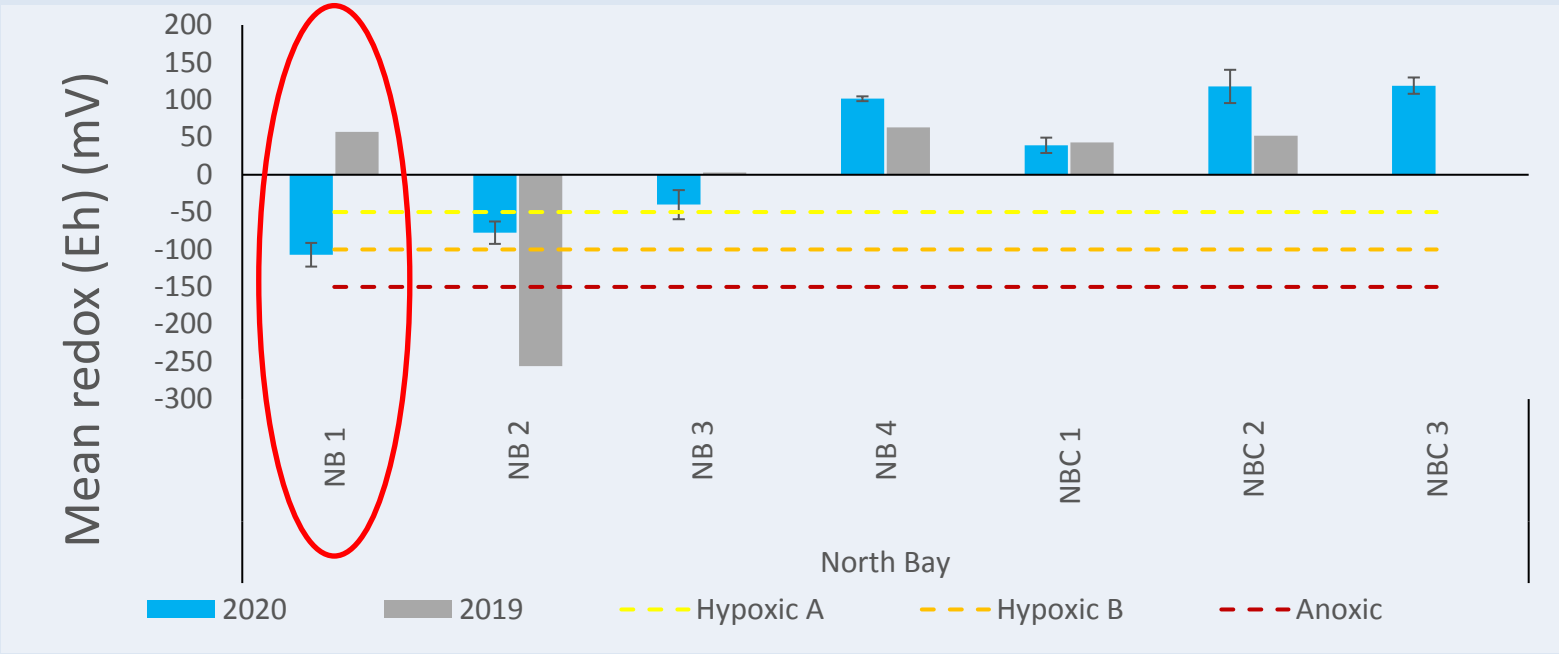
Findings:

- Sulphide and redox are not appropriate variables for monitoring aquaculture impacts at hard substratum sites – difficulty in collecting required sediment for analysis and identifying potential impacts.
- Bathymetry survey required to determine extent of hard substrata, identify accumulation points for organic matter.
- No aquaculture installations currently above site B4 – no management triggered.
- B4 - Point of natural organic matter accumulation due to hard substrata?
- Other factors influencing redox values? Sediment did not visually show signs of high organic loading, no strong odour.
- B4 - monitor closely, if negative redox values that exceed the threshold persist, reconsider aquaculture in the vicinity of this site.

Results and Discussion:

North Bay

- In both 2019 and 2020, redox values differed amongst sites.
- Redox values exhibited similar trends between 2019 and 2020.
- All sites compliant except NB1 - exceeded the low oxygen (Hypoxic B) threshold and was significantly different to average redox values at reference stations.
- NB1 - considerable difference in redox values between years.
- NB1 is relatively sheltered with the current directions likely resulting in the deposition of organic matter from the NB ADZ in this area (Pulfrich 2017).
- Sediment did not visually show signs of high organic loading, no strong odour.



North Bay

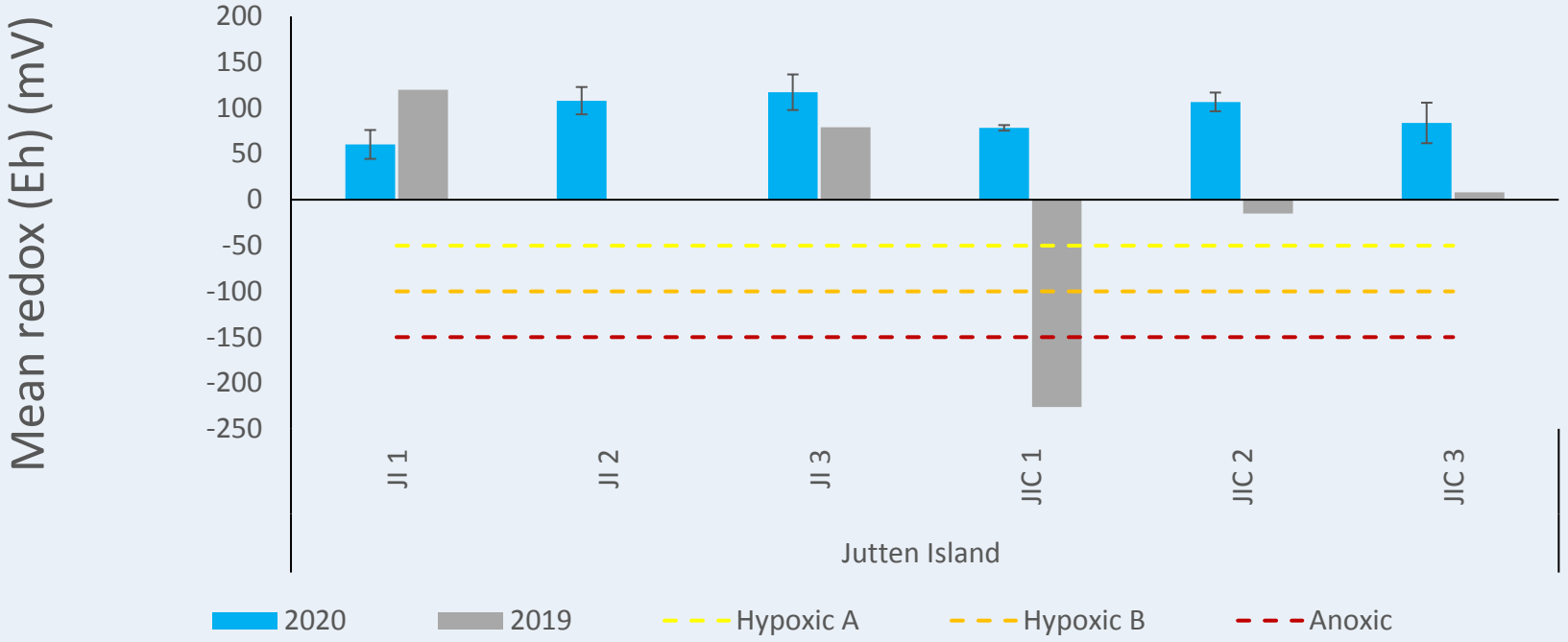
Findings:

- Redox values in the more sheltered section of the bay are negative (NB1, NB2 and NB3), while sites in the more exposed sections tend to be positive (NB4, NBC1, NBC2 and NBC3).
- Suggests sites in the inner part of the bay should be monitored closely.
- Sites mostly compliant with thresholds – no management triggered.
- Site NB1 - No farm structures above site, differences between years - no management triggered.
- NB1 - monitor closely, should persistent negative redox values that exceed the threshold be observed, management interventions may be required, conduct further analyses to determine cause of negative values.

Results and Discussion:

Jutten Island

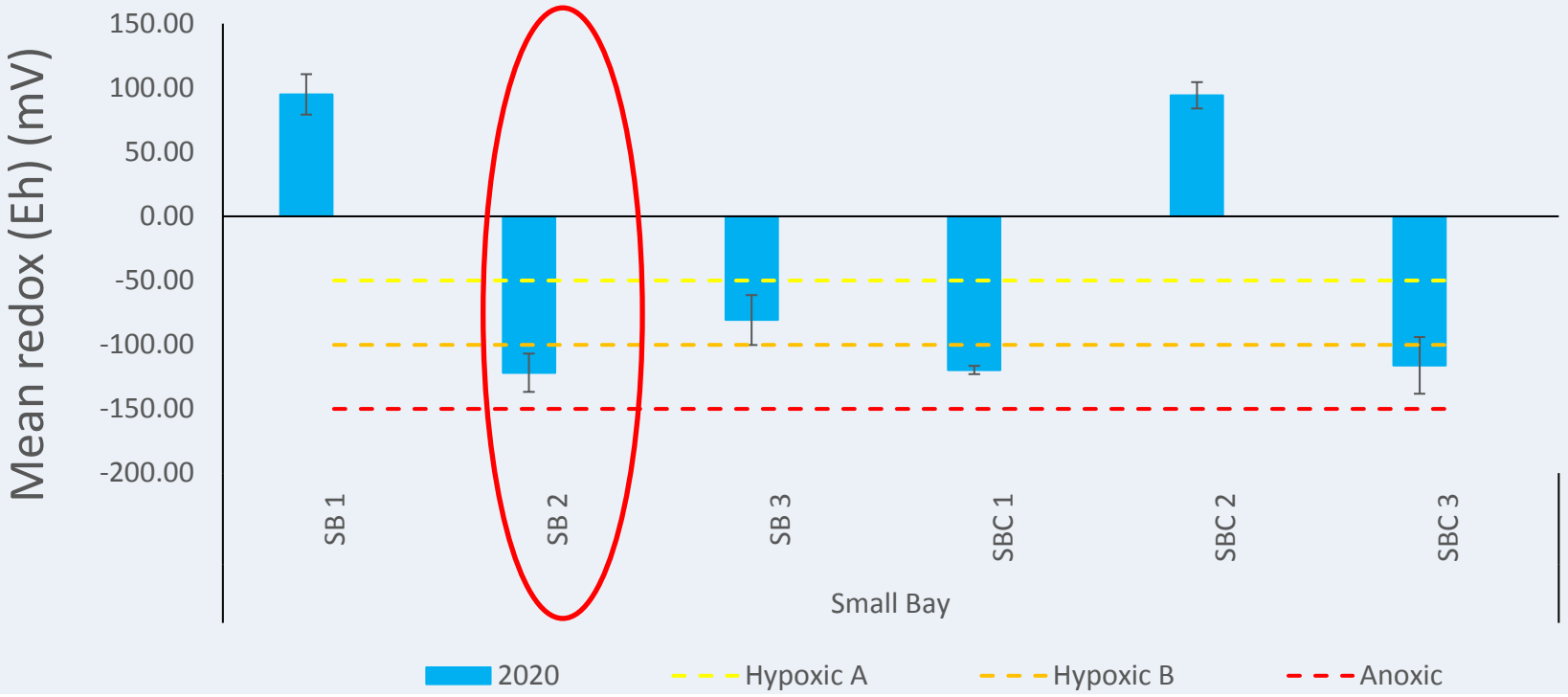
- Jutten Island - sites all recorded positive redox measurements which were significantly below the threshold levels.
- Sites either fell within the Oxic A or Oxic B categories
- Currently no farm installations at in this area, the values serve as a good baseline for measuring future impacts against.
- Hard substrata possibly present – evident with the difficulty in collecting samples at JI2 in both 2019 and 2020, this should be investigated further (diver or bathymetry survey).



Results and Discussion:

Small Bay redox survey

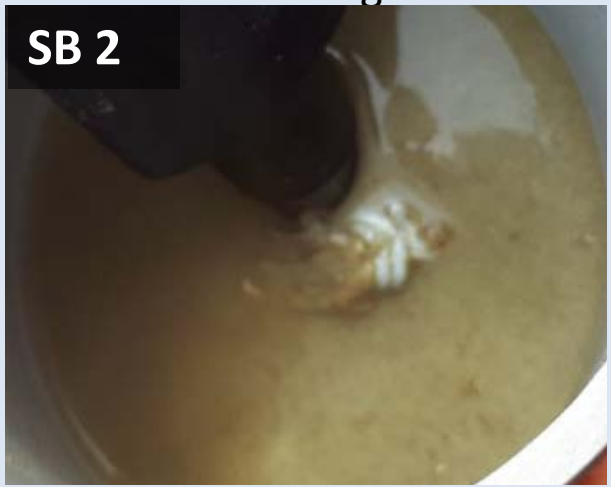
- High variability SB 1 - positive redox values, SB 2 and SB 3 - negative values.
- SB 2 redox values significantly exceeded the threshold placing it in the low oxygen (Hypoxic B) category.
- SB2 was, however, not significantly different to reference stations SB C1 and SB C3.
- Although SB2 exceeds the stipulated threshold, it has statistically similar redox values to two of the reference stations and does not trigger management action.



Results and Discussion:

Small Bay redox survey

- Overall, redox values tend to be lower than in Big Bay or Outer Bay.
- Likely due to the more sheltered nature of small bay, reducing the oxygenation of the sediments.
- High input of organic matter from various sources such fish factory wastes, biogenic waste from mussel and oyster culture as well as sewage effluent from the wastewater treatment works.
- All contribute to high organic loading and resultant low redox values.
- No visual evidence of organic load or strong odours.
- Concerns that reference stations SB C1 and SB C3 are deeper (14m and 12m respectively) than impact sites (approximately 7m).
- Deeper sites typically accumulate more organic matter – therefore not ideal for comparisons.



Conclusions:

- Redox (Eh) only serves as a proxy for Sulphide (S^{2-}). In future surveys samples should be collected and S^{2-} concentrations determined in the laboratory.
- Redox measurements should still be taken at the time of Sulphide sample collection to compare redox measurements taken to date.
- Due to hard substrata being present in Big Bay and Jutten Island a full detailed bathymetry survey should be done using side scan sonar to identify the present day extent of hard substrata and possible accumulation areas for organic matter.

Conclusions:

- Factors that may influence redox values in sediment, such as granulometry and organic content, should also be measured at the same time.
- These sediment characteristics (granulometry and organic content) will also be used to monitor potential impacts of ADZ development and will make better use of the sediment samples collected.
- The two reference stations in Small bay SB C1 and SB C3 should be relocated to a comparable depth to the impact stations a suitable distance away from the lease area.

Thank You

References:

- Aquaculture Stewardship Council. 2017. ASC Salmon Standard, v 1.1 103pp.
- Aquaculture Stewardship Council. 2017. ASC Bivalve Standard, version 1.0. 56 pp.
- Cranford PJ, Anderson R, Archambault P, Balch T, Bates SS, Bugden G, Callier MD, Carver C, Comeau L, Hargrave B, Harrison WG. 2006. Indicators and thresholds for use in assessing shellfish aquaculture impacts on fish habitat. DFO Canadian Scientific Advisory Secretariat Research Document. 34:116.
- DAFF. 2018. Protocols for environmental monitoring of the Aquaculture Development Zone in Saldanha Bay, South Africa. A report for Department of Agriculture, Forestry and Fisheries by T Probyn.
- Hargrave BT, Holmer M, Newcombe CP. 2008b. Towards a classification of organic enrichment in marine sediments based on biogeochemical indicators. Marine Pollution Bulletin. 56(5):810-24.
- Pulfrich 2017 Concept for a proposed sea-based aquaculture development zone in Saldanha Bay, South Africa Marine Ecology Specialist Study. Report prepared by PISCES Environmental Services (Pty) Ltd for SRK Consulting. 141pp.