		Date:	4 September 2023
TO:	**The Director-General** **Department of Forestry, Fisheries and the Environment** **Attention: Dr D Fischer**	Email:	dfischer@dffe.gov.za
FROM:	BIODIVERSITY LAW CENTRE		kate@biodiversitylaw.org / nina@biodiversitylaw.org
Total pages:	29 pages including Annexure	Our ref:	BLC/Penguins1/003

Dear Sirs

RE: Comment in respect of the Intention to Amend the Environmental Impact Assessment Regulations, Listing Notice 1, Listing Notice 2 and Listing Notice 3 of the Environmental Impact Assessment Regulations, 2014 for activities identified in terms of section 24(2) and 24D of the National Environmental Management Act, 1998 (Act No. 107 of 1998)

A) Introduction

1. The Biodiversity Law Centre (**BLC**) is a non-profit organisation and law clinic, registered in 2021. Our vision is flourishing indigenous species and ecosystems that support sustainable livelihoods in Southern Africa. The BLC's mission is to use the law to protect, restore and preserve indigenous ecosystems and species in Southern Africa. This comment responds to the Intention to Amend the Environmental Impact Assessment Regulations and Listing Notices 1 to 3 published in under Government Notice 3773 in *Government Gazette* 49081 of 4 August 2023 (**Proposed Amendments**).

2. The BLC notes that the Proposed Amendments appear primarily to refine definitions relating to activities regulated by the Mining and Petroleum Resources Development Act, 28 of 2002 (**MPRDA**). To the extent that such clarity is provided, the BLC welcomes the Proposed Amendments. However, we note, with concern, amendments pertaining to "offshore activities" and "coastal public property" as they:

    2.1. appear to remove key protections, checks and balances over "coastal public property" – a term which is not defined in the Proposed Amendments; existing Environmental Impact Assessment Regulations (**EIA Regulations**); Listing Notices;

or the National Environmental Management Act, 107 of 1998 (**NEMA**), but which is defined in the National Environmental Management: Integrated Coastal Management Act, 24 2008 (**ICMA**), section 1(1) read with section 7 – with critical implications for biodiversity and coastal environment protections;

2.2. have implications for environmental impact assessment of offshore "mining activities" (as per the definition in paragraph 3(d) of the Proposed Amendments); and

2.3. highlight the misalignment with regulation of the full spectrum of environmental impacts of offshore activities associated with "offshore installations" as variously defined in the Mine Health and Safety Regulations; Marine Pollution (Control and Civil Liability Act), 6 of 1981 (**Marine Pollution Control Act**); and Marine Traffic Act, 2 of 1981 (**Marine Traffic Act**).

3. This last concern is particularly important in light of the apparent acceptance by the Department of Forestry, Fisheries and the Environment (**DFFE**) and Transnet National Ports Authority (**TNPA**) that ship-to-ship transfers and bunkering (**STS Bunkering**) is not subject to the EIA Regulations.

3.1. As an activity which entails storage and transfer of hazardous substances and which may occur within the areas defined in sections 3, 4, 7 and 8 of the Maritime Zones Act, 15 of 1994 (**Maritime Zones Act**), this activity has been recognized as a high risk environmental activity at international level, including in the MARIPOL Convention to which South Africa is a party and which informs the provisions of, *inter alia*, the Marine Pollution Control Act.

3.2. Further, while other activities entailing transfer and storage of hazardous substances – including oil and gas – are subject to the environmental assessments and controls regulated by the EIA framework, STS bunkering remains a critical lacunae. With the clarification that all Listed Activities occurring "offshore" are to be subject to the EIA Regulations, this lacunae becomes inexplicable.

4. We address our concerns in detail below.

B) Concerns regarding proposed amendments regarding offshore activities

<u>The proposed definition of "offshore activities" is internally inconsistent</u>

5. Paragraph 3(e) of the Proposed Amendments provides that the definition of "offshore activities" is:

> "*activities in the Environmental Impact Assessment Regulations Listing Notice 1 of 2014, Listing Notice 2 of 2014 or Listing Notice 3 of 2014 published in terms of the Act, <u>which activities are proposed within the exclusive economic zone and continental shelf of the Republic referred to in sections 3, 4, 7 and 8 of the Maritime Zones Act, 1994 (Act No. 15 of 1994)</u>".*
>
> (emphasis added).

5.1. While this definition refers to "*the exclusive economic zone"* and "*continental shelf"*, it also refers to those areas defined in sections 3, 4, 7 and 8 of the Maritime Zones Act. There appears to be an omission of the terms "internal waters" (as expressed by section 3 of the Maritime Zones Act) and "territorial waters" (as defined in section 4 of the Maritime Zones Act).

5.2. To resolve this inconsistency, the definition should read:

"activities in the Environmental Impact Assessment Regulations Listing Notice 1 of 2014, Listing Notice 2 of 2014 or Listing Notice 3 of 2014 published in terms of the Act, which activities are proposed within the internal waters, territorial waters, the exclusive economic zone and continental shelf of the Republic referred to in sections 3, 4, 7 and 8 of the Maritime Zones Act, 1994 (Act No. 15 of 1994)".

(Additional text underlined).

5.3. Such amendment would align this definition with paragraph (a) of the definition of "*coastal waters*" which appears in the ICMA (i.e. "*the internal waters, territorial waters, exclusive economic zone and continental shelf of the Republic referred to in sections 3, 4, 7 and 8 of the Maritime Zones Act, 1994 (Act No. 15 of 1994) respectively*". This, in turn, would align the definition with that of "coastal public property" in the ICMA, which is defined, *inter alia*, with reference to "coastal waters".[1]

Proposed Amendments to Regulation 39 are potentially contradictory; remove key environmental protections; and unduly restrict the State's ability to adhere to its obligations to protect coastal public property as required by the ICMA

6. Paragraph 15 of Proposed Amendments expresses the intention to amend Regulation 39 of the EIA Regulations. The effect of this paragraph of the Proposed Amendments is to create a misalignment with the purpose and objects of the ICMA in respect of the state's obligations in respect of coastal public property.

7. The differentiation between "offshore activities" and "activities on coastal public property" does not seem to have a rational basis and risks introducing requirements which are incoherent and contradictory.

7.1. Non-application of consent requirements to mining activities

7.1.1. It is entirely unclear to us why "*mining activities, including hydraulic fracturing and reclamation and the expansion of mining activities hydraulic fracturing and reclamation*" should be excluded from the requirement of written consent by the landowner or person in control of land prior to application for an environmental authorisation. This appears to be the effect of paragraph 15(a) of the proposed Amendments.

[1] ICMA, section 7(1)(a)

7.1.2. A critical protection for landowners, holders of surface rights and persons exercising rights over land in terms contemplated in the Interim Protection of Land Rights Act, 31 of 1996, lies in the requirement to obtain written consent. This is equally critical for privately-owned land designated for environmental protection under the National Environmental Management: Protected Areas Act, 57 of 2003 or National Forests Act, 30 of 1998.

7.1.3. The requirement for written consent in Regulation 39(1) goes beyond the purpose and process of public participation as set out in Regulations 40 and 41 read with the applicable principles expressed derived from legislation and case-law. Not only does it provide for security in respect of use of land, but it empowers the owners and controllers of land to secure the integrity of ecosystems as well as ecological, spiritual and ecological processes which occur on the land in question.

7.1.4. Removing the requirement for written consent will inevitably make it easier for proponents of mining activities to avoid meaningful engagement with such owners / controllers to find mutually aggregable solutions. Moreover, it has the effect of permitting owners / controllers only the same input into the environmental authorization process as for other interested and affected parties, minimizing the primacy of ownership rights and environmental, spiritual and cultural rights and obligations of communities, individuals and organs of state who may own or control the land in question.

7.2. <u>Non-application of consent requirements to activities proposed on coastal public property</u>

7.2.1. Paragraphs 15(c) and 15(e) of the Proposed Amendments, indicate that written consent of owners / controllers of coastal public property is not required – however, the relevant responsible organ of state must be "notified" by the proponent of an activity.

7.2.2. We note that "ownership" may not be an appropriate concept in the context of coastal public property in light of section 11 of ICMA which vests ownership in the citizens of South Africa. However, we understand the trusteeship role of the organ of state responsible for "*managing*" any part of coastal public property as analogous to the role of an owner / controller as contemplated in EIA Regulation 39(1) as it currently stands. This is particularly so if the State is to be able to carry out its trusteeship function on behalf of South African citizens as required by section 12 of ICMA.

7.2.3. The relationship between the citizens of South Africa, the State and the rights and responsibilities associated with ownership and control are not removed by ICMA. Rather, a system is put in place whereby collective "ownership" is exercised through the State's actions as coastal public property trustee.

Accordingly, it seems entirely inappropriate that the requirement of written consent should be replaced with mere "notification".

7.2.4. This is even more so, given the breadth of obligations on the State under the ICMA when read with principle 2(4)(r) of NEMA which provides that:

> "*sensitive, vulnerable, highly dynamic or stress ecosystems, such as coastal shores, estuaries, wetlands and similar systems require specific attention in managing and planning procedures, especially where they are subject to significant human resource usage and development pressure*."

7.2.5. Accordingly, we would propose that, insofar as "*activities proposed on coastal public property"* are to be excluded from the consent requirements in EIA Regulation 39(1), the language of the text to be insert after subregulation (2) should read:

> "*Where the activity is* proposed *to be undertaken on coastal public property, the proponents must, before applying for an environmental authorization in respect of the activity, obtain the written consent of all organs of state responsible for managing and/or controlling any part of that area of coastal public property"*
>
> (Text to be amended underlined).

7.3. Non-application of consent requirements to offshore activities

7.3.1. As indicated above, the definition of "coastal public property" in section 7 of ICMA includes "*coastal waters*".

a) "Coastal waters" are defined in section 1(1) of ICMA as:

> "*(a) the internal waters, territorial waters, exclusive economic zone and continental shelf of the Republic referred to in sections 3, 4, 7 and 8 of the Maritime Zones Act, 1994 (Act No 15 of 1994, respectively; and*
>
> *(b) an estuary"*.

b) The Proposed Amendments intend to introduce the definition of "offshore activities" with reference sections 3, 4, 7 and 8 of the Maritime Zones Act – accordingly corresponding with paragraph (a) of the definition of "coastal waters" in ICMA.

7.3.2. While both "activities proposed on coastal public property" and "offshore activities" are proposed to be excluded from the written consent requirements of Regulation 39(1), only "activities proposed on coastal public property" require notification of the managing organ of state. Without conceding the adequacy of this proposal, we do not understand how a distinction can be made between

"offshore activities" and those activities to be carried out on "coastal public property".

a) This is because, the proposed insertion of Regulation 39(3) (expressed in paragraph 15(e) of the Proposed Amendments) requires all activities proposed to be carried out on coastal public property to be subject to "notice".

b) This, in turn, means that all activities to be carried out in "coastal waters" (as defined in the ICMA) will require "notice" to the responsible organ of state prior to an environmental authorization application.

c) Activities that occur in "coastal waters" include all those which occur within areas defined by sections 3, 4, 7 and 8 of the Maritime Zones Act.

d) This means that all "offshore activities" as per the definition in paragraph 3(e) (assuming it is corrected) will require notice to the responsible organ of state.

7.3.3. Accordingly, we recommend that "offshore activities" are not included in the list of exemptions in Regulation 39(2) as contemplated in paragraph 15(2) of the Proposed Amendments.

7.3.4. In addition, and for the sake of clarity, we recommend that the text to be inserted as Regulation 39(3) as already revised above, read:

> *"Where the activity (including any offshore activity) is proposed to be undertaken on coastal public property, the proponents must, before applying for an environmental authorization in respect of the activity, obtain the written consent of all organs of state responsible for managing and/or controlling any part of that area of coastal public property.*

C) Concerns relating to STS Bunkering

The Proposed Amendments align the Listing Notices with maritime regulation but ignore offshore installations

8. The Proposed Amendments express a clear intention to align the EIA Regulations with the regulation of the maritime zone. We welcome this attempt to align legislative frameworks governing environmental protections and maritime economic activity.

9. In this regard, we draw attention to section 9 of the Maritime Zones Act which makes laws in force in South applicable to "installations" as well as associated legislation dealing with ocean-based economic activity.

9.1. The Maritime Zones Act defines an "installation" as situated within "*internal waters, territorial waters or the exclusive economic zone or on or above the continental shelf*" and including:

> "*(a) Any installation, including a pipeline, which is used for the transfer of any substance to or from:*
>
> *(i) a ship;*
>
> *(ii) a research, exploration or production platform; or*
>
> *(iii) the coast of the Republic.*
>
> *(b) Any exploration or production platform used in prospecting for or the mining of any substance.*
>
> *(c) Any exploration or production vessel used in prospecting for or the mining of any substance.*
>
> *(d) A telecommunications line as defined in section 1 of the Post Office Act, 1958 (Act No. 44 of 1958).*
>
> *(e) Any vessel or appliance used for the exploration or exploitation of the seabed.*
>
> *(f) Any safety zone as defined in section 1 of the Marine Traffic Act, 1981 (Act No. 2 of 1981).*
>
> *(g) Any area situated under or above an installation referred to in paragraph (a) or (b)."*

9.2. Paragraphs (a) to (e) of this definition are repeated in the definition of an "offshore installation" in the Marine Traffic Act.

9.3. Similarly the Mine Health and Safety Regulations define an "offshore installation" as:

> "*an offshore structure supported on the seabed or a vessel used at sea in connection with the prospecting for or the mining of natural oil and on which persons are normally present"*

9.4. Significantly, the Marine Pollution Control Act which expressly contemplates STS Bunkering defines an "offshore installation" as:

> "*a facility situated wholly or partly within the prohibited area and which is used for the transfer of harmful substances from a ship or a tanker to a point on land or from a point on land to a ship or tanker or from a bunkering vessel to a ship or tanker, and includes any exploration or production platform situated within the prohibited area*"
>
> [where the "prohibited area" is the internal waters, territorial waters, exclusive economic zone and sea within limits of the continental shelf].

9.5. There is, accordingly, a clear connection between the notion of an "offshore installation" and a range of offshore economic activities in the legislative framework governing South Africa's ocean territory including telecommunications; "mining activities"; and transfer of hazardous substances – the latter including through STS Bunkering.

9.6. In the circumstances, we find it peculiar that the Proposed Amendments purport to regulate the EIA process and require environmental authorization for "offshore activities" (which we welcome) while failing to consider that the Listing Notices appear to have been interpreted by the DFFE to exclude STS Bunkering. We emphasise, however, that the effect of the definition of "offshore activities" is not entirely clear: we assume that it means that any already Listed Activity that is to be conducted "offshore" (i.e. within the areas defined by sections 3, 4, 7 and 8 of the Maritime Zones Act), However, if this is not the intended meaning, the definition would appear meaningless insofar as there are no activities which are expressly referred to as "offshore activities" in the current (or proposed) Listings.

9.7. This is a long-standing issue of which the DFFE and Minister of Forestry, Fisheries and the Environment (**Minister**) are well aware.

9.7.1. By way of example, the BLC expressed its concerns about the lack of EIA regulation of STS Bunkering in a comprehensive letter addressed to the Minister on 9 September 2022.

9.7.2. On 1 November 2011, the Minister stated, *inter alia*, that the DFFE was "*investigating the desirability of such listing with a view to determine whether it is an appropriate tool to mitigate the negative effect that bunkering may have on the coastal environment, and specifically on African Penguin colonies….*".

9.7.3. She further indicated that the DFFE was considering Strategic Environmental Assessment (**SEA**).

9.7.4. While we would support the initiation of a SEA, this does not preclude the necessity of incorporating STS Bunkering as a Listed Activity. Such listing serves an entirely separate purpose of requiring environmental assessment on authorization on a case-by-case basis, notwithstanding the broader assessments that may be undertaken regarding STS Bunkering – and any industry-level decisions taken by the DFFE and/or Minister to halt or restrict STS Bunkering should it pose an unacceptable environmental risk.

9.8. The BLC has heard nothing further in relation to the DFFE's deliberations regarding the Listing of STS Bunkering, despite requesting an update in this regard on 5 June 2023. Accordingly, we have set out our motivations for including this as a Listed Activity – with particular reference to the impacts of STS Bunkering on the viability

of African Penguin (*Spheniscus demersus*) populations which the DFFE has recognized as being effected by STS Bunkering.[2]

D) The need for specifically including STS Bunkering as Listed Activity

STS Bunkering – Overview

10. "Bunkering" means the supply of fuel for use by ships and includes the shipboard logistics of loading fuel and distributing it among available bunker tanks and "ship-to-ship operations" means the transfer of liquid bulk cargo from one vessel to another, also known as "Lightering". There is no distinction between "Lightering" and STS operations.[3] Our concern relates to bunkering that occurs offshore between vessels i.e. STS Bunkering.

11. Currently, STS Bunkering occurs primarily in Algoa Bay (the only location at which long-term STS Bunkering operations have been approved). The first operator, Aegean Bunkering Marine Services, received South African Maritime Safety Authority (**SAMSA**) approval and was and licenced by the TNPA in 2016. This application was followed by further approval and licencing of South African Marine Fuels in 2018, and Heron Marine in 2019.

12. We are aware that a moratorium currently prevents further licences for STS Bunkering in Algoa Bay being awarded by the TNPA / approvals being granted by SAMSA and that the TNPA is currently engaged in a once-off general environment risk assessment (**ERA**).[4]

    12.1. However, the basis, duration and decision-makers behind the moratorium are unclear.

    12.2. A once-off, general risk assessment can never be a replacement for a rigorous assessment of project-specific impacts related to the carrying out of a particular activity in a particular location.

    12.3. Moreover, the ERA will be limited to Algoa Bay and appears to have been called for by the Port of Ngqura only without covering other coastal regions into which STS Bunkering may expand.

    12.4. It is also unclear how the Port of Port Elizabeth will engage with the ERA and its findings and/or recommendations.

13. As you will be aware, Algoa Bay is an area of rich biodiversity and ecological sensitivity:

    13.1. It includes the Addo Elephant Marine Protected Area, which was declared in 2019 for the purpose of protecting a linked system of shore, estuarine, bay, island and

[2] See for example, Draft Biodiversity Management Plan for the African Penguin, GN2302 in *Government Gazette* 47061 of 22 July 2022 (**Penguin BMP**).
[3] Draft Bunkering Code of Practice, September 2022.
[4] https://easytenders.co.za/tenders/request-for-proposal-tnpa-2022-06-0489-5185-rfp-81479.

shelf ecosystems and their associated biodiversity and ecosystem processes, to facilitate fisheries management, for the protection of threatened species and the physical features and ecological processes on which they depend and finally to protect and regulate a scenic area and its marine wildlife to support sustainable nature-based tourism;[5]

13.2. It includes the Algoa to Amathole (Offshore of Port Elizabeth) Ecologically and Biologically Significant Area,[6] designated as such for its unique ecological features including rare habitat types, an important benthic and pelagic area that supports important ecological processes, seabird breeding and foraging areas, fish spawning and nursery areas and areas used by endangered leatherback turtles;

13.3. It comprises the Algoa Bay Islands and Addo Elephant National Park Important Bird Area, where fourteen seabird, several shorebird and 33 terrestrial bird species have been recorded, and where eight seabird species currently breed;[7]

13.4. It was declared a Hope Spot by Dr Sylvia Earle in 2014;[8] and

13.5. In 2021, Algoa Bay was declared a Whale Heritage Site. Since 2018, an annual Welcoming of the Whales Festival is celebrated in June when the first Humpback whales arrive on their migration route from Antarctic feeding grounds. The importance of these beautiful animals for the communities and the need for their conservation in the wild are at the heart of these celebrations. Marine tour operators, conservation projects, private companies, educational institutions, and NGOs come together to engage with and educate the public about the whales living off their coasts, as well as all the other marine life and addressing issues like plastic pollution.

14. Critically, Algoa Bay provides habitats for endangered African Penguins as well as other endangered seabirds, cetaceans and seals.[9]

14.1. Two groups of islands in Algoa Bay, the St Croix Island group and the Bird Island group, together support globally important populations of the endangered African Penguin and Cape Gannet (*Morus capensis*).[10]

14.2. In 2015, Algoa Bay supported 54% of South Africa's population of African Penguin. St Croix Island was the largest colony of this species by a significant margin, contributing 40% of the South African population. It has been confirmed that in 2023 there were only 783 breeding pairs of African Penguins on St Croix Island.[11] This

[5] GN 757 in *Government Gazette* 24278 of 23 May 2019.
[6] https://www.cbd.int/ebsa/.
[7] https://www.birdlife.org.za/iba-directory/algoa-bay-islands-addo-elephant-national-park/.
[8] Algoa Bay Hope Spot - Sustainable Seas Trust (sst.org.za).
[9] Pichegru et al "Maritime traffic trends around the southern tip of Africa – Did marine noise pollution contribute to the local penguins' collapse?" Science of the Total Environment 849 (2022) page 1.
[10] Pichegru et al, page 2.
[11] DFFE: Unpublished data.

means that there has been a 38% decrease since 1262 pairs were recorded in 2022, and a 90% decrease in the St Croix population since before bunkering activities commenced in Algoa Bay in 2015. The colony is therefore likely to be the 7th largest population in South Africa, compared to 2015 when the St Croix colony was the largest globally with 39% of the South African population.

15. As the DFFE has recorded in the Penguin BMP the African Penguin is Africa's only extant penguin and is endemic to both Namibia and South Africa. The species has suffered an enormous reduction from over one million pairs in the 1920s, to numbers of approximately 10 041 pairs in 2022.[12] It is currently classified as Endangered by the International Union for Conservation of Nature (**IUCN**) and under the Threatened or Protected Marine Species Regulations (**TOPMS**)[13] published under the National Environmental Management: Biodiversity Act, Act 10 of 2004 (**NEM:BA**).

16. Protecting African Penguins is not just important for the species itself, but for the entire ecosystem of which they are a critical part. As the Penguin BMP notes, African Penguins are considered sentinels of ecosystem health, playing an important role in the functioning of marine ecosystems. Thriving African Penguin colonies will give some indication of the status of other marine top predators that target the same prey and, more broadly, to the relative condition of the marine ecosystem.[14]

17. African Penguins face a variety of cumulative pressures, including food scarcity (due to competition with commercial fisheries), breeding habitat modification, human disturbance in colonies, oil spills, disease outbreak, predation, and maritime industries such as oil and gas exploration.[15] Significantly, African Penguin populations on St Croix Island have declined dramatically since the advent of STS bunkering in Algoa Bay. This decline, which stands to affect the ecosystem as a whole, is indicative of the negative impacts that may be suffered by an ecosystem as a result of STS Bunkering.

<u>Environmental Risks posed by STS Bunkering</u>

18. STS Bunkering presents serious safety, health and environmental risks, including explosions and spillage during transfer, resulting in pollution, loss of biodiversity and ecological disturbances and loss of efficient functioning of the port. Bunkering activities have in particular been shown to have a devastating impact on endangered seabirds in Algoa Bay, especially African Penguin populations, whose numbers have declined from

[12] Makhado, Crawford, Sherley and Upfold "the ongoing decrease of African Penguins globally and in South Africa, 1989–2022", Table 1, page 7.
[13] GN 476 in *Government Gazette* 40875 of 30 May 2017.
[14] Penguin BMP, page 7.
[15] Penguin BMP, pages 23 to 31.

more than 50 000 breeding pairs in 2004,[16] to a record low of 10 041 pairs in 2022.[17] This is a truly catastrophic decline.

19. The fuelling of large vessels through STS Bunkering increases the likelihood and risk of oil spills and disturbance on marine wildlife. The Penguin BMP notes that "*addressing and mitigating the threat that ship-to-ship bunkering has to* [sic] *African penguins (and other marine life) requires more focused attention.*"[18] It does not, however, elaborate further on the nature of such "attention".

20. As it is, four devastating oil spills have occurred as a result of STS Bunkering operations in Algoa Bay, two of which resulted in significant numbers of oiled wildlife:

Year	**STS Fuel Bunkering operator**	**Receiving vessel**	**Species and numbers affected**
2016	Previously Aegean Oil Petroleum Network, now renamed under Minerva Bunkering	*MV* Energy Challenger	150 African Penguins
2019	South African Marine Fuels	*MV* Chrysanthi S	109 African Penguins 13 Cape Gannets 3 Cape Cormorants
2021	Heron Marine	*MV* Solin	1 African Penguin 3 Cape Gannets Note that it was a stroke of luck that the spill occurred during the annual moult cycle for African penguins, thus they were confined to the islands.
2022	Minerva Bunkering	*MT* Umnenga	No oiled seabirds reported Note that the number of African Penguins on St Croix is now so low that the few remaining individuals could have avoided the slick.

21. Whilst it is possible to report on the number of seabirds captured and treated by local NGOs, it is important to note that there is an unquantifiable impact to marine species caused by hydrocarbon spills that are never recovered, thus we never truly grasp the full magnitude of a spill incident.

[16] Penguin BMP, page 7.
[17] Makhado, Crawford, Sherley and Upfold "the ongoing decrease of African Penguins globally and in South Africa, 1989–2022", Table 1, page 7.
[18] Penguin BMP, page 29

22. There is consequently no doubt that STS Bunkering poses a great risk of oil spills that stand to have devastating impacts on marine wildlife.

23. In terms of disturbance faced by marine wildlife as a result of increased shipping, maritime traffic has increased exponentially in Algoa Bay in recent years, particularly since 2016, when STS Bunkering commenced within the defined Port of Ngqura at anchorage (approximately 5km from St Croix Island).

    23.1. The impacts of marine noise pollution have been documented in a groundbreaking new study compiled by L. Pichegru *et al* entitled "*Maritime traffic trends around the southern tip of Africa – Did marine noise pollution contribute to the local penguins' collapse?*" (**Pichegru Study**), which has provided the first scientific evidence that an increase in vessel-driven noise after STS Bunkering commenced in Algoa Bay in 2016 was significantly associated with the fastest short-term decline of an African Penguin population on record, i.e. 83% decline of the once largest colony at St Croix Island since 2015.[19]

    23.2. The Pichegru Study, which assessed the relationship between annual vessel-derived noise estimates and the annual counts of African Penguin breeding pairs using standard linear regression, found as follows.

        23.2.1. Increases in maritime traffic in Algoa Bay, and subsequent noise levels emitted, are correlated with the establishment and expansion of STS Bunkering operations in the bay.

        23.2.2. STS Bunkering mainly attracts bulk carriers, which are among the noisiest vessels in transit. It is therefore clear that this activity is a major contributor to the altered anthropophony of the bay.

        23.2.3. In the period between 2013 and 2019, the number of African Penguin breeding pairs declined from 7,657 pairs, to 3,638 pairs, a decrease of 52%. The world's largest remaining African Penguin colony, located within 5-15km of the most intense maritime traffic activities in Algoa Bay, therefore more than halved, significantly correlating with the concurrent underwater noise levels in the bay as a result of STS bunkering. This is the greatest short-term decrease of an African Penguin colony on record.[20]

        23.2.4. The intensification of underwater noise levels in the African Penguin's foraging habitat was therefore linked to the initiation and expansion of STS bunkering activities which intensified the maritime traffic in the area. Noise levels were

[19] Pichegru et al "Maritime traffic trends around the southern tip of Africa – Did marine noise pollution contribute to the local penguins' collapse?" Science of the Total Environment 849 (2022) page 1.
[20] Pichegru et al, page 7.

significantly related to the collapse of what had been the world's largest remaining colony of endangered African Penguins.[21]

23.2.5. The impact of underwater noise not only affects African Penguins, but other marine wildlife. High levels of underwater noise levels can directly affect individual animals by decreasing their foraging success, impacting their sensory abilities (e.g. hearing, orientation) and inducing higher stress levels.[22]

23.3. A copy of the Pichegru Study is included under cover hereof as **Annexure 1**.

24. There is consequently no question that STS Bunkering activities are having catastrophic impacts on marine biodiversity within Algoa Bay.

25. In addition, impacts on marine biodiversity have cascading impacts on other sectors of the South African economy. Marine wildlife is a critical component of ecotourism in South Africa. This industry generates much revenue and creates many jobs, which stand to be lost if the biodiversity on which the sector depends is compromised. While figures particular to Algoa Bay are lacking, comparable studies have been conducted in relation to the socio-economic benefits of the Boulders Bay African Penguin colony:

25.1. the colony generates tourist and resident expenditure of approximately R311 million per annum with ~35% of this amount being spent within Simon's Town;[23]

25.2. a total of 855 jobs can be associated with the Penguin colony within all parts of Cape Town, with in the order of 250 of these to be found in Simon's Town and surrounds;[24]

25.3. Penguin-based tourism forms an integral part of the R25 billion Western Cape tourism sector.[25]

26. Similar findings would undoubtedly be associated with the Algoa Bay colonies, and the broader marine ecotourism industry which depend on thriving marine wildlife.

27. An activity which stands to have so significant an impact on marine wildlife populations, livelihoods and tourism should be subject to the highest level of impact assessment and scrutiny to determine whether or not it should be authorised.

<u>Current regulation of STS bunkering activities does not provide for environmental assessments and therefore does not enable the State to adhere to its environmental</u>

[21] Pichegru et at, page 7.
[22] Pichegru et al, page 7.
[23] Van Zyl and Kinghorn "The Economic Value and Contribution of the Simon's Town Penguin Colony" Technical Report, September 2018, page 17.HYJ
[24] Van Zyl and Kinghorn "The Economic Value and Contribution of the Simon's Town Penguin Colony" Technical Report, September 2018, page 17.
[25] Lewis, Turpie & Ryan "Are African penguins worth saving? The ecotourism value of the Boulders Beach colony" *African Journal of Marine Science* 2012, page 1.

responsibilities in terms of the environmental management framework and section 24 of the Constitution

28. STS Bunkering is currently regulated outside the National Environmental framework by:

    28.1. TNPA in terms of section 80(2) of the National Ports Act, Act 12 of 2005 (**National Ports Act**) read with Rule 148 of the National Ports Rules;[26] and

    28.2. SAMSA in terms of section 21 of the Marine Pollution Control Act read and Marine Notice No. 3 of 2016.

29. Rule 148 of the Ports Rules requires that a person who carries out bunkering activities must obtain a licence from TNPA.

30. Section 21 of the Marine Pollution Act provides that no person shall outside a harbour or a fishing harbour and within the prohibited area, transfer any oil or other prescribed harmful substance from any ship or tanker to any other ship or tanker or to an offshore installation or from such offshore installation to any ship or tanker, without SAMSA's permission. SAMSA is empowered to impose conditions in giving its permission.

31. Marine Notice 3 of 2016 contains the requirements for an application for SAMSA's permission to conduct a bunker or oil transfer operation outside a port.

32. However, neither of these statutes provides a comprehensive framework (comparable to the EIA Regulations, 2014) for assessing the full range of direct, indirect, and cumulative impacts associated with STS bunkering.

33. The TNPA has a set of standard conditions in relation to safety, health, environment and efficiency which are imposed on bunkering licences.[27] However, these conditions are extremely limited, and only relate to pollution as a result of an oil spill, and not the broader impacts (for example, underwater noise) that stand to affect marine wildlife, livelihoods and tourism.

34. SAMSA released a Bunkering Code of Practice[28] and an STS Transfer Code of Practice[29] for public comment in late 2021.

    34.1. In September 2022, revised versions were published for a second round of comments.

    34.2. Although these Codes are being developed with a view to improving the management of STS bunkering in South Africa, they will not be implemented under the authority of the DFFE, and we remain concerned that the drafts as they currently

[26] GN 255 in *Government Gazette* 31986 of 6 March 2009.
[27] Annexure G, Guidelines for Agreements, Licences and Permits in terms of the National Ports Act No. 12 of 2005.
[28] Dated October 2021.
[29] Dated October 2021.

stand do not go nearly far enough in assessing and addressing the full range of environmental impacts associated with STS bunkering.

34.3. Furthermore, the Codes will not have the effect that the DFFE and Minister are adhering to their own environmental oversight role in terms of NEMA and the obligations under Chapter 5 of that Act.

35. We note that the most recent version of the Codes include, in Chapter 14, a description of the Environmental Risk Management Plan (**ERMP**) that must accompany an application for SAMSA's permission to conduct bunkering activities. The Code requires the ERMP to contain, amongst other things:

35.1. a description of the activity and the environment that may be affected;

35.2. a description of the need and desirability of the activity;

35.3. a summary of the issues raised during any local participation processes followed;

35.4. an assessment of the significance, nature, duration, extent, probability and reversibility of the environmental and cumulative impacts and whether these impacts can be mitigated;

35.5. environmental management and mitigation measures that should be taken.[30]

36. The above language is drawn directly from the EIA Regulations and is clearly indicative of an acknowledgement that STS bunkering activities should be subject to an EIA. This acknowledgement in itself is reason enough to list STS bunkering in the EIA Regulations, such that the activity requires an environmental authorisation before it may be conducted.

37. We note further that in the stakeholder consultation held as part of TNPA's ERA on 2 August 2022 (which was attended by the BLC), there was a clear indication that EIA Regulation was to be considered and that the TNPA was itself concerned with inadequate controls in respect of STS Bunkering.

<u>The requirement of Listing STS Bunkering</u>

38. As you are aware, and as is indicated in the Proposed Amendments, the Minister is empowered in terms of section 24(2)(a) read with section 24D of NEMA to publish lists of activities which may not commence without an environmental authorisation from the competent authority.

[30] Draft Bunkering Code of Practice, page 70.

39. The purpose of listing activities under NEMA is to bring such activities within the ambit of integrated environmental management and the regulatory framework imposed by NEMA. Integrated environmental management requires:[31]

    39.1. the integration of NEMA section 2 principles of environmental management into all decisions that may affect the environment;

    39.2. the identification, prediction and evaluation of actual and potential impacts on the environment, socio-economic conditions and cultural heritage, the risks and consequences and alternatives and options for mitigation of activities;

    39.3. ensuring that the effects of activities on the environment receive adequate consideration before actions are taken in connection with them; and

    39.4. crucially, ensuring adequate and appropriate opportunity for public participation in decisions that may affect the environment.

40. It is clear that none of the regulatory processes currently applicable to STS Bunkering described above comply with principles of integrated environmental management. No provision is made for relevant impact assessments, including specialist assessments, on biodiversity and endangered seabirds, socio-economic impacts, and modelling to determine the effect of emissions and spills from the STS Bunkering operations. While the Codes include requirements for an Environmental Risk Management Plan, these fall far short of the level of assessment required by the EIA Regulations. This is wholly inadequate considering the impacts STS Bunkering is already having on marine biodiversity in South Africa, and Algoa Bay in particular, as evidenced by the catastrophic decline in African Penguin populations and impacts of oil spills between 2016 and 2022.

41. We are therefore strongly of the view that STS Bunkering needs to be included as a Listed Activity to bring the activity within the ambit of integrated environmental management in terms of NEMA. By so listing STS Bunkering, in addition to enabling the rigorous assessment of the full range of direct, indirect, and cumulative impacts associated with the activity by suitably qualified experts:

    41.1. the regulatory controls of STS Bunkering will align with those of other offshore activities and activities taking place on coastal public property;

    41.2. interested and affected parties will be afforded the opportunity to participate in the decision whether or not to authorise STS Bunkering, which will enable important information to serve before the competent authority in making its decision;

    41.3. the competent authority will have an opportunity to impose conditions in relation to the activity, thereby mitigating potential negative impacts associated with STS Bunkering (should the activity be authorised) and ensuring the activities are

[31] Section 23, NEMA.

conducted with as little risk to marine biodiversity, tourism and livelihoods as possible;

41.4. STS Bunkering activities, if authorised, would be subject to regular audits in terms of the EIA Regulations, thereby facilitating scrutiny of the holder's compliance with conditions of the environmental authorisation;

41.5. clarity would be provided to the TNPA, SAMSA, the relevant Harbour Masters and key stakeholders engaged in managing coastal public property, ports, harbours and associated areas, regarding the approach to managing environmental risk relating to STS Bunkering;

41.6. any changes in the nature and / or scope of STS Bunkering activities would need to be subject to the amendment process as contemplated in the EIA Regulations, including public participation, which would also increase the degree of scrutiny over such activities;

41.7. an EMPr will need to be compiled which details information on any proposed management, mitigation, protection or remedial measures that will be undertaken to address the environmental impacts that have been identified; and

41.8. the STS Bunkering activities, if authorised, will be brought within the ambit of the compliance and enforcement provisions contained in Part 2 of Chapter 7 of NEMA, enabling greater compliance with both NEMA and the conditions of any environmental authorisation issued, and the imposition of significant penalties for any non-compliance.

42. Including STS Bunkering as a Listed Activity in terms of the EIA Regulations would also be consistent with South Africa's obligations under international law – in particular, as a Contracting Party to the Convention on Biological Diversity (**CBD**); the Convention on the Conservation of Migratory Species of Wild Animals (**CMS**); the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (**AEWA**); and the Benguela Current Convention (**BCC**).

42.1. For instance, Article 14(1)(a) of the CBD calls for the introduction of appropriate EIA requirements for proposed projects that are likely to have significant adverse effects on biodiversity, and the Convention's Conference of the Parties has explicitly encouraged impact assessments for activities that may have significant adverse impacts on noise-sensitive species.[32]

[32] CBD Decision XII/23.

42.2. The CMS Conference of the Parties has similarly urged that environmental assessments be undertaken on "*the introduction of activities that may lead to noise-associated risks for CMS-listed marine species and their prey*".[33]

42.3. Article 4(2)(b) of the BCC provides that Parties shall "*undertake environmental impact assessment for proposed activities that are likely to cause adverse impacts on the marine and coastal environments*".

42.4. Parties to AEWA are required to take measures to restore the African Penguin and various other species of threatened seabirds to a favourable conservation status, and this treaty's International Working Group for Benguela Coastal Seabirds has expressed concern regarding STS Bunkering and agreed that it would be beneficial if this activity required an EIA.[34]

43. The ecological and socio-economic impacts of STS Bunkering should undoubtedly be assessed before approvals to conduct bunkering are granted. For this reason, STS bunkering should be listed as a Listed Activity in terms of the EIA Regulations, and be subjected to the rigorous EIA process contemplated therein before any further bunkering activities are authorised.

E) Conclusion

44. It is evident that there are a number of inconsistencies in the definitions and proposed approach to "offshore activities" and "coastal public property" in the Proposed Amendments – including a persistent lacunae around the environmental regulation and control of STS Bunkering.

45. To ensure consistency between the EIA Regulations and related environmental management and maritime frameworks, we propose the following:

45.1. The definition of "offshore activities" correctly reflects the contents of sections 3, 4, 7 and 8 of the Maritime Zones Act by reading:

> *"activities in the Environmental Impact Assessment Regulations Listing Notice 1 of 2014, Listing Notice 2 of 2014 or Listing Notice 3 of 2014 published in terms of the Act, which activities are proposed within the internal waters, territorial waters, the exclusive economic zone and continental shelf of the Republic referred to in sections 3, 4, 7 and 8 of the Maritime Zones Act, 1994 (Act No. 15 of 1994)".*

45.2. "Mining activities" are not excluded from the application of Regulation 39(1).

45.3. "Offshore activities" should not be referenced in Regulation 39(2) at all.

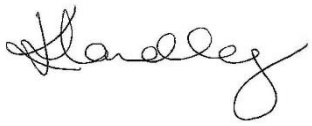
[33] CMS Resolution 12.14.
[34] Rolling Work Plan 2021-2025 - AEWA Benguela Coastal Seabirds International Working Group, page 10.

45.4. Insofar as “activities proposed on coastal public property” are excluded from application of Regulation 39(1), and include offshore activities, the insertion of Regulation 39(3) should read:

> *“Where the activity (including any offshore activity) is proposed to be undertaken on coastal public property, the proponents must, before applying for an environmental authorization in respect of the activity, obtain the written consent of all organs of state responsible for managing and/or controlling any part of that area of coastal public property*.

45.5. The Listing Notices to the EIA Regulations should be amended to expressly include STS Bunkering.

Yours faithfully,

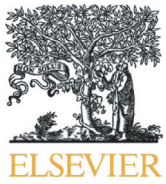


BIODIVERSITY LAW CENTRE NPC

Per **Nina Braude and Kate Handley**

Science of the Total Environment 849 (2022) 157878

Annexure 1



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Maritime traffic trends around the southern tip of Africa – Did marine noise pollution contribute to the local penguins' collapse?

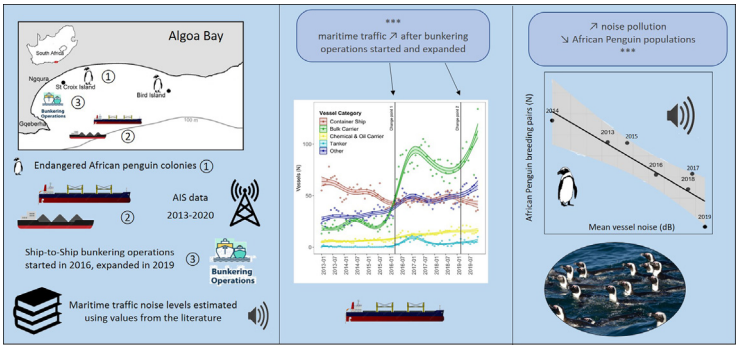
Lorien Pichegru [a,*,1], Laëtitia Vibert [a,1], Andréa Thiebault [a,b], Isabelle Charrier [b], Nicky Stander [c], Katta Ludynia [c,d], Melissa Lewis [e], Tegan Carpenter-Kling [a,e], Alistair McInnes [e,f]

[a] Institute for Coastal and Marine Research, Nelson Mandela University, Gqeberha 6001, South Africa
[b] Université Paris-Saclay, CNRS UMR 9197, Institut des Neurosciences Paris-Saclay, 91400 Saclay, France
[c] Southern African Foundation for the Conservation of Coastal Birds, Cape Town 7441, South Africa
[d] Department of Biological Sciences, University of Cape Town, 7700, South Africa
[e] BirdLife South Africa, Cape Town 8001, South Africa
[f] FitzPatrick Institute of African Ornithology, University of Cape Town, 7700, South Africa

HIGHLIGHTS

- Maritime traffic increases globally, with associated noise pollution.
- Using AIS data, vessel noise emissions estimated in a marine biodiversity hotspot.
- Vessel-derived noise increased after initiation of offshore ship-to-ship bunkering.
- Local endangered African Penguin colony collapsed concomitantly.
- First evidence of impact of maritime traffic noise pollution on seabirds

GRAPHICAL ABSTRACT



ARTICLE INFO

Editor: Rafael Mateo Soria

Keywords:
Anthropophony
Marine conservation
Seabirds
Shipping route
Ship-to-ship bunkering
Underwater noise

ABSTRACT

The rapid increase in seaborn trade since the 1990s has resulted in an increase in vessel-derived noise pollution, yet there is little evidence linking these activities to a decline in many marine taxa, such as seabirds. Algoa Bay, South Africa, is a marine biodiversity hotspot, providing habitats for the largest populations of endangered African Penguins (*Spheniscus demersus*), as well as other endangered seabirds, cetaceans and seals. The bay is situated on a major shipping route and since 2016 has hosted the first offshore ship-to-ship (STS) bunkering operations in the country, i.e. the supplying of fuel from one ship to another outside of harbours. Using Automatic Identification System (AIS) data, we estimated noise emissions from vessels as a proxy for underwater ambient noise levels within the core penguin utilisation area. Frequency of vessels using the bay doubled during our study, with numbers of bulk carriers increasing ten-fold. Ambient underwater noise levels were generally high in the bay (ca 140 dB re 1 μPa since 2015) but significantly increased by 2 dB SPL after the initiation of STS bunkering in 2016, corresponding to double the underwater noise intensity. This increase coincided with a significant and dramatic decline by 85% in penguin numbers from St Croix Island since 2016. Algoa Bay is now one of the noisiest bays in the world. This is the first study to assess the potential impact of vessel-derived underwater noise levels on a seabird population. Penguins, like marine

* Corresponding author.
E-mail address: lorien.pichegru@mandela.ac.za (L. Pichegru).
[1] These authors contributed equally to the work.

http://dx.doi.org/10.1016/j.scitotenv.2022.157878
Received 8 May 2022; Received in revised form 13 July 2022; Accepted 3 August 2022
Available online 6 August 2022

mammal species, are known to be sensitive to marine noise pollution and urgent management interventions are required to mitigate this recent disturbance, to preserve the remaining stronghold of the African penguin and the marine mammals' populations sharing the penguins' habitat.

1. Introduction

Maritime traffic has increased exponentially since the end of the second world war (Malakoff, 2010) and currently incorporates over 90 % of international trade in terms of volume (UNCTAD, 2019). In 2018, the total volume of merchandise transiting through the sea reached 11 billion tons for a global fleet of almost 92,300 ships (UNCTAD, 2019). Maritime traffic is a major source of pollution. The combustion of heavy fuel oil for maritime transport represents 15 % of world sulphur emissions (Qi et al., 2020), harmful to the health of human populations in ports and coastal cities (Zhen et al., 2019). Oil spills (accidental or illegal discharges, e.g. Polinov et al., 2021) are perhaps the most obvious and well-known pollution risks from sea-going vessels, being the most publicly visual and with often large scale, long-lasting impacts on the environment and communities that depend on healthy marine ecosystems (Chilvers et al., 2021). Less obvious to the public and with infrequent reports recorded, vessel collisions with large marine animals have a clear significant impact on cetacean populations worldwide (Schoeman et al., 2020). In addition, hull fouling and ballast water, as major transport vectors for marine organisms, present a significant threat of biological invasions to marine ecosystems (Sardain et al., 2019). The impacts of anthropogenic noise pollution emitted from vessel activities on a wide range of taxa have only recently been given recognition (Duarte et al., 2021). While environmental sustainability has started to become a major policy concern in global maritime transport in more recent years (e.g., limits to the sulphur content in fuel oil used by ships in 2016 (Lindstad et al., 2017), successful mitigation measures implemented since the 1960s to reduced pollution from shipping and the offshore oil industry (Camphuysen, 2010; Chilvers et al., 2021), and the creation of the International Convention for the Control and Management of Ships' Ballast Water and Sediments in 2004 (see Ji et al., 2021), mitigation of marine noise pollution remains in its infancy. This is despite a range of guidelines for noise measurement and ship design and engineering having been set by the International Maritime Organisation (IMO) in 2014, with the aim of reducing the underwater noise produced by ships (IMO, 2014).

The reason for this lag is likely due to a paucity of research linking specific sources of sound to animal taxa-specific sound thresholds (Popper et al., 2020). There is, however, an abundance of literature linking various noise sources to a diversity of negative direct and indirect impacts associated with a wide range of taxa (Duarte et al., 2021), although research of such impacts on seabirds is limited. Overall low-frequency noise recorded below the surface in major shipping routes has increased 32-fold over the past 50 years (Malakoff, 2010), doubling every decade (Weilgart, 2017) and transforming the underwater soundscape with added anthropophony to the existing natural biophony and geophony (Pijanowski et al., 2011). In areas such as the Arctic, shipping frequency has changed from an occasional disturbance to a dominant noise source, with the potential to impact behavioural responses of animals using these areas (Aulanier et al., 2017). Most marine species, from invertebrates to marine mammals, invariably use underwater auditory cues for crucial biological functions such as foraging, orientation, communication, predator avoidance, mating and care of their young (Au and Hastings, 2008). Anthropogenic noise can thus greatly impact these animals' vital functions, with impacts ranging from low disturbance to lethal injuries (Chou et al., 2021). Calls for measures to address this threat and establish policies to minimise the impacts of marine noise pollution on marine ecosystems are growing world-wide, including by the governing bodies of several conservation treaties such as the Convention on Biological Diversity (CBD, Decision XII/23, 2014), the Convention on the Conservation of Migratory Species of Wild Animals (CMS, Resolution 12.14, 2012), and several of the latter's ancillary Agreements.

In parallel with increased maritime traffic, the demand for refuelling options along major shipping routes has seen a corresponding increase, to save time by avoiding berthing at port and maximising economic profits from the voyage. Consequently, offshore ship-to-ship (STS) bunkering activities, i.e., the supplying of fuel from one ship to another outside of harbours, are rapidly expanding (Credence Research, 2019). STS bunkering operations involve the use of large tankers (mother ships) which replenish the fuel stores of smaller tankers (daughter vessels) which in turn dispense fuel to sea-going vessels at anchor. In addition to these activities presenting a clear risk of oil pollution (Akyuz et al., 2018), with 7 % of the annual global spills originating from bunkering operations (ITOPF, 2020), they are also expected to induce high levels of underwater noise by concentrating additional (and larger) vessels in a specific area, thereby compounding existing levels of shipping and other sources of noise pollution. There is, however, no study to date that has investigated the potential link between STS bunkering operations and underwater ambient noise levels, with associated impacts on the environment.

Algoa Bay, off Gqeberha (formerly known as Port Elizabeth) in South Africa, is located on a major global maritime route and offers since 2016 the first offshore STS bunkering services in the country. It is the largest bay in South Africa providing shelter to anchored ships. The bay also hosts two major commercial and industrial ports, the original port of Port Elizabeth and the deep-water port of Ngqura, which opened in 2008 and which has since seen rapid development and operational expansion. The location of these ports has facilitated the expansion of the ocean economy in this region under the South African government's 'Operation Phakisa', which aims to unlock the marine space for various initiatives, including oil and gas exploration, aquaculture, tourism, and marine conservation (Holness et al., 2022). The bay is a hotspot of marine biodiversity, with large populations of cetaceans and seals (e.g., Bouveroux et al., 2018) and two groups of islands in Algoa Bay falling within a globally Important Bird and Biodiversity Area (Donald et al., 2019): the St Croix Island group and the Bird Island group. These island groups together support globally important populations of the endangered African Penguin (*Spheniscus demersus*) and Cape Gannet (*Morus capensis)* (BirdLife International, 2020). Both species are endemic to southern Africa and have undergone significant declines in their populations (Sherley et al., 2019, 2020) due to various threats, from competition with fisheries, to degradation of their habitat and global climate change (Crawford et al., 2011). As a Contracting Party to the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA), South Africa has committed to taking various measures to address the threats facing these species (including both marine pollution and disturbance), with the aim of restoring their populations to a favourable conservation status (AEWA, Annex 3). St Croix Island is located within 5–15 km of the port of Ngqura, in close proximity to the anchorage areas where STS bunkering activities take place (Fig. 1). Since the initiation of STS bunkering, four oil spills have occurred (in 2016, 2019, 2021 and 2022), causing oiling of hundreds of seabirds (Ryan et al., 2019; SANCCOB, 2020).

While an on-going scientific experiment is assessing the benefits of purse-seine fishing exclusion for penguins in Algoa Bay (Pichegru et al., 2010; Sherley et al., 2018), no study has investigated the level of underwater ambient noise in their habitat. African penguins are known to be sensitive to noise disturbance (Pichegru et al., 2017) and have recently been shown to use acoustic communication to increase group foraging efficiency (McInnes et al., 2020). Here, we studied the recent trend (2013 − 2020) of maritime traffic in Algoa Bay and associated noise emissions using the maritime very high frequency (VHF) Universal Automatic Identification System (AIS) data. The system was originally designed for Vessel Traffic

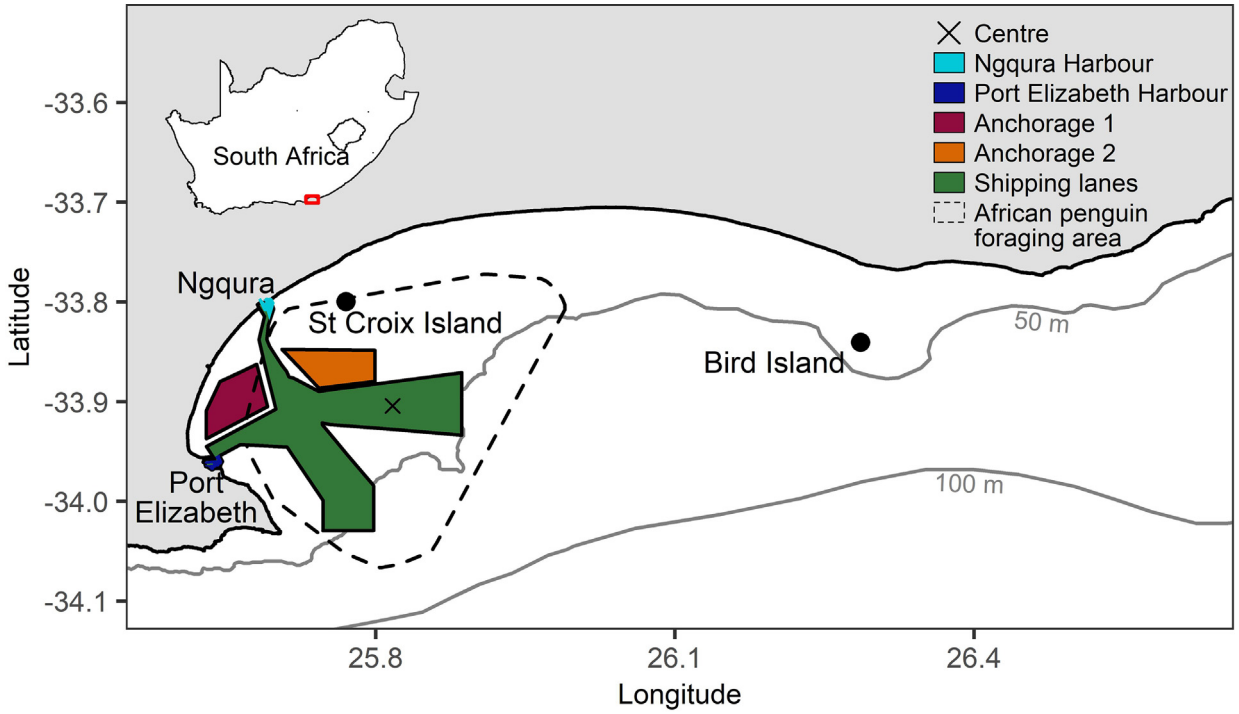


Fig. 1. Map of the study area, showing Ngqura (light blue) and Port Elizabeth (dark blue) harbours, anchorage areas 1 and 2, shipping lanes, as well as the main African penguin foraging area (dotted line) from St Croix Island and its centre (back cross).

Systems (VTS), as a mandatory collision avoidance measure (Robards et al., 2016), but the data are now increasingly used in research for maritime traffic, gas emissions, pollution (oil spills and noise) or interactions with wildlife (Svanberg et al., 2019). From the engine size associated with the different vessel types using data from the literature (Veirs et al., 2016), and the vessel's daily location while transiting in the bay (speed >1 kn.), we estimated the underwater ambient noise levels potentially received by African Penguins in their core foraging area around St Croix Island. We related these noise levels to the penguin population trend on St Croix Island over the same period. We hypothesised that underwater noise levels would intensify after the initiation of STS bunkering operations, with a noticeable negative impact on penguin numbers. This study is the first to explore the impact of maritime traffic noise pollution on a seabird, and the consequence of offshore bunkering activities on underwater noise levels. The outcomes are discussed in the context of South Africa's current legislative framework for ship-to-ship bunkering authorisations.

2. Methods

2.1. Trends in vessel category and zone use in Algoa Bay

AIS information was obtained for vessels transiting within or through Algoa Bay between January 2013 and September 2020 from Clarksons Platou (H. Clarksons & Company Limited). AIS autonomously and hourly transmits messages containing static data (vessel identification data such as name, call sign, IMO number, type, and individual features) and dynamic navigation sensor data (i.e., vessel GPS location, speed over ground, course over ground, heading and rate of turn). As required under SOLAS (the International Convention for the Safety of Life at Sea) since 1 July 2008, all ships ≥300 gross tonnage that undertake international voyages, all cargo ships ≥500 gross tonnage irrespective of travel destination, tankers, and all passenger ships irrespective of size must use AIS. AIS is not required on smaller fishing vessels, recreational boats, inland vessels, warships, and naval auxiliary vessels. Due to the high number of vessel types in the AIS data (N = 105, see Table S1), they were grouped for the purpose of this analysis into five categories: based on a monthly median of ≥5 vessels and a non-zero % change in monthly median vessel numbers during the study period –'Bulk Carrier', 'Container Ship' and 'Chemical and Oil Carriers'; based on ≥400 % increase in monthly median vessels over the study period – 'Tanker'; and, all the other vessel types – 'Other' (Table S1). The maritime areas considered in this study follow the Department of Transport's Transnet jurisdiction, corresponding to the traffic and/or activities herein: the two harbours (Port Elizabeth and Ngqura), anchorage areas 1 and 2 (where STS bunker transfers occur), and shipping lanes used by vessels to enter or leave the harbours (Fig. 1). GPS coordinates of each transiting vessel (with speed over ground >1 kn.) were extracted from the AIS dataset and assigned to one of the five areas. Coordinates were extracted only once a day for each vessel, between 12 pm and 1 pm, corresponding to the African Penguin peak foraging activity (see below, van Eeden et al., 2016).

We used Generalised Additive Models (GAM, Wood, 2000) to assess change over time, at monthly intervals, of the a) number of vessels per type within Algoa Bay (i.e., vessel category) and b) number of vessels present per zone (i.e., vessel zone). GAMs were run separately for vessel category and vessel zone. Due to unprecedented changes to vessel traffic trends in 2020 during the COVID-19 global pandemic, only data until December 2019 were used for these analyses. Specifically, vessel count per month was set as the response variable and date (year-month) with either vessel category or vessel zone included as a categorical variable (using the "by" argument in the gam function in the mgcv R package, Wood, 2017), thus allowing smooths to be generated for each vessel category or zone. Smoothers were fitted to predictors using penalised regression splines with the number of smoothing parameters selected using an Un-Biased Risk Estimator (UBRE). All models were fitted with a Poisson distribution with a log link. Finally, to limit residual autocorrelation, a temporal autoregressive correlation structure of order 1 (CorAR1) was implemented within each model.

To obtain an unbiased estimate of significant change points in the number of vessels in the bay at any given month during the study period, we applied a Bayesian change point analysis (BCPA) using R package bcp (Erdman and Emerson, 2007) following the methods of Wang and Emerson (2015). The BCPA uses the Markov chain Monte Carlo (MCMC)

method to estimate the posterior means of unknown data blocks partitioned in the data series and change points at any given location. We applied the BCPA to a sequential time series of all vessels quantified per month using 500 MCMC samples and discarded the first 50 as burn-in. Change points were selected with posterior probability values >0.5.

2.2. Noise estimates in the African Penguin foraging area

The at-sea distribution of African Penguins rearing chicks on St Croix Island was tracked with GPS loggers as part of a long-term monitoring project (Pichegru et al., 2010, 2012), with relevant ethics clearances (University of Cape Town 2009/V2/LP and Nelson Mandela Metropolitan University NMMU-A15-SCI-ZOO-008) and permit approvals (South African National Parks (PICL578), the South African Department of Forestry, Fishery and the Environment (res2013–05)). Chick-rearing African Penguins were equipped with GPS loggers (earth & OCEAN Technologies™, Germany, or CatTrack™, USA) recording locations every minute at an accuracy of <10 m and weighing <2.5 % of adult body mass (see Pichegru et al., 2010 for details). To estimate the core marine utilisation area for African Penguins breeding on St Croix Island, we used methods developed by BirdLife International (Lascelles et al., 2016; Dias et al., 2018) to identify Marine Important Bird and biodiversity Areas (mIBA). We used complete tracks (n = 46) recorded between 2015 and 2018 and the R package *track2KBA* (Beal et al., 2021) to generate the core marine utilisation areas. The geometric centre of this foraging area was identified using the R package *sf* (Pebesma, 2018).

Due to a lack of referenced conversion factors for noise produced by ships at anchor, underwater noise levels were estimated for transiting vessels only, i.e., for vessels with a speed over ground >1 kn. Estimating noise levels is a challenging and complex task, as vessel noise production depends on intrinsic features (ship shape design, size, engine power, propeller type, etc) and external factors (water depth, wave height, etc) (Abrahamsen, 2012; McKenna et al., 2013; Gaggero et al., 2015). Nevertheless, for containerships for example, the speed as well as the size appear to be the main variables in modelling the resulting noise emitted (Abrahamsen, 2012). We thus estimated noise levels on main vessel types (Table 1) based on reference values (i.e., mean broadband sound pressure levels between 20 and 40,000 Hz) from the literature (Veirs et al., 2016), as the range of speed values of vessels transiting in Algoa Bay approximated the range of values used in this study (Table 1).

While noise is produced throughout the day by vessels transiting the bay, hourly variation was negligible (data not shown). We focused our analyses on the traffic occurring between 12 pm and 1 pm daily, which corresponds to the peak of penguin foraging activity (van Eeden et al., 2016).

Table 1
Sample size and speed values (mean ± SD, in knot) from AIS data for vessels transiting (speed >1 kn) in Algoa Bay between 2013 and 2020, in comparison with speed values considered in Veirs et al. (2016), as well as mean Source Level (SL) values (dB re 1 μPa @ 1 m) emitted by various passing vessel types described in Veirs et al. (2016) and used in the estimate of underwater noise levels in Algoa Bay.

Vessel category	N	Speed (kn)	Speed (kn)	Mean SL
	Algoa Bay	Algoa Bay	(Veirs et al., 2016)	(Veirs et al., 2016)
Bulk carrier	82,788	9.96 ± 3.19	13.7 ± 1.5	173
Containership	46,185	9.73 ± 5.47	19.2 ± 1.9	178
Tug	1629	5.81 ± 3.72	8.2 ± 2.3	170
Cargo	9256	10.80 ± 4.12	14.4 ± 2.3	175
Vehicle carrier	8804	10.10 ± 5.53	16.9 ± 1.8	176
Tanker	25,793	7.03 ± 4.49	13.8 ± 1.4	174
Military vessel	142	10.10 ± 3.62	11.1 ± 3.1	161
Fishing vessel	8734	6.65 ± 3.03	9.1 ± 2.2	164
Passenger vessel	833	12.1 ± 4.41	14.4 ± 4.	166
Others	6969	7.62 ± 3.96	11.2 ± 5.8	163
Leisure craft	70	9.25 ± 3.39	12.4 ± 4.9	159
Research boat	498	7.32 ± 3.48	11.1 ± 1.8	167

Therefore, each vessel present in the study area was considered only once daily in the following analyses.

Considering only vessels transiting (speed >1 kn) between 12 pm and 1 pm, we then calculated (1) the noise received by penguins in the centre of their mIBA from each ship daily, (2) the cumulative underwater noise level from all vessel traffic (with AIS) daily, and (3) the average daily noise level received per month, following the equations below:

(1) The received sound level (RL, dB re 1 μPa), i.e., the level of noise received at the centre of the penguin foraging area as emitted by each vessel, was calculated daily as per Eq. (1):

$$RL = SL - TL \quad (1)$$

where SL = mean broadband (20–40,000 Hz) Source Level, i.e. the level of noise at 1 m produced by the vessel depending on its type, as described from the literature (Veirs et al., 2016) (Table 1); and TL = Transmission Loss, i.e., the reduction in noise level with distance (in m), estimated based on the distance of the vessel to the centre of the mIBA following Eq. (2), taking into account the shallow bathymetry of the study area (<50 m) and considering the seafloor characteristics of our study area which is relatively uniform (Schoeman et al., 2022):

$$TL = 10 * log_{10}(dist) \quad (2)$$

(2) The daily Received sound Level (RL_{day}) was then calculated as the cumulative noise level received at the centre of the mIBA from all vessels between 12 pm and 1 pm on each day (Eq. (3)), where n is the number of vessels:

$$RLday = 10 * log_{10}\left(\sum_{i=1}^{n} 10^{\frac{RL}{10}}\right) \quad (3)$$

(3) and the monthly averaged daily Received sound Level (RL_{month}) was calculated following (Eq. (4)), where n is the number of days in the month.

$$RLmonth = 10 * log_{10}\left(\sum_{i=1}^{n} \frac{10^{\frac{RLday}{10}}}{n}\right) \quad (4)$$

2.3. African Penguin population trend and underwater noise levels

We assessed the relationship between annual vessel-derived noise estimates and the annual counts of African Penguin breeding pairs using standard linear regression. Annual vessel-derived noise estimates were averaged across the 12 months of data using the Eq. (4) (replacing RLday for RLmonth and n = 12 months). Penguin counts were extracted from the annual count conducted by the Department of Forestry, Fishery and the Environment (DFFE) following a standard method (see Sherley et al., 2020 for details). All data analyses were performed in the R statistical environment (R version 3.6.1; R Core Team, 2019).

3. Results

3.1. Trends in vessel category and zone use in Algoa Bay

Vessel traffic in Algoa Bay more than doubled between 2013 and 2019, from 96 vessels on average per month in early 2013 to 245 vessels per month in 2019, with two significant change points identified in April

2016 and in March 2019 (Fig. 2, Table S2). This trend was strongly influenced by vessel category (Fig. 2a) and zone use (Fig. 2b), with the majority of explanatory smooth terms (Vessel Category: all terms except s(nYM): Chemical and Oil Carrier; Zone: all terms except s(nYM)) in the GAM outputs fitting well to the data and being highly significant ($P < 0.001$, Table S2).

Bulk carriers were the vessel types that increased the most during our study period, with a ten-fold increase from 13 vessels per month in January 2013 to 134 in December 2019 (Fig. 2a). This increase was largely driven by two periods of significant changes in vessel numbers, around the two significant change points: from 22 ± 6 vessels (median ± Inter Quartile Range, IQR) before April 2016, to 81 ± 16 and 96 ± 18 vessels after change points 1 and 2 respectively (Fig. 2a). The average number of container ships in the bay remained fairly constant over time, averaging close to 50 ships per month, but Chemical and Oil Carriers, as well as Tankers, increased by 200 to 400 % during our study period (from 1 to 3 to 11–21 per month, Table S1). All other vessel types remained in low numbers (1–4), with little change over time (Table S1).

Most of the increases in vessel traffic occurred in the shipping lanes and in anchorage area 1 (Fig. 2b, Fig. S1). Vessels in shipping lanes increased from 108 ± 16 vessels before April 2016 to 184 ± 18 and 214 ± 16 vessels after change points 1 and 2 respectively. Vessels in anchorage area 1 increased from 22 ± 6 vessels before April 2016 to 84 ± 22 and 115 ± 25 vessels after change points 1 and 2 respectively (Fig. 2b). The use of anchorage area 2 also increased sharply after 2016, but not after March 2019, while the vessel traffic in Ngqura harbour increased relatively slowly and constantly during the study period. By contrast, the use of Port Elizabeth harbour varied more over time but remained relatively constant when compared to vessel trends in the anchorage areas and shipping lanes (Fig. 2b).

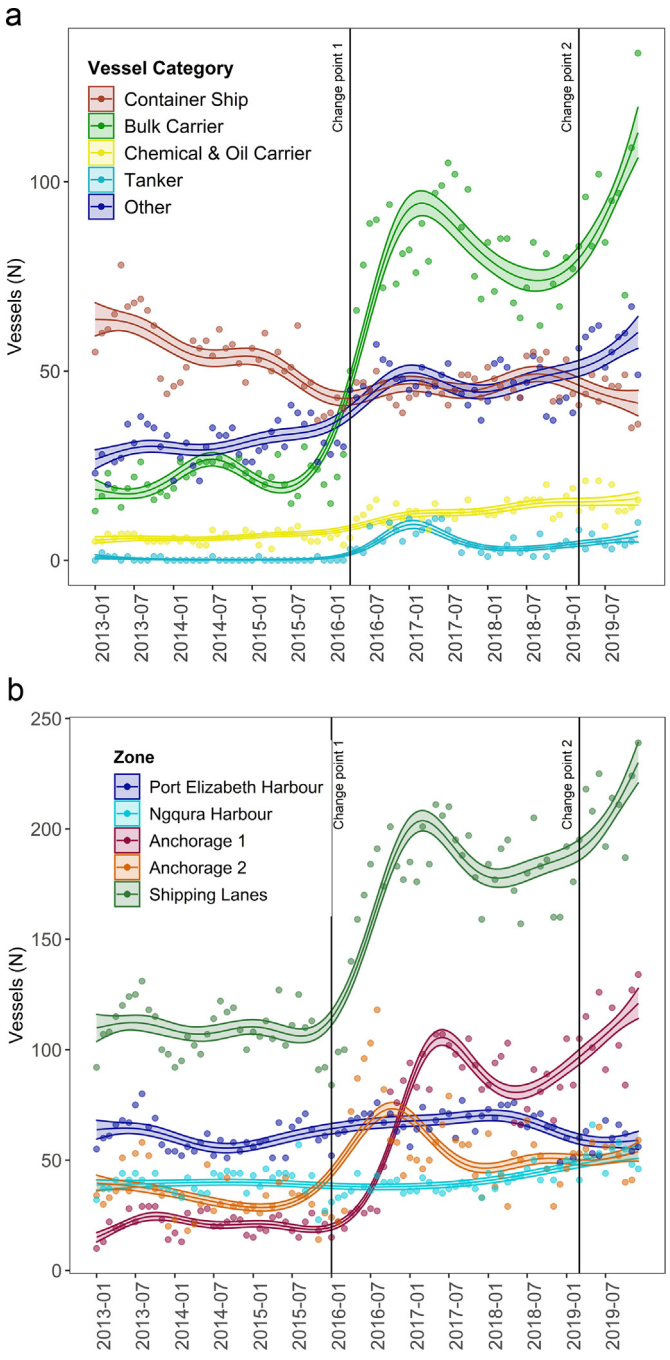


Fig. 2. Trend (smooths from generalized additive mixed models and SE) in monthly number of vessels in Algoa Bay per type (a) and area of use (b) between January 2013 and December 2019. The two black vertical lines show the significant change points from the Bayesian change point analysis (BCPA).

3.2. Noise estimates in the African Penguin foraging area

The annual mean ambient underwater noise level estimates received at the centre of the penguin foraging area have been constantly high since 2013. Noise estimates increased from <140 dB re 1 μPa in 2013 to >142 dB re 1 μPa from 2016 onward (Fig. 3, Table S3), which corresponds to double the noise intensity from before to after 2016.

Importantly, the variability within years of noise levels decreased since 2016. Prior to 2016, monthly variations were apparent throughout the year with monthly noise levels ranging from 137 to 143 dB re 1 μPa during this period. Highest noise levels estimated occurred in the summer months (Fig. 3, Table S3). From 2017 onwards, this variability decreased (<2 dB re 1 μPa between months; Table S3), with received noise levels being higher and more constant throughout the year (between 141 and 143 dB, Fig. 3).

In 2020, due to the national lockdown implemented during the global pandemic, underwater noise levels dropped drastically from >140 dB re 1 μPa to ca. 133 dB re 1 μPa in just a few weeks (Fig. 3).

3.3. African Penguin population trend

There was a strong negative relationship ($R^2 = 0.83$, linear regression model estimates: $t = -4.9$, $P = 0.005$) between the annual number of

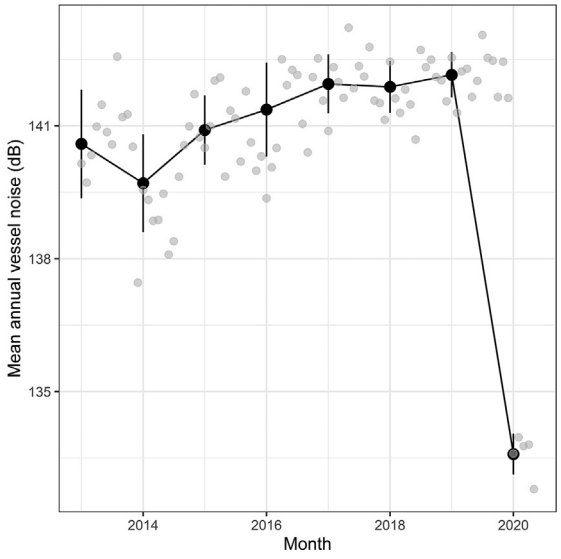


Fig. 3. Mean (± SD) annual underwater vessel noise levels (in dB re 1 μPa) received between 2013 and 2020 at the centre of the St Croix Island African penguin foraging area. Monthly averages are also shown (grey dots).

African Penguin breeding pairs on St Croix Island and annual estimates of vessel-derived noise received levels at the centre of the penguins' foraging area in Algoa Bay during the study period (Fig. 4). Increase in annual estimates of vessel noise corresponded to a significant average decrease of 976 ± 285 (mean ± SE) penguin pairs per year during our study period (Fig. 4). It is worth noting from Fig. 4 that the lowest recorded numbers of penguins' breeding pairs correspond to the period after the initiation of STS bunkering in 2016 (2016–2019).

4. Discussion

The impacts of vessel-derived noise pollution on ecosystems are difficult to estimate, partly because of a limited knowledge of taxa specific sound thresholds, and partly because spatial data for global maritime traffic has, until recently, remained sparse. AIS data has only been generalized to vessels for just over a decade, and its use to understand the impacts of maritime vessel activities on marine biota and ecosystems is in its infancy (Robards et al., 2016). These data are, however, essential to monitor changes following for example the expansion of maritime activities such as offshore STS bunkering, which has been forecast to become one of the most rapidly expanding maritime industries in the near future (Credence Research, 2019).

In this study, we observed a rapid 10-fold increase in the number of bulk carriers and a significant increase in vessel activity in shipping lanes and anchorage areas, both linked to significant temporal change points, which corresponded to first the initiation of STS bunkering in 2016 and the subsequent expansion of its operations in early 2019, with the operationalisation of the third STS bunkering company. Changes in areas used overtime also reflect STS activity patterns as STS bunkering operations were first established in anchorage area 2 in April 2016, as shown by the rapid increase in vessel use of the area after 2016, but were subsequently transferred to anchorage area 1 in early 2017 after the first oil spill that occurred in August 2016 (Fig. 2b). Noise levels emitted by maritime traffic in the bay consequently rose and the estimated average received underwater noise levels at the centre of the core utilisation area of African Penguins breeding on St Croix Island steadily increased from <140 dB to a plateau at around 142 dB re 1 μ Pa (broadband source level estimation) since 2017, placing Algoa Bay among the noisiest bays in the world (Duarte et al., 2021). For example, the bays with the busiest maritime traffic in Brazil had noise levels reaching up to 110 dB re 1 μPa for the 200–700 Hz frequency band (Bittencourt et al., 2014). At various sites in United Kingdom waters, median noise levels were measured between 81.5 and 95.5 dB re 1μPa for one-third octave bands from 63 to 500 Hz (Merchant et al., 2016). Broadband received levels (11.5–40.000 Hz) near the shoreline in Haro Strait (United States of America), a transiting area for the shipping port of Vancouver, were 110 ± 7 dB re 1 μPa on average (Veirs et al., 2016), while chronic anthropogenic noise in Saguenay–St. Lawrence Marine Park, Canada, reached 112.6 dB re 1μPa (broadband noise, 0.01–23.3 kHz) (Gervaise et al., 2012).

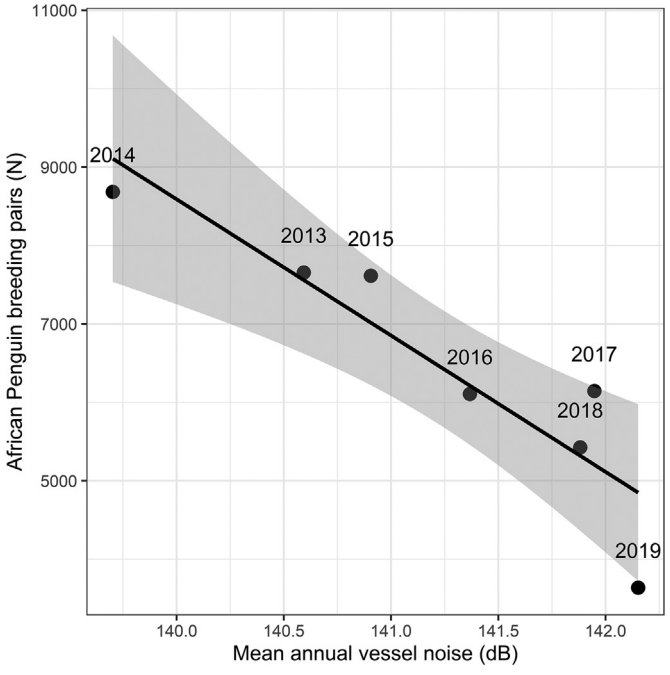


Fig. 4. Linear regression (and 95 % confidence interval) between the mean annual underwater vessel noise levels (in dB re 1 μPa) received at the centre of the St Croix Island African penguin foraging area and corresponding annual breeding pairs of African penguins recorded on St Croix Island between 2013 and 2019.

Estimation of vessel traffic noise is complex and depends on but is not limited to, vessel size, speed and frequency (Abrahamsen, 2012; Gaggero et al., 2015). Speed can vary during the course of the day or between usage zones (e.g., anchorage areas versus shipping lanes), which we did not take into account in the present study, as we only considered average values (Table 1). We also did not consider the cumulative impact of biophony, from wind for example (Schoeman et al., 2022), on overall ambient underwater noise levels. However, a recent assessment of the soundscape of Algoa Bay in 2015 using in-situ hydrophones revealed the significant contribution of maritime traffic, especially of large vessels in shipping lanes (Schoeman et al., 2022). The authors predicted an increase of this contribution in the near future due to the planned development of the national ocean economy (Schoeman et al., 2022). Our results, focusing on the relative change over time of estimated noise levels from maritime traffic, validate the authors' concerns.

It is important to note that, while AIS data is mandatory for vessels larger than 65 ft., it is not required for fishing or recreational vessels, vessels <300 t Gross Tonnage, tankers and passenger vessels <150 t Gross Tonnage (NMEA, 2010). Recreational vessels are known to be responsible for a substantial proportion of ambient underwater noise, especially in shallow coastal waters (Hermannsen et al., 2019). For example, in a study conducted in Denmark, recreational vessels (i.e., non-AIS vessels) caused more noise than AIS-vessels as they are predominant in Danish shallow coastal waters, and these motorised vessels can elevate third-octave band noise centred at 0.125, 2 and 16 kHz by 47–51 dB (Hermannsen et al., 2019). Similarly, a study conducted in the Wilmington, North Carolina Intracoastal Waterway, showed that the recreational boat traffic in this area produced mean underwater noise received levels ranging from 109 to ~118 dB re 1 μ Pa within a day (Haviland-Howell et al., 2007). Underwater noise levels in Algoa Bay are thus very likely to be significantly higher if recorded from acoustic stations (e.g., Merchant et al., 2014; Schoeman et al., 2022) compared to the present estimates using sound proxies, only for vessels that are legally required to have AIS. In addition, our estimation only considered transiting vessels and not vessels at anchor or undergoing STS bunkering operations. Anchored vessels can be an important source of noise (Abrahamsen, 2012; Baltzer et al., 2020), depending on the type of vessels, with anchor vibrations potentially affecting marine mammals or fish up to 700 m away from the vessels (Baltzer et al., 2020). No published data exist on noise emissions during STS bunkering operations, and this information is crucial for a full picture of the potential underwater noise pollution derived from this activity, not only from the attraction of maritime traffic but also from the activity itself.

Importantly, the increase of ca 3 dB in noise level estimates measured during our study period corresponds to a doubling of the noise intensity in seven years. This is among the fastest increase in sound (0.38 dB p.a.) measured to date from the literature, due to maritime traffic. For example, Ross (1993) estimated an increase of 0.55 dB per year between 1950 and 1975 in the East Pacific, East and West Atlantic oceans, while other studies using different methods showed increased ambient noise levels in the past decades of 0.3. dB per year off the Californian coast (Andrew et al., 2002) or 2.5–3.0 dB per decade in the Northern Pacific

Ocean (McDonald et al., 2006). Such rapid doubling of noise intensity in an area is likely to significantly affect resident wildlife.

High levels of underwater noise levels can directly affect individual animals by decreasing their foraging success, impacting their sensory abilities (e.g. hearing, orientation) and inducing higher stress levels (see Kight and Swaddle, 2011 for a review; Committee on the Assessment of the Cumulative Effects of Anthropogenic Stressors on Marine Mammals, 2017; Putland et al., 2019), thereby directly influencing adult survival. While little is known on the hearing range of African Penguins (e.g., Wever et al., 1969), Gentoo Penguins (*Pygoscelis papua*) have demonstrated a strong directional avoidance reaction to underwater noise at received levels between 110 and 120 dB re 1μPa RMS, while no behavioural response was observed with received levels at 100 dB re 1 μPa RMS (Sørensen et al., 2020). Similar behavioural avoidance responses were noted for the common murre (*Uria aalge*), with received noise levels varying from 110 to 137 dB re 1 μ Pa RMS (Hansen et al., 2020). It is thus highly likely that constant anthropogenic noise levels averaging 142 dB re 1 μPa around St Croix Island have directly affected penguins. African Penguins are known to be sensitive to underwater noise levels and avoid areas closer to seismic survey activities (Pichegru et al., 2017). In addition, recent findings revealed the importance of acoustic communication in group foraging in African Penguins (McInnes et al., 2020). Thus, increased ambient underwater noise levels could exacerbate inferred Allee Effects currently impacting the foraging performance of this species (Ryan et al., 2012), and contribute to the cumulative threats that impact African Penguins and their prey availability, such as competition with fisheries and climate change (Pichegru et al., 2010; Sherley et al., 2018; IPCC, 2022). Indeed, during the short period of our study, a population which at the onset of the study was the world's largest remaining African Penguin colony (*ca* 8500 breeding pairs, Sherley et al., 2020), located within 5–15 km of the most intense maritime traffic activities in the bay, more than halved which significantly correlated with the concurrent underwater noise levels in the bay associated with maritime traffic. High mortality of adult penguins was also observed during monthly beach surveys conducted in the bay during the study period (Pichegru et al., 2020, unpubl. report). As far as we are aware this is the greatest short-term decrease of an African Penguin colony on record. As of 2022, this population has now decreased by 85 % (*ca* 1200 pairs; Pichegru, unpubl data).

Increases in maritime traffic in Algoa Bay, and subsequent noise levels emitted, are correlated with the establishment and expansion of STS bunkering operations in the bay, with an average of 82 vessels being bunkered every month in Algoa Bay between April 2016 and January 2019 (Fig. S1). STS bunkering mainly attracts bulk carriers (Fig. 2), which are among the noisiest vessels in transit (Table 1, Veirs et al., 2016). It is therefore clear that this activity is a major contributor to the altered anthropophony of the bay. In addition to globally significant seabird populations, Algoa Bay is home to high population densities of dolphins and whales (Reisinger and Karczmarski, 2009; Bouveroux et al., 2018; Melly et al., 2018) and Cape fur seals (*Arctocephalus pusillus pusillus*), which are all sensitive to underwater noise levels (Duarte et al., 2021). The impact of STS bunkering activities in terms of noise pollution should, therefore, be assessed before authorisation is granted to operate. Indeed, South Africa is a Contracting Party to the Convention on Biological Diversity (CBD), and as such has been encouraged to, inter alia, conduct impact assessments for activities that may have significant adverse impacts on noise-sensitive species, combine acoustic mapping with habitat mapping to identify areas where these species may be exposed to noise impacts, mitigate underwater noise through the spatio-temporal management of activities, and consider thresholds as a tool to protect noise-sensitive species (CBD Decision XII/23). Similarly, Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS) have also been urged to undertake 'relevant environmental assessments on the introduction of activities that may lead to noise-associated risks for CMS-listed marine species and their prey', to prevent adverse effects on these species and their prey by restricting the emission of underwater noise, and – where noise cannot be avoided – 'to develop an appropriate regulatory framework or implement relevant measures to ensure a reduction or mitigation of anthropogenic marine noise'. The necessity for a precautionary approach has been emphasised in this context (CMS Resolution 12.14). As a Contracting Party to these and other relevant environmental treaties (such as AEWA), South Africa should clearly be taking measures to assess and address the impacts of anthropogenic underwater noise on African Penguins and other species – whether through project-level impact assessments or broader planning processes, and taking into account the precautionary principle. This includes the underwater noise induced by STS bunkering through associated increases in vessel traffic. The current working plan for the AEWA Benguela Coastal Seabirds International Working Group highlights concerns regarding the potential impacts of ship-to-ship bunkering and associated vessel traffic and recognises the need for these impacts to be properly assessed and for noise pollution to be reduced (AEWA Benguela Coastal Seabirds International Working Group 2021, https://www.unep-aewa.org/sites/default/files/document/benguela_iwg_report_workplan_final_2021.pdf).

However, to date, Ship-to-Ship bunkering is not listed as an activity requiring environmental authorisation in terms of South Africa's National Environmental Management Act 107 of 1998. As such, the 2014 Environmental Impact Assessment (EIA) Regulations are not applicable. STS bunkering operations require permission from the South African Maritime Safety Authority (SAMSA) in terms of the Marine Pollution (Control and Civil Liability) Act 6 of 1981 and a licence from the Transnet National Port Authority (TNPA) in terms of the 2009 Port Rules. Neither of these instruments provides a comprehensive framework (comparable to the EIA Regulations) for assessing the full range of direct, indirect, and cumulative impacts associated with STS bunkering. A Bunkering Code of Practice is currently being developed with a view to improving the management of STS bunkering in South Africa. However, it remains to be seen how effectively this will address gaps in the existing regulatory framework.

This local context contrasts sharply with the international efforts that are currently underway to explore avenues to decrease commercial ships' noise emissions, including the development of standard measurement protocols by the International Organization for Standardization (ISO, 2016, 2019). The IMO's Marine Environment Protection Committee also approved guidelines on reducing underwater noise from commercial shipping in 2014, which are currently being reviewed (IMO, 2021). Noise reduction measures may include reducing the speed of vessels underway or limiting time periods of ships' activities, including bunkering, in biologically important areas (e.g., Veirs et al., 2018; Williams et al., 2019). The use of quieting technologies (Simmonds et al., 2014), like new propeller designs ("Battling noise pollution, underwater | Hellenic Shipping News Worldwide," 2019) or four-strokes engines rather than two-strokes (Chahouri et al., 2022 and references therein), would also rapidly decrease noise levels emitted. International and trans-disciplinary and trans-institutional collaborations are required to effectively implement the necessary noise level reduction measures (Southall et al., 2017). Marine Protected Areas with spatial and temporal exclusions of noise emitting sources probably remain the most efficient way to protect marine life from the negative impacts of underwater sound (e.g., Simmonds et al., 2014).

5. Conclusion

The intensification of underwater noise levels in the African Penguin's foraging habitat was linked to the initiation and expansion of ship-to-ship bunkering activities which intensified the maritime traffic in the area. Noise levels were significantly related to the collapse of what had been the world's largest remaining colony of endangered African Penguins. The underwater soundscape of Algoa Bay, a hotspot of biodiversity, has now been profoundly modified. The situation is likely to worsen in the near future as global maritime traffic is predicted to increase by 240–1209 % by 2050 (Sardain et al., 2019) due to anticipated increased demands for goods associated with a projected increase in the global human population compounded by a general push for expansion of the Blue Economy in many

countries. Unless mitigated against, underwater ambient noise levels will also increase and these will be exacerbated in regions where vessels congregate, such as in ports and sheltered bays that provide maritime and refuelling services, with likely ecosystem-wide impacts.

CRediT authorship contribution statement

Lorien Pichegru: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft. **Laëtitia Vibert:** Data curation, Formal analysis, Writing – original draft. **Andréa Thiebault:** Formal analysis, Methodology, Writing – review & editing. **Isabelle Charrier:** Methodology, Writing – review & editing. **Nicky Stander:** Writing – review & editing. **Katta Ludynia:** Writing – review & editing. **Melissa Lewis:** Writing – review & editing. **Tegan Carpenter-Kling:** Formal analysis, Methodology, Writing – review & editing. **Alistair McInnes:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to thank Clarksons Platou (H. Clarksons & Company Limited) for providing the AIS data, the South African Maritime Safety Authority (SAMSA) for providing information on bunkering activities in Algoa Bay, and the Department of Forestry, Fishery and the Environment for penguin counts. We thank Dr. E. Vermeulen for the shapefiles of the harbours as well as for earlier comments on this study. We also thank Dr. R.P. Schoeman for constructive discussions on the earlier phase of this research. SANCCOB is supported by a wide range of donors.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2022.157878.

References

Abrahamsen, K., 2012. The ship as an underwater noise source. Presented at the ECUA 2012 11th European Conference on Underwater Acoustics, Edinburgh, Scotland, p. 070058. https://doi.org/10.1121/1.4772953.

Akyuz, E., Celik, M., Akgun, I., Cicek, K., 2018. Prediction of human error probabilities in a critical marine engineering operation on-board chemical tanker ship: the case of ship bunkering. Saf. Sci. 110, 102–109. https://doi.org/10.1016/j.ssci.2018.08.002.

Andrew, R.K., Howe, B.M., Mercer, J.A., Dzieciuch, M.A., 2002. Ocean ambient sound: comparing the 1960s with the 1990s for a receiver off the California coast. Acoust. Res. Lett. Online 3, 65–70. https://doi.org/10.1121/1.1461915.

Au, W.L.W., Hastings, M.C., 2008. Hearing in marine animals. In: Au, W.W.L., Hastings, M.C. (Eds.), Principles of Marine Bioacoustics, Modern Acoustics and Signal Processing. Springer US, New York, NY, pp. 337–400. https://doi.org/10.1007/978-0-387-78365-9_9.

Aulanier, F., Simard, Y., Roy, N., Gervaise, C., Bandet, M., 2017. Effects of shipping on marine acoustic habitats in Canadian Arctic estimated via probabilistic modeling and mapping. Mar. Pollut. Bull. 125, 115–131. https://doi.org/10.1016/j.marpolbul.2017.08.002.

Baltzer, J., Maurer, N., Schaffeld, T., Ruser, A., Schnitzler, J.G., Siebert, U., 2020. Effect ranges of underwater noise from anchor vibration operations in the Wadden Sea. J. Sea Res. 162, 101912. https://doi.org/10.1016/j.seares.2020.101912.

Battling noise pollution, 2019. Underwater | Hellenic shipping news worldwide [WWW document]. Hell. Shipp. News URL. https://www.hellenicshippingnews.com/battling-noise-pollution-underwater/. (Accessed 8 January 2022).

Beal, M., Oppel, S., Handley, J., Pearmain, E.J., Morera-Pujol, V., Carneiro, A.P.B., Davies, T.E., Phillips, R.A., Taylor, P.R., Miller, M.G.R., Franco, A.M.A., Catry, I., Patrício, A.R., Regalla, A., Staniland, I., Boyd, C., Catry, P., Dias, M.P., 2021. track2KBA: an R package for identifying important sites for biodiversity from tracking data. Methods Ecol. Evol. 12, 2372–2378. https://doi.org/10.1111/2041-210X.13713.

BirdLife International, 2020. The IUCN Red List of Threatened Species 2020.

Bittencourt, L., Carvalho, R.R., Lailson-Brito, J., Azevedo, A.F., 2014. Underwater noise pollution in a coastal tropical environment. Mar. Pollut. Bull. 83, 331–336. https://doi.org/10.1016/j.marpolbul.2014.04.026.

Bouveroux, T., Caputo, M., Froneman, P.W., 2018. Largest reported groups for the indo-Pacific bottlenose dolphin (Tursiops aduncus) found in Algoa Bay, South Africa: trends and potential drivers. Mar. Mammal Sci. 34. https://doi.org/10.1111/mms.12471.

Camphuysen, C., 2010. Declines in oil-rates of stranded birds in the North Sea highlight spatial patterns in reductions of chronic oil pollution. Mar. Pollut. Bull. 60, 1299–1306. https://doi.org/10.1016/j.marpolbul.2010.03.012.

Chahouri, A., Elouahmani, N., Ouchene, H., 2022. Recent progress in marine noise pollution: a thorough review. Chemosphere 291. https://doi.org/10.1016/j.chemosphere.2021.132983.

Chilvers, B.L., Morgan, K.J., White, B.J., 2021. Sources and reporting of oil spills and impacts on wildlife 1970–2018. Environ. Sci. Pollut. Res. 28, 754–762. https://doi.org/10.1007/s11356-020-10538-0.

Chou, E., Southall, B., Robards, M., Rosenbaum, H., 2021. International policy, recommendations, actions and mitigation efforts of anthropogenic underwater noise. Ocean Coast. Manag. 202, 105427. https://doi.org/10.1016/j.ocecoaman.2020.105427.

Committee on the Assessment of the Cumulative Effects of Anthropogenic Stressors on Marine Mammals, 2017. Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. The National Academies Press, Washington, DC. https://doi.org/10.17226/23479.

Convention on Biological Diversity, 2014. Decision XII/23.

Convention on Migratory Species, 2012. Resolution 12.14.

Crawford, R., Altwegg, R., Barham, B., Barham, P., Durant, J., Dyer, B., Geldenhuys, D., Makhado, A., Pichegru, L., Ryan, P., Underhill, L., Upfold, L., Visagie, J., Waller, L., Whittington, P., 2011. Collapse of South Africa's penguins in the early 21st century. Afr. J. Mar. Sci. 33, 139–156. https://doi.org/10.2989/1814232X.2011.572377.

Credence Research, 2019. Bunkering Services Market By Fuel Grade (MDO, MFO, IFO, MGO and HFO), Vessel Type (Tankers, Containers, Bulk Carriers, Fishing Vessels And Others) - Growth, Share, Opportunities & Competitive Analysis, 2018 – 2026.

Dias, M.P., Carneiro, A.P.B., Warwick-Evans, V., Harris, C., Lorenz, K., Lascelles, B., Clewlow, H.L., Dunn, M.J., Hinke, J.T., Kim, J.-H., Kokubun, N., Manco, F., Ratcliffe, N., Santos, M., Takahashi, A., Trivelpiece, W., Trathan, P.N., 2018. Identification of marine Important Bird and Biodiversity Areas for penguins around the South Shetland Islands and South Orkney Islands. Ecol. Evol. https://doi.org/10.1002/ece3.4519.

Donald, P.F., Fishpool, L.D.C., Ajagbe, A., Bennun, L.A., Bunting, G., Burfield, I.J., Butchart, S.H.M., Capellan, S., Crosby, M.J., Dias, M.P., Diaz, D., Evans, M.I., Grimmett, R., Heath, M., Jones, V.R., Lascelles, B.G., Merriman, J.C., O'brien, M., Ramírez, I., Waliczky, Z., Wege, D.C., 2019. Important Bird and Biodiversity Areas (IBAs): the development and characteristics of a global inventory of key sites for biodiversity. Bird Conserv. Int. 29, 177–198. https://doi.org/10.1017/S0959270918000102.

Duarte, C.M., Chapuis, L., Collin, S.P., Costa, D.P., Devassy, R.P., Eguiluz, V.M., Erbe, C., Gordon, T.A.C., Halpern, B.S., Harding, H.R., Havlik, M.N., Meekan, M., Merchant, N.D., Miksis-Olds, J.L., Parsons, M., Predragovic, M., Radford, A.N., Radford, C.A., Simpson, S.D., Slabbekoorn, H., Staaterman, E., Opzeeland, I.C.V., Winderen, J., Zhang, X., Juanes, F., 2021. The soundscape of the Anthropocene Ocean. Science https://doi.org/10.1126/science.aba4658.

van Eeden, R.B., Reid, T., Ryan, P.G., Pichegru, L., 2016. Fine-scale foraging cues for african penguins in a highly variable marine environment. Mar. Ecol. Progr. Ser. 543, 257–271. https://doi.org/10.3354/meps11557.

Erdman, C., Emerson, J.W., 2007. bcp: An R package for performing a Bayesian analysis of change point problems. J. Stat. Softw. 23, 1–13. https://doi.org/10.18637/jss.v023.i03.

Gaggero, T., Karaselo, I., Otsberg, M., Folegot, T., Six, L., van der Schaar, M., Andre, M., Rizzuto, E., 2015. Validation of a simulation tool for ship traffic noise. OCEANS 2015 - Genova, 2015, pp. 1–7. https://doi.org/10.1109/OCEANS-Genova.2015.7271489.

Gervaise, C., Simard, Y., Roy, N., Kinda, B., Ménard, N., 2012. Shipping noise in whale habitat: characteristics, sources, budget, and impact on belugas in Saguenay–St. Lawrence Marine Park hub. J. Acoust. Soc. Am. 132, 76–89. https://doi.org/10.1121/1.4728190.

Hansen, K.A., Hernandez, A., Mooney, T.A., Rasmussen, M.H., Sørensen, K., Wahlberg, M., 2020. The common murre (Uria aalge), an auk seabird, reacts to underwater sound. J. Acoust. Soc. Am. 147, 4069–4074. https://doi.org/10.1121/10.0001400.

Haviland-Howell, G., Frankel, A., Powell, C., Bocconcelli, A., Herman, R., Sayigh, L., 2007. Recreational boating traffic: a chronic source of anthropogenic noise in the Wilmington, North Carolina intracoastal waterway. J. Acoust. Soc. Am. 122, 151–160. https://doi.org/10.1121/1.2717766.

Hermannsen, L., Mikkelsen, L., Tougaard, J., Beedholm, K., Johnson, M., Madsen, P.T., 2019. Recreational vessels without automatic identification system (AIS) dominate anthropogenic noise contributions to a shallow water soundscape. Sci. Rep. 9, 15477. https://doi.org/10.1038/s41598-019-51222-9.

Holness, S.D., Harris, L.R., Chalmers, R., De Vos, D., Goodall, V., Truter, H., Lombard, A.T., 2022. Using systematic conservation planning to align priority areas for biodiversity and nature-based activities in marine spatial planning: a real-world application in contested marine space. Biol. Conserv. 271, 109574.

IMO, 2014. Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life [WWW document]. URL https://www.ascobans.org/sites/default/files/document/AC21_Inf_3.2.1_IMO_NoiseGuidelines.pdf. (Accessed 8 January 2022).

IMO, 2021. Ship noise [WWW document]. URL https://www.imo.org/en/MediaCentre/HotTopics/Pages/Noise.aspx. (Accessed 29 April 2022).

IPCC, 2022. Climate Change 2022: Impacts, Adaptation, and Vulnerability. In: Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., Rama, B. (Eds.), Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press.

ISO, 2016. ISO 17208-1:2016 [WWW document]. ISO URL. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/06/24/62408.html.

ISO, 2019. ISO 17208-2:2019 [WWW document]. ISO URL. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/06/24/62409.html. (Accessed 1 April 2022).
ITOPF, 2020. Oil Tanker Spill Statistics 2020.
Ji, X., You, X., Xiao, F., 2021. Research on the risk joint prevention and control mechanism for alien biological invasion in ships ballast water in China. In: Xing, Y. (Ed.), Fifth International Conference on Traffic Engineering and Transportation System (ICTETS 2021). Presented at the 5th International Conference on Traffic Engineering and Transportation System (ICTETS 2021). SPIE, Chongqing, China, p. 171. https://doi.org/10.1117/12.2619931.
Kight, C., Swaddle, J., 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. Ecol. Lett., 1052–1061. https://onlinelibrary.wiley.com/doi/10.1111/j.1461-0248.2011.01664.x.
Lascelles, B.G., et al., 2016. Applying global criteria to tracking data to define important areas for marine conservation. Biodivers. Res. https://doi.org/10.1111/ddi.12411.
Lindstad, H.E., Rehn, C.F., Eskeland, G.S., 2017. Sulphur abatement globally in maritime shipping. Transp. Res. Part Transp. Environ. 57, 303–313. https://doi.org/10.1016/j.trd.2017.09.028.
Malakoff, D., 2010. A push for quieter ships. Science 328, 1502–1503. https://doi.org/10.1126/science.328.5985.1502.
McDonald, M.A., Hildebrand, J.A., Wiggins, S.M., 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. J. Acoust. Soc. Am. 120, 711–718. https://doi.org/10.1121/1.2216565.
McInnes, A.M., Thiebault, A., Cloete, T., Pichegru, L., Aubin, T., McGeorge, C., Pistorius, P.A., 2020. Social context and prey composition are associated with calling behaviour in a diving seabird. Ibis 162, 1047–1059. https://doi.org/10.1111/ibi.12806.
McKenna, M.F., Wiggins, S.M., Hildebrand, J.A., 2013. Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. Sci. Rep. 3, 1760. https://doi.org/10.1038/srep01760.
Melly, B.L., McGregor, G., Hofmeyr, G.J.G., Plön, S., 2018. Spatio-temporal distribution and habitat preferences of cetaceans in Algoa Bay, South Africa. J. Mar. Biol. Assoc. U. K. 98, 1065–1079. https://doi.org/10.1017/S0025315417000340.
Merchant, N.D., Pirotta, E., Barton, T.R., Thompson, P.M., 2014. Monitoring ship noise to assess the impact of coastal developments on marine mammals. Mar. Pollut. Bull. 78, 85–95. https://doi.org/10.1016/j.marpolbul.2013.10.058.
Merchant, N.D., Brookes, K.L., Faulkner, R.C., Bicknell, A.W.J., Godley, B.J., Witt, M.J., 2016. Underwater noise levels in UK waters. Sci. Rep. 6, 36942. https://doi.org/10.1038/srep36942.
NMEA, 2010. Automatic Identification Systems.
Pebesma, E., 2018. Simple features for R: standardized support for spatial vector data. R J. 10, 439–446.
Pichegru, L., Grémillet, D., Crawford, R.J.M., Ryan, P.G., 2010. Marine no-take zone rapidly benefits endangered penguin. Biol. Lett. 6, 498–501. https://doi.org/10.1098/rsbl.2009.0913.
Pichegru, L., Ryan, P.G., van Eeden, R., Reid, T., Grémillet, D., Wanless, R., 2012. Industrial fishing, no-take zones and endangered penguins. Biol. Conserv. 156, 117–125 Seabirds and Marine Protected Areas planning http://dx.doi.org/10.1016/j.biocon.2011.12.013.
Pichegru, L., Nyengera, R., McInnes, A.M., Pistorius, P., 2017. Avoidance of seismic survey activities by penguins. Sci. Rep. 7, 16305. https://doi.org/10.1038/s41598-017-16569-x.
Pichegru, L., Vibert, L., Hofmeyr, G., 2020. Observed mortality trend from strandings in two endangered seabirds in Algoa Bay between 2013 and 2020. Seabird Scientific Task Team – Department of Environment, Forestry and Fisheries Document.
Pijanowski, B.C., Farina, A., Gage, S.H., Dumyahn, S.L., Krause, B.L., 2011. What is soundscape ecology? An introduction and overview of an emerging new science. Landsc. Ecol. 26, 1213–1232. https://doi.org/10.1007/s10980-011-9600-8.
Polinov, S., Bookman, R., Levin, N., 2021. Spatial and temporal assessment of oil spills in the Mediterranean Sea. Mar. Pollut. Bull. 167, 112338. https://doi.org/10.1016/j.marpolbul.2021.112338.
Popper, A.N., Hawkins, A.D., Thomsen, F., 2020. Taking the animals' perspective regarding anthropogenic underwater sound. Trends Ecol. Evol. 35, 787–794. https://doi.org/10.1016/j.tree.2020.05.002.
Putland, R.L., Montgomery, J.C., Radford, C.A., 2019. Ecology of fish hearing. J. Fish Biol. 95, 39–52. https://doi.org/10.1111/jfb.13867.
Qi, J., Wang, S., Qu, X., 2020. Emission evaluation of marine traffic. In: Qu, X., Zhen, L., Howlett, R.J., Jain, L.C. (Eds.), Smart Transportation Systems 2020, Smart Innovation, Systems and Technologies. Springer, Singapore, pp. 201–211. https://doi.org/10.1007/978-981-15-5270-0_18.
R Core Team, 2019. R: A Language and Environment for Statistical Computing. (Vienna, Austria) Retrieved from https://www.r-project.org/.
Reisinger, R.R., Karczmarski, L., 2009. Population size estimate of Indo-Pacific bottlenose dolphins in the Algoa Bay region, South Africa. Mar. Mammal Sci. 26, 86–97. https://doi.org/10.1111/j.1748-7692.2009.00324.x.
Robards, M., Silber, G., Adams, J., Arroyo, J., Lorenzini, D., Schwehr, K., Amos, J., 2016. Conservation science and policy applications of the marine vessel automatic identification system (AIS)-a review. Bull. Mar. Sci. -Miami- 92, 75–103. https://doi.org/10.5343/bms.2015.1034.
Ross, D., 1993. On Ocean Underwater Ambient Noise, pp. 5–8.
Ryan, P.G., Edwards, L., Pichegru, L., 2012. African penguins Spheniscus demersus, bait balls and the allee effect. Ardea 100, 89–94. https://doi.org/10.5253/078.100.0113.
Ryan, P.G., Ludynia, K., Pichegru, L., 2019. Ships' risky fuel transfers are threatening African Penguins [WWW document]. The Conversation URL http://theconversation.com/ships-risky-fuel-transfers-are-threatening-african-penguins-121575. (Accessed 4 December 2020).
SANCCOB, 2020. SANCCOB report 2019-2020 [WWW document]. URL https://sanccob.co.za/wp-content/uploads/SANCCOB-Integrated-Report-of-2019-2020_e-version.pdf. (Accessed 21 December 2020).
Sardain, A., Sardain, E., Leung, B., 2019. Global forecasts of shipping traffic and biological invasions to 2050. Nat. Sustain. 2, 274–282. https://doi.org/10.1038/s41893-019-0245-y.
Schoeman, R.P., Patterson-Abrolat, C., Plön, S., 2020. A global review of vessel collisions with marine animals. Front. Mar. Sci. 7, 292. https://doi.org/10.3389/fmars.2020.00292.
Schoeman, R.P., Erbe, C., Plön, S., 2022. Underwater chatter for the win: a first assessment of underwater soundscapes in two bays along the Eastern Cape Coast of South Africa. J. Mar. Sci. Eng. 10, 746. https://doi.org/10.3390/jmse10060746.
Sherley, R.B., Barham, B.J., Barham, P.J., Campbell, K.J., Crawford, R.J.M., Grigg, J., Horswill, C., McInnes, A., Morris, T.L., Pichegru, L., Steinfurth, A., Weller, F., Winker, H., Votier, S.C., 2018. Bayesian inference reveals positive but subtle effects of experimental fishery closures on marine predator demographics. Proc. R. Soc. B Biol. Sci. 285, 20172443. https://doi.org/10.1098/rspb.2017.2443.
Sherley, R.B., Crawford, R.J., Dyer, B.M., Kemper, J., Masotla, M., Pichegru, L., Pistorius, P.A., Roux, J.-P., Ryan, G., Tom, D., Upfold, L., Winker, H., 2019. The Status and Conservation of Cape Gannets Morus capensis, p. 37.
Sherley, R.B., Crawford, R.J.M., de Blocq, A.D., Dyer, B.M., Geldenhuys, D., Hagen, C., Kemper, J., Makhado, A.B., Pichegru, L., Tom, D., Upfold, L., Visagie, J., Waller, L.J., Winker, H., 2020. The conservation status and population decline of the african penguin deconstructed in space and time. Ecol. Evol. 10, 8506–8516. https://doi.org/10.1002/ece3.6554.
Simmonds, M.P., Dolman, S.J., Jasny, M., Parsons, E.C.M., Weilgart, L., Wright, A.J., Leaper, R., 2014. Marine noise pollution - increasing recognition but need for more practical action. J. Ocean Technol. 9, 71–90.
Sørensen, K., Neumann, C., Dähne, M., Hansen, K.A., Wahlberg, M., 2020. Gentoo penguins (Pygoscelis papua) react to underwater sounds. 7, 191988. https://doi.org/10.1098/rsos.191988.
Southall, B., Scholik-Schlomer, A.R., Hatch, L., Bergmann, T., Jasny, M.D., Metcalf, K., Weilgart, L.S., Wright, A., 2017. Underwater Noise from Large Commercial Ships—International Collaboration for Noise Reduction. Encyclopedia of Maritime and Offshore Engineering. https://doi.org/10.1002/9781118476406.EMOE056.
Svanberg, M., Santén, V., Hörteborn, A., Holm, H., Finnsgård, C., 2019. AIS in maritime research. Mar. Policy 106, 103520. https://doi.org/10.1016/j.marpol.2019.103520.
UNCTAD, 2019. Review of Maritime Transport 2019. Rev. Marit. Transp.
Veirs, S., Veirs, V., Wood, J.D., 2016. Ship noise extends to frequencies used for echolocation by endangered killer whales. PeerJ 4. https://doi.org/10.7717/peerj.1657.
Veirs, S., Veirs, V., Williams, R., Jasny, M., Wood, J., 2018. A Key to Quieter Seas: Half of Ship Noise Comes From 15% of the Fleet. PeerJPreprints, p. 6. https://doi.org/10.7287/peerj.preprints.26525v1.
Wang, X., Emerson, J.W., 2015. Bayesian change point analysis of linear models on graphs [WWW document]. https://www.coursehero.com/file/53500301/Wang-Emerson-2015Bayesian-Change-Point-Analysis-of-Linear-Models-on-Graphs-0pdf/. (Accessed 15 January 2022).
Weilgart, L., 2017. Din of the deep: noise in the ocean and its impacts on cetaceans. In: Butterworth, A. (Ed.), Marine Mammal Welfare: Human Induced Change in the Marine Environment and its Impacts on Marine Mammal Welfare, Animal Welfare. Springer International Publishing, Cham, pp. 111–124. https://doi.org/10.1007/978-3-319-46994-2_7.
Wever, E.G., Herman, P.N., Simmons, J.A., Hertzler, D.R., 1969. Hearing in the Blackfooted Penguin, Spheniscus demersus, as represented by the cochlear potentials. PNAS 63, 676–680. https://doi.org/10.1073/pnas.63.3.676.
Williams, R., Veirs, S., Veirs, V., Ashe, E., Mastick, N., 2019. Approaches to reduce noise from ships operating in important killer whale habitats. Mar. Pollut. Bull. 139, 459–469. https://doi.org/10.1016/j.marpolbul.2018.05.015.
Wood, S.N., 2000. Modelling and smoothing parameter estimation with multiple quadratic penalties. J. R. Stat. Soc. Ser. B 62 (2), 413–428.
Wood, S.N., 2017. Generalized Additive Models: An Introduction With R. Second edition. Chapman & Hall/CRC texts in statistical science. CRC Press/Taylor & Francis Group, Boca Raton.
Zhen, L., Zhuge, D., Murong, L., Yan, R., Wang, S., 2019. Operation management of green ports and shipping networks: overview and research opportunities. Front. Eng. Manag. 6, 152–162. https://doi.org/10.1007/s42524-019-0027-2.