

SC/68C/REP/04

Sub-committees/working group name: REP

Report of the Workshop on Tursiops Taxonomy, virtual meeting, 6 April 2021



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Report of the Workshop on *Tursiops* Taxonomy

1. INTRODUCTORY ITEMS

1.1 Opening remarks

The virtual workshop was held on 6 April 2021. Porter welcomed participants on behalf of the co-conveners of the IWC SC Sub-Committee on Small Cetaceans. Natoli (Convenor) welcomed participants and introduced three new members to the group, Barreto, Costa, and Louis, and provided an introduction on goals of the meeting which were to (1) review new publications (2018-2021) on *Tursiops* taxonomy and update Annexes D and E of the 2018 *Tursiops* Workshop Report (IWC 2019) with new information, and (2) review the geographic data gaps.

1.2 Election of Chair and appointment of Rapporteurs

Natoli was appointed as Chair, Cipriano was appointed as rapporteur.

1.3 Participants

The list of participants is provided in Annex 1.

1.4 Adoption of the Agenda

The workshop Agenda is provided in Annex 2.

1.5 Documents Cited and Available

The list of documents cited in this report are provided below under **References cited**, and additional documents reviewed during the intersessional period and the online workshop are provided in Annex 3.

2. TURSIOPS TAXONOMY

2.1 Overview

Bottlenose dolphins are among the most widely distributed cetaceans. Worldwide, more than 20 different *Tursiops* species have been described historically but only two - *T. truncatus* (Montagu, 1821) and *T. aduncus* (Ehrenberg, 1832) - are currently recognised (Committee on Taxonomy, 2017). In many regions where bottlenose dolphins occur, different forms have been described, based on distribution, morphology, and genetic profiles. Understanding whether there is consistency in the recognition of the taxonomic and/or population status of various local forms across the distributional range, and to which taxonomic or population unit(s) they should be assigned, has been challenging; the status of many forms worldwide is still unresolved. Bottlenose dolphins are known to show morphological and genetic divergence throughout their range, raising issues for recognition of discrete units needed for effective conservation and management. In the IWC/SC context, the issue of "taxonomy" mainly concerns the potential for unrecognised diversity - distinct species, sub-species and demographically independent populations are fundamental management units, and if they have not been recognised there is the potential for conservation issues, especially in areas with known threats. Bottlenose dolphins have a cosmopolitan distribution, show morphological and genetic divergence throughout their range, and in some regions show strong population structure, often over a very fine geographic scale. This raises issues about the recognition of discrete units needed for effective conservation and management.

2.2 Background and history of the taxonomy review

Over the course of three years (2015-2017), the Sub-committee on Small Cetaceans reviewed all relevant morphological, genetic and occurrence information available for *Tursiops* worldwide. After reviewing the available information, the Sub-committee then focused on evaluating the support provided for taxonomic (subspecies, species) and population-level distinctions proposed in the publications we reviewed. This included, *inter alia*, proposals for the recognition of new species and/or subspecies, and evidence for population-level divergence significantly strong to warrant recognition of the bottlenose dolphins in particular areas as worthy of designation as distinct 'management units'. An additional aim of this exercise was to develop a widely applicable taxonomic-assessment framework for small cetaceans. Detailed summaries of available evidence and conclusions from each of the 2015-2017 reviews are included in the sub-committee reports for that year (IWC 2016, IWC 2017, IWC 2018).

In January 2018, the IWC convened an intersessional workshop on the taxonomy of *Tursiops*. Workshop participants drew from the worldwide review of the genus *Tursiops* by the Sub-committee on Small Cetaceans during IWC Scientific Committee meetings held in 2015, 2016 and 2017. The *Resolving Tursiops Taxonomy*

Worldwide workshop report (IWC 2019) included a comprehensive list of the available papers relevant to understanding of the taxonomy of the genus and a summary table (Annex D) providing information, by geographic region, on behavioural and environmental data, morphological data, genetic data (by marker type), and sample sizes. Annex E highlighted important data-deficient geographic regions where our knowledge of *Tursiops* is poor.

The January 2018 workshop participants agreed it would be important to maintain these two Annexes, updating them with new information relevant to understanding *Tursiops* taxonomy as research results and publications became available. In 2020 Almansouri and Natoli conducted a preliminary literature search to identify new publications on *Tursiops*. In 2021 an Intersessional Correspondence Group (ICG), convened under Natoli, reviewed that list and added new publications. In April 2021, a virtual pre-meeting was held to review relevant research published between 2018 and 2021; attendees included some participants at the 2018 Workshop (Archer, Cipriano, Hoelzel, Krützen, Lang, Natoli, Rosel), plus Barreto, Costa, Porter, Louis, Almansouri and Stewart. The ICG and pre-meeting participants identified many new publications on *Tursiops* population structure, population abundance, acoustics, health, etc. The goal of the literature review was to update Annexes D and E from the 2018 workshop report, in order to provide them to the Sub-Committee on Small Cetaceans at the 2021 virtual Scientific Committee Meeting.

Before reviewing new publications, participants agreed that the focus should be on publications providing significant new information on taxonomy, systematics, and population-level distinctions relevant to management decisions within the genus *Tursiops*. Unless a publication included clear taxonomic, systematic, or management unit relevance, or reported the presence of samples from Data Deficient areas (as defined at the 2018 Workshop), it was not reviewed by the ICG or at the pre-meeting, nor added to Annexes D or E. A full list of publications satisfying these criteria is available below, as Annex C.

2.3 Pre-meeting review of data-deficient areas

It was noted that the original list of data deficient regions has not changed, and one participant suggested that the western South Atlantic should no longer be considered data deficient given there have been significant improvements to the understanding of *Tursiops* taxonomy in the region. Some questions for that region remain and refinements are necessary, for example better defining the northern range of distribution of Lahille's bottlenose dolphin and the possibility that there is a third type or population in Argentina. Compared to other regions, for example the eastern South Atlantic, there is now considerable information available for the western South Atlantic. Participants agreed there are different levels of data deficiency, and noted that the purpose of Annex E was to flag such deficiencies and encourage further work, especially collaborations to address them.

2.4 Pre-meeting review of new information relevant to taxonomic and population-level distinctions

Some information relevant to *Tursiops* taxonomy was reviewed by the intersessional correspondence group and noted in the updated Annex D table, but is not summarized below. During the pre-meeting, participants reviewed nine of the new papers most relevant to outstanding taxonomic and population divergence questions as described below, but did not review all papers identified as relevant. The full list of taxonomy-relevant papers is provided in Annex C.

Hoelzel summarised Moura et al. (2020). This paper was reviewed at the 2018 *Tursiops* Workshop as a working paper but is now published. Sampling was worldwide but incomplete in some areas. Using RADseq data, two well supported lineages were identified representing *T. aduncus* and *T. truncatus* and analysis dated the split between the two at 1-2 million years before present (MYBP). There are also well-defined lineages within the two primary groups. Within the *aduncus* lineage, three clusters were identified representing *Tursiops* from the Indian Ocean (including the *aduncus* holotype), Australasia, and the Burranan dolphin (putative *T. australis*) lineages. The *truncatus* lineage contained several unique clusters as well with the most differentiated group coming from coastal waters of the western North Atlantic. Unlike previous mitochondrial (mtDNA) trees, the Black Sea samples were monophyletic (they were paraphyletic in mtDNA trees) and Mediterranean and offshore samples were also distinct lineages.

Krützen noted that the sampling for the putative *T. australis* is an issue. In South Australia, putative *australis* samples appear to be closer to *aduncus* while putative *australis* samples from Victoria group closer to *truncatus*. Some admixture may be occurring. This is an area that requires further study and would be best accomplished by collaboration and sharing of samples among researchers that work in this region. Hoelzel noted that if the same enzymes were used, ddRAD data from this region could be compared against the data from Moura et al. (2020), as those data are now in the NCBI public database. Participants agreed and *encouraged* that future research on *Tursiops* taxonomy in South Australia include pooling of samples or data, and that a consistent genomic approach be applied to all samples. In addition, integrating the genomic and available morphological data would be useful, particularly if there are samples for which both genomic and morphological data are both available.

Hoelzel summarised Vijay et al. (2018). Using whole genome sequences for both *T. truncatus* and *T. aduncus*, the authors examined historical effective population sizes for both species. Pseudo-diploid analysis showed evidence for population structure for *T. truncatus* in the northwest Pacific (samples from China and Japan), but not for *T. aduncus* for samples collected off South Korea (the latter not surprising given the single geographic origin). Their data also suggested differential historical demography among species and regions in the northwest Pacific (e.g. a sample from Japan showed a different demography than several *T. truncatus* samples from China). Supplementary figures show comparisons between the northwest Pacific and northwest Atlantic *T. truncatus* samples, illustrating clear population genetic structure, while the strongest effects were for comparisons between *T. truncatus* and *T. aduncus*.

Barreto summarised Hohl et al. (2020) which analyzed cranial variability of *T. truncatus* from different parts of the world including the eastern North Pacific, eastern North Atlantic, eastern South Atlantic, and western South Atlantic oceans. The results continue to support the distinction of subspecies *T. truncatus gephyreus* from *T. truncatus truncatus* in the western South Atlantic. The authors concluded that *T. truncatus gephyreus* deserves species recognition, based on morphology, because diagnostic morphological characters are present, including stable characters that are not simply related to size.

A number of new publications on *Tursiops* from the western South Atlantic were reviewed. Costa summarised Costa et al. (2019). This study focused on *T. truncatus gephyreus* and *T. truncatus truncatus* in the western South Atlantic. Using cranial morphological analyses coupled with mitochondrial DNA analysis and nuclear microsatellite analysis using paired samples (i.e. the same animals were used in both genetic and morphological analyses), the authors found strong differentiation in skull morphology. However, the genetic data did not support separate species because *gephyreus* samples were not reciprocally monophyletic and there was at least one shared haplotype between the two subspecies. Costa et al. (2019) concluded that *gephyreus* is better described for now as a subspecies rather than a separate species. Barreto noted that only two animals did not fit the pattern and asked why the genetic data were not considered strong-enough support for species-level status. Costa agreed that *T. truncatus* and *T.t.gephyreus* showed genetic differentiation but that the available data were not sufficient to meet the species-level threshold and suggested that we are possibly seeing incipient speciation (speciation in action). Participants agreed that analysis of a wider (higher number of individuals analysed) and deeper (more loci included) nuclear data set may provide a more conclusive view of the level of differentiation between these two taxa.

Costa also summarised Loizaga et al. (2020). This research extended sampling of bottlenose dolphins further south along the Argentinian coast than previous studies and found sympatry of coastal and offshore forms, based on dorsal fin morphology. Results suggest this area of the western South Atlantic may be more complex, with the different morphotypes intermixing and potentially sharing mitochondrial DNA haplotypes. More work is needed in the region to understand whether there is admixture between the morphotypes. Hoelzel noted that nuclear genomic DNA data could greatly facilitate the analysis of admixture in this system. Archer noted that recognised *Neophocoena* species have diagnostic morphological characters, share mitochondrial haplotypes and have an overlap in distribution similar to what is seen in the western South Atlantic. Thus, they may be a good example to bring up in relation to studies of the morphotypes in the western South Atlantic.

Finally, Costa summarised Pereira et al. (2020) and Simões-Lopes et al. (2019). The former used stable isotope data from teeth collected from stranded *Tursiops* of both subspecies from the coast of Santa Catarina, southern Brazil. No differences were found for nitrogen isotopes, but for carbon, *T. t. gephyreus* had higher $\delta^{13}\text{C}$ levels than *truncatus* samples. These results support previous studies which indicated Lahille's bottlenose dolphins have a more nearshore, coastal distribution while common bottlenose dolphins generally occupy more offshore habitats. The authors found some indication of niche overlap, but concluded there was not competition between the two subspecies for the same prey, but rather overlap in habitat use. Simões-Lopes et al. (2019) examined external morphology including body colour and dorsal fin shape for *Tursiops* across a wide geographic along the coast of southern and southeastern Brazil. They found significant differences in both features between the two subspecies. Lahille's bottlenose dolphins had much more triangular fins and were also lighter in body colour. An area of overlap in distribution was found, but both subspecies were never seen in the same area at the same time, supporting a parapatric distribution and differential habitat use by the two subspecies.

Participants were delighted to see all the new studies that have occurred on *Tursiops* in the western South Atlantic and **noted** that there would be much to gain in our understanding of distribution, habitat use, and taxonomy by moving towards a unified approach for the region that merged different sample sets to (1) identify sampling gaps, and (2) conduct a nuclear DNA analysis across the entire geographic range to address outstanding questions of taxonomy and relationships of the different groups of *Tursiops* identified in the western South Atlantic. Costa noted there is an ongoing project collecting samples along the entire range, so more samples will be available in the near future.

In 2020, the status of *Tursiops* in the Mediterranean was reassessed by the IUCN through a comprehensive review of all the scientific information available (assessment under revision). Only *Tursiops truncatus* is present in the Mediterranean and it is considered a distinct subpopulation. The review did not identify any taxonomic issues at the species or subspecies level for the region.

Hoelzel summarised Gray et al. (2018) and Gray et al. (2021), which focus on *Tursiops* in the Indian Ocean. Using mitochondrial and nuclear DNA data, a new ‘*aduncus*-type’ lineage was identified from waters of Oman, Pakistan and India. New samples from Bangladesh are currently being added to this study to better understand the distribution of this lineage. Archer noted there was a sample from India in the *T. aduncus* holotype lineage, suggesting some potential overlap with this new lineage. Hoelzel confirmed that there is some range overlap in Oman and Pakistan, but that the assignment to lineage is strong for those samples. Natoli recommended that morphological comparisons of this new lineage should be made; Hoelzel indicated such work was in progress.

3. DRAFT RECOMMENDATIONS ARISING FROM THE 2021 REVIEW

Attention: R

*The Committee recalls its previous recommendations (IWC 2019, p 49) and, given the lack of progress in clarifying the phylogenetic affinity of the “T. australis” mtDNA lineage in the context of both T. truncatus and T. aduncus, **encourages** researchers working on bottlenose dolphin taxonomy in southern Australia to focus future efforts to ensure that (1) such efforts include collaborations to allow analysis of samples from around Australia, (2) a consistent genomic approach is applied to all samples, (3) analysis of “ancient DNA” from historical (bone) samples also be incorporated, if possible, and (4) the available mitochondrial DNA, nuclear DNA and morphological data are incorporated into the analysis, particularly if there are samples for which both genomic and morphological data are available. Updated information should be supplied to the IWC Scientific Committee (SM Sub-committee) when available.*

Attention: R

*The Committee recalls its previous recommendations (IWC 2019, p 49) and welcomes recent progress in characterising divergence between coastal and offshore forms in the western South Atlantic Ocean, and now **encourages** researchers working on Lahille’s bottlenose dolphin to (1) investigate the possibility that there is a third type or population of bottlenose dolphins in Argentine waters. Updated information should be supplied to the IWC Scientific Committee (SM Sub-committee) when available; given increasing concern for this subspecies prompt attention is also **encouraged**.*

Attention: R

*The Committee recalls its previous recommendations (IWC 2019, p 49) and welcomes recent progress in characterising divergence between coastal and offshore forms of bottlenose dolphins in the western South Atlantic Ocean; and now **encourages** researchers working on bottlenose dolphins in Brazil, Uruguay, and Argentina to adopt a unified approach for understanding the distribution, habitat use, taxonomic and population-level divergence of Southwest Atlantic bottlenose dolphins, including collaborations to allow merging of independent sample sets to (1) identify sampling gaps, and to (2) allow analysis of nuclear DNA data from across the entire geographic range to address outstanding questions of taxonomic and population-level divergence of the different forms of *Tursiops* identified in that region. Updated information should be supplied to the IWC Scientific Committee (SM Sub-committee) when available.*

Attention: SC

The Committee recalls its previous recommendation (IWC, 2019, p49) and **agrees** that Annexes D and E, developed by the 2018 Tursiops taxonomy workshop to summarize available data relevant to this topic for the major geographic areas worldwide, and indicative of where such data are still lacking or incomplete, will continue to be updated and be available as a publicly available 'living document' on the IWC website. Such updates should be supplied to the IWC Scientific Committee (SM Sub-committee) at regular intervals, preferably not more than 2-3 years apart, if possible.

Attention: R, SC

The Committee again **draws attention to** the need for bottlenose dolphin research in areas the 2018 Tursiops Taxonomy Workshop identified as data deficient (IWC, 2018, p49): the eastern South Atlantic, the African coast of the eastern North Atlantic, the southern and eastern Mediterranean Sea, the eastern South Pacific, and the Mexican mainland and Central American coasts of the eastern North Pacific, eastern Australia and in the western Pacific islands of Micronesia, Melanesia, Polynesia, the Philippines and Vietnam. The Committee **encourages** Tursiops research and collaborative efforts to examine and analyse Tursiops specimens throughout these regions. Updated information should be supplied to the IWC Scientific Committee (SM Sub-committee) when available. The Committee recalls its previous recommendation (IWC, 2019, p49) and **agrees** that the Sub-committee on Small Cetaceans should continue compilation of specimen, study, and researcher details, and concentrated effort to improve our understanding of Tursiops in data-deficient areas.

4. UPDATED INFORMATION AVAILABLE ONLINE

Updates to the list of references, summary table and table of data deficient regions is available from the link to Supplements at <https://iwc.int/jcrm> (see Supplement 21). These include:

Annex D – Updated *Tursiops* Summary Table

Annex E- Updated Table of Outstanding Areas for Further Research and Poorly Known Regional Populations that are Data Deficient

5. ADOPTION OF REPORT

The report was edited via email correspondence, finalized, and adopted, and also provided to SC/68C in the form of draft report text plus recommendations.

References cited

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- Gray, H.W.I., Nishida, S., Welch, A.J., Moura, A.E., Tanabe, S., Shoaib Kiani, M.S., Culloch, R., Möller, L., Natoli, A., Ponnampalam, L.S., Minton, G., Gore, M., Collins, T., Willson, A., Baldwin, R., and Hoelzel, A.R. 2018. Cryptic lineage differentiation among Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in the Northwest Indian Ocean. *Molecular Phylogenetics and Evolution* 122: 1-14.
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- Hohl, L.S.L., Sicuro, F.L., Wickert, J.C., Moreno, I.B., Rocha-Barbosa, O., and Barreto, A.S. 2020. Skull morphology of bottlenose dolphins from different ocean populations with emphasis on South America. *Journal of Morphology* 281:564-577.
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- Vijay, N., Park, C., Oh, J., Jin, S., Kern, E., Kim, H.W., Zhang, J., and Park, J.-K. 2018. Population genomic analysis reveals contrasting demographic changes of two closely related dolphin species in the last glacial. *Molecular Biology and Evolution* 35:2026-2033.

Annex 1

List of Participants

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Aimee Lang	NOAA,SWFSC, La Jolla, CA USA
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Rus Hoelzel	University of Durham, UK

Annex 2

Pre-Meeting Workshop Agenda

AGENDA

1. INTRODUCTORY ITEMS

- 1.1. Opening remarks
- 1.2. Election of chair and appointment of rapporteurs
- 1.3. Participants
- 1.4. Agenda
- 1.5. Documents cited and available

2. TURSIOPS TAXONOMY UPDATE

- 2.1. Overview
- 2.2. Background and history of the taxonomy review
- 2.3. Pre-meeting review of data-deficient areas
- 2.4. Pre-meeting review of new information relevant to taxonomic and population-level distinctions

3. DRAFT RECOMMENDATIONS ARISING FROM THE 2021 REVIEW

4. UPDATED INFORMATION AVAILABLE ONLINE

5. ADOPTION OF REPORT

Annex 3 – Results of Literature Search for *Tursiops* worldwide 2018-2021

Publications are divided by region as delineated in the 2018 *Tursiops* taxonomy workshop. Publications with * were reviewed during the pre-meeting and added to Annex D as relevant to *Tursiops* taxonomy. Publications with ** were reviewed intersessionally and also added to Annex D. Remaining publications were not directly relevant to taxonomy, but involved analysis of samples from Data Deficient Areas.

General

- *Hohl, L.S.L., Sicuro, F.L., Wickert, J.C., Moreno, I.B., Rocha-Barbosa, O., and Barreto, A.S. 2020. Skull morphology of bottlenose dolphins from different ocean populations with emphasis on South America. *Journal of Morphology* 281:564-577.
- **Horreo, J. L. 2019. New insights into the phylogenetic relationships among the oceanic dolphins (Cetacea: Delphinidae). *Journal of Zoological Systematics and Evolutionary Research* 57:476-480.
- *Moura, A.E., Shreves, K., Pilot, M., Andrews, K.R., Moore, D.M., Kishida, T., Möller, L., Natoli, A., Gaspari, S., McGowen, M., Chen, I., Gray, H., Gore, M., Culloch, R.M., Kiani, M.S., Willson, M.S., Bulushi, A., Collins, T., Baldwin, R., Wilson, A., Minton, G., Ponnampalam, L. and Hoelzel, A.R. 2020. Phylogenomics of the genus *Tursiops* and closely related Delphininae reveals extensive reticulation among lineages and provides inference about eco-evolutionary drivers. *Molecular Phylogenetics and Evolution* 146: 106756.

EIO (eastern Indian Ocean)

- **van Aswegen, M., Christiansen, F., Symons, J., Mann, J., Nicholson, K., Sprogis, K., and Bejder, L. 2019. Morphological differences between coastal bottlenose dolphin (*Tursiops aduncus*) populations identified using non-invasive stereo-laser photogrammetry. *Scientific Reports* 9:1-14.
- **Batley, K.C., Sandoval-Castillo, J., Kemper, C.M., Zanardo, N., Tomo, I., Beheregaray, L.B., and Möller, L.M. 2021. Whole genomes reveal multiple candidate genes and pathways involved in the immune response of dolphins to a highly infectious viral disease. *Molecular Ecology*.
- **Jedensjö, M., Kemper, C.M., and Krützen, M. 2016. Cranial morphology and taxonomic resolution of some dolphin taxa (Delphinidae) in Australian waters, with a focus on the genus *Tursiops*. *Marine Mammal Science* 33: 187-205. (This is published version of SC/66a/SM/10 presented to Scientific Committee in 2015.)
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- Marley, S.A., Erbe, C., Salgado Kent, C.P., Parsons, M.J.G., and Parnum, I.M. 2017. Spatial and temporal variation in the acoustic habitat of bottlenose dolphins (*Tursiops aduncus*) within a highly urbanized estuary. *Frontiers in Marine Science* 4. 197.
- **Tomo, I., Kemper, C.M., and Sciutteri, V. 2018. Pathology of the skeleton of Indo-Pacific bottlenose dolphins *Tursiops aduncus*: a comparison of adjacent gulfs in South Australia. *Diseases of Aquatic Organisms* 131: 95-105.

WIO (western Indian Ocean)

- Costa, M., Fumagalli, M., and Cesario, A. 2019. Review of cetaceans in the Red Sea. In Oceanographic and biological aspects of the Red Sea. Rasul N., Stewart I. (eds). Pp. 281-303. Springer Oceanography, Cham.
- *Gray, H.W.I., Nishida, S., Welch, A.J., Moura, A.E., Tanabe, S., Shoab Kiani, M.S., Culloch, R., Möller, L., Natoli, A., Ponnampalam, L.S., Minton, G., Gore, M., Collins, T., Willson, A., Baldwin, R., and Hoelzel, A.R. 2018. Cryptic lineage differentiation among Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in the Northwest Indian Ocean. *Molecular Phylogenetics and Evolution* 122: 1-14.
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- **Mapunda, E.C., Othman, O.C., Akwilapo, L.D., Bouwman, H., and Mwevura, H. 2017. Concentrations of metallic elements in kidney, liver, and lung tissue of Indo-Pacific bottlenose dolphin *Tursiops aduncus* from coastal waters of Zanzibar, Tanzania. *Marine Pollution Bulletin* 122: 483-487.
- **Ngqulana, S.G., Pistorius, P., Galatius, A., Plön, S., and Hofmeyr, G.J.G. 2018. Variation in cranial morphology of bottlenose dolphins (genus *Tursiops*) off South Africa. *Marine Mammal Science* 35: 617-636.
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WSP (western South Pacific)

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