

SC/67b/RP14

CMP - Assessing continued isolation of the
Arabian Sea humpback whale population
through geographic variation in song



INTERNATIONAL
WHALING COMMISSION

PROJECT PROPOSAL REQUEST

1. PROPOSAL TITLE

Please provide the title of the project or the name of the workshop/meeting.

Assessing continued isolation of the Arabian Sea humpback whale population and continuity across the Arabian Sea through geographic variation in song

2. BRIEF OVERVIEW OF THE PROPOSAL AND ITS EXPECTED OUTCOME

Give a very brief overview (max 150 words) on your proposal and its expected outcomes. Use bullet point to list outcomes. Be succinct and clear as this may be used to summarise your project for the report.

We presented in SC/67B/CMP/19 a study of geographic variation in humpback whale song indicating that the Arabian Sea song from Oman is distinct from the Southwest Indian Ocean song, and evidence from a small Indian sample suggesting continuity in song between the western and eastern Arabian Sea. We here propose to follow up on this work with a detailed comparison of song across the Arabian Sea, and continued assessment of song differences with the SWIO:

1. Assess the connectivity of Arabian Sea humpback whales from Oman to India by comparing existing samples of song between the two regions from several different years.
2. Assess and re-examine the differences in song exhibited between Oman and the SWIO with more recent data, particularly in light of evidence that SWIO singers were found off Oman during the Boreal summer of 2012.

3. RELEVANT IWC SCIENTIFIC COMMITTEE GROUPS OR SUB-GROUPS

List all the IWC Scientific Committee groups or sub-groups that the outcomes of this work would be relevant to and provide a brief (1-2 lines) explanation of how it would contribute more widely to their ongoing programmes of work. Where possible, do not simply list only the sub-committee within which or for which the project proposal was generated.

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4. TYPE OF PROJECT (PLEASE TICK)

Research project	X
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Modelling	
Workshop/meeting	
Database creation/maintenance	
Compilation work/editing (e.g. on whalewatching regulations, SOCER, etc.)	
Other (please specify below)	

5. BRIEF DESCRIPTION OF THE PROPOSAL AND ITS CONNECTION WITH SCIENTIFIC COMMITTEE RECOMMENDATIONS (DO NOT EXCEED 1500 WORDS)

(A) BACKGROUND, RATIONALE, AND RELEVANCE TO THE PRIORITIES IDENTIFIED BY THE IWC SCIENTIFIC COMMITTEE:

Provide a clear explanation of the background and rationale for the proposal and its relevance to Scientific Committee identified priorities. Clearly identify the most relevant and recent Scientific Committee recommendations.

Existing genetic, demographic and behavioural evidence indicates that Arabian Sea humpback whales (ASHW) represent an isolated and unique population (Minton et al 2011, Pomilla, Amaral et al. 2014). The population exhibits a Northern Hemisphere breeding cycle, is believed to feed year-round, and lacks the typical latitudinal migrations and seasonal separation of breeding and feeding ecology exhibited by other populations of humpback whales globally. The population has been the subject of a standing agenda item and numerous recommendations for research and conservation actions in the IWC's Scientific Committee since 2010. These recommendations include the formation of a Conservation Management Plan for the population (e.g. IWC, 2016).

A key feature of humpback whale breeding behaviour is the male acoustic breeding display, song, studied extensively around the world. Key characteristics of humpback whale song include: all males within a population share the same song patterns (phrases); a population's song changes progressively over time with all individuals in a population incorporating changes; and populations that do not overlap or exchange individuals have distinctly different songs, whereas populations in contact share some or all phrases. This makes studies of geographic variation in song an ideal method to assess connectivity and interaction between populations on a broad scale, as has been used in all ocean basins globally.

Cerchio et al. (2018b) compared song samples collected through long-term acoustic monitoring off the coast of Oman from 2011-2013 with song samples collected in the Southwest Indian Ocean (SWIO) and off the west coast of India. There were four major findings of consequence in the results of this study: (1) Assessment of an extensive sample revealed a distinct difference between Oman

Boreal winter song and SWIO Austral winter song with no phrase content shared between the regions based . In contrast to this finding, a small sample of song fragments from India revealed two phrase types that matched phrases from Oman in the same year. (2) Oman singers exhibited a globally unique temporal stasis in song over the three monitored years, displaying very little of the progressive change that is typical of all previously studied humpback whale populations. (3) The presence of SWIO song was documented off Oman during the Boreal summer of 2012, indicating that SWIO males had moved into the Arabian Sea during their Austral winter breeding season. And (4) despite the presence of these singers and the opportunity for exchange of song material, there was a lack of diffusion of SWIO song into the Arabian Sea population's song.

These results indicated both isolation of the ASHW and potential continuity / connectivity across the Arabian Sea between Oman and India. Somewhat incongruent to this finding, the presence of SWIO whales off Oman indicates the opportunity for cultural transmission and mixing of populations. It was proposed that behavioural isolation mechanisms may exist that maintain the isolation of the ASHW, as exhibited by the lack of song diffusion and relative temporal stasis of Arabian Sea song.

In addition to the preliminary comparison of songs between Oman and India, the movement of a satellite tagged whale from Oman to the west and south coasts of India, and then back to Oman, during 2018 suggests connectivity across the Arabian Sea (Willson et al. 2018). Recent independent documentation of humpback whale song and sightings along the west coast of India further indicate the potential importance of habitat in the eastern Arabian Sea (Mahanty et al. 2015, Madhusudhana et al. 2018, Sutaria 2018).

We here propose to further assess the connectivity of humpback whales across the Arabian Sea by comparing song existing samples from Oman and India collected between 2011 and 2018. We will also further assess findings of the 2011-2013 comparison by comparing songs from the SWIO (Madagascar) in Austral winter 2016 and 2017 with concurrent data from Oman to test if the differences documented previously were maintained. Furthermore, a series of samples from Oman between 2013 and 2017 will be examined to assess whether the relative stasis observed in 2011-2013 is maintained, or if there is any evidence of rapid change of song phrases suggesting song diffusion from another population (i.e., SWIO).

(B) SPECIFIC OBJECTIVES OR TOR AND DELIVERABLES/OUTCOMES:

Provide the specific objectives and the expected deliverables. In the case of workshops and meetings, include the Terms of Reference (ToR) and expected outcomes.

Objectives:

1. Within Arabian Sea Geographic Variation:
 - a. Qualitatively compare songs recording in India during 2011, 2017 and, if available, 2018 with concurrent samples collected in Oman to assess similarities in phrase content.

- b. If homologous phrases are identified (representing the same phrase lineages), and sample size allows, conduct a quantitative comparison of acoustic feature variables to assess degree of variation between Oman and India singers.
2. Arabian Sea – SWIO Geographic Variation :
 - a. Qualitatively compare songs collected off Oman and Madagascar during 2016-2017 to assess whether the differences documented in 2011-2013 are maintained across this span of years.
3. Oman Song stasis assessment
 - a. Qualitatively assess songs collected off Oman from 2013 to 2017 to assess whether the temporal stasis documented in 2011-2013 is maintained across this span of years. This includes determining whether any dramatic changes in phrase content has taken place in Oman songs between 2013-2017 that might indicate the diffusion of song from the SWIO.

Deliverables:

1. Report to the 2019 IWC Scientific Committee meeting on results of comparisons.
2. Submission of peer-reviewed paper.

(C) METHODOLOGICAL APPROACH/WORK PLAN/ADMINISTRATIVE DETAILS

Specify the methods to be applied (novel methods require more explanation than standard ones) and the broad workplan – the detailed timetable appears under Item 5 below.

In the case of workshops and meetings, include the broad work plan including any pre-requisites for the workshop/meeting to take place (apart from funding, e.g. completed analyses, papers etc.) and administrative details (e.g. location, dates, number of participants).

Within Arabian Sea Geographic Variation

Existing samples of song have been identified from three separate sources:

1. Short samples recorded off southwestern coast of India near Cochin, Kerala, using an autonomous archival recorder between January and March 2011 as reported in Mahanty et al. 2015.
2. Short samples of high signal to noise ratio (SNR) recorded off the central western coast of India near Goa, using an autonomous archival recorder on nine separate days in March 2017, as reported in Madhusudhana et al. 2018.
3. A medium duration (several minutes) boat-based sample of song recorded off the central western coast of India near Goa in March 2017 by colleagues of D. Sutaria .

In addition to these existing samples, there is a planned effort by D. Sutaria in 2018 to attempt to collect targeted boat-based samples from singing whales in the general location where a whale satellite tagged off Oman spent several weeks on the south coast of India. Each of these samples is paired with concurrent boat-based samples collected off the coast of Oman, and the first has already been compared in Cerchio et al. (2018b).

Songs from each year and location will first be qualitatively characterized in terms of phrase content and compared to assess whether the same phrase types and lineages are found in each pair. If the same phrase lineages are detected, we will then attempt a more detailed quantitative analysis of time-frequency acoustic features (e.g., as conducted in Cerchio et al. 2001, and ideally incorporating analytic methods developed by Madhusudhana et al. 2018). This will involve

identifying homologous units within phrases and making quantitative measurements of time and frequency characteristics, as well as comparing quantitative measurements at the phrase level such as phrase duration and number of units. A comparison across the sample will evaluate whether there is more variation between the regions than within the Oman sample. This will provide inference as to whether the India songs may represent the same singers as off Oman (same contiguous population) or potentially represent a sub-population division. This will only be possible or attempted if the sample size of Indian samples allows such a quantitative comparison, to be assessed at the start of the analysis.

Arabian Sea – SWIO Geographic Variation

Extensive recordings of humpback whale song have been collected off the northwest coast of Madagascar in the SWIO during acoustic monitoring in the Austral winters of 2016 and 2017, as described in Cerchio et al. (2018a). These recordings present the opportunity to compare with Oman song during the concurrent years, and establish if the lack of song sharing demonstrated during 2011-2013 in Cerchio et al. (2018b) has been maintained across this eight year span. Boat-based recordings were collected off Oman during the Boreal winters of 2015/2016, 2016/2017, and 2017/2018, so bracketing the Madagascar recordings before, in between and after the two Southern Hemisphere sample years. A qualitative assessment of phrase content will be conducted on a selection of the best SNR samples from each region/season as described above and detailed in Cerchio et al. (2018b). If available data allows, at least five samples (individual singers) per region/season will be examined for a total of 25 samples; this sample size was established as sufficient to diagnose major regional differences/similarities as well as subtle quantitative variation by Cerchio et al. (2001) comparing two regions and two time periods in the North Pacific.

Oman Song Stasis Assessment

After 2013, annual seasonal effort off the coast of Oman was conducted until the most recent 2017/2018 Boreal winter season. This included boat-based collection of song samples in all years for a complete series of seasonal samples between 2010/2011 and 2017/2018 (the 3 seasons examined in Cerchio et al 2018b, plus an additional 5 seasons). Sampling varied among years, however at least some song was collected in each year. Song samples will be evaluated for length and SNR and the best samples will be chosen for qualitative assessment of phrase content, again striving for 5 samples per year. As described in Cerchio et al. (2018b) homologous phrase lineages across years will be evaluated for temporal change vs. relative stasis as observed from 2011 to 2013. This process will furthermore represent the first stage in a detailed quantitative assessment of song stasis in Arabian Sea song, to be conducted as a separate future project since it is beyond the scope of available funding for this study. However, we will evaluate if the sample size exists for such a detailed quantitative study.

During this assessment of progressive change vs. stasis, we will also be particularly interested if there is a radical change over in phrase content, such that lineages present in 2011-2013 disappear and are replaced by novel lineages. Such a replacement would signal that a cultural diffusion event occurred and would suggest that the Arabian Sea population adopted the song of migrants coming in from another population (i.e., the SWIO). This is a distinct possibility given the

documentation of SWIO singers off Oman in 2012, and this assessment will represent a test of some of the hypotheses proposed in Cerchio et al. (2018b) regarding potential behavioural isolation mechanisms.

(D) SUGGESTIONS FOR OUTREACH

Please, note that successful proponents will be requested to produce ad hoc material that will be used by the IWC Secretariat for dissemination and outreach.

Results of the proposed work will be highlighted and publicised by the Environment Society of Oman, and the New England Aquarium, each having outreach capacity that ranges from their local region to global in scope. Materials will be made available for to the IWC Secretariat to disseminate and use for outreach.

6. TIMETABLE FOR ACTIVITIES AND OUTPUTS

Specify the timetable for project activities and expected outputs separately. For projects with multiple distinct elements please indicate interim goals and timeframes. Add as many rows as you need to the tables below. If publications are an expected output please note whether you will submit the manuscript to the IWC's Journal of Cetacean Research and Management.

Activity to be undertaken	Key person(s)	Start(mm/yy)	Finish (mm/yy)
Analysis of Song Data	Cerchio	01/19	03/19
Write up of paper	Cerchio	03/19	04/19

Expected outputs	Completion date (mm/yy)
Report to IWC Scientific Committee	04 or 05/19
Submission to peer-reviewed journal	07/19

7. RESEARCHERS' (OR STEERING GROUP) NAME(S) AND AFFILIATION

Please, also specify if the project team has any direct connection (e.g. same research group or institute, collaborator on common project) with people involved or likely to be involved in taking the funding decision (e.g. IWC SC heads of delegations, SC convenors, etc.). Add as many rows as you need to the table below.

Name	Affiliation	Connection with decision
Salvatore Cerchio	New England Aquarium	None
Andrew Willson	Five Oceans Environmental Sciences	None
Shyam K Madhusudhana	Cornell University Bioacoustics Research Program	None
G. Latha	National Institute of Ocean Technology	None
Dipani Sutaria	James Cook University	None

8. TOTAL BUDGET

Breakdown into: (1) salaries/wages (include name/position of each individual and breakdown of time and duties i; (2) travel/subsistence expenses (breakdown by person and justification) unless for IPs for workshops where a total estimate based on an average for the total number of IPs is acceptable; (3) services (e.g. aircraft/vessel time, consultancy fees, ARGOS fees, etc.); (4) reusable capital equipment (e.g. reusable equipment such as a hydrophone, cameras, etc. Note that this equipment will have to be registered at the IWC Secretariat and will remain property of the IWC at the end of the project), (5) expendable capital equipment (e.g. consumables, tags, stationery), (6) shipping costs, (7) insurance costs, (8) in kind co-funding (specify whether other funding is available for personnel/name, equipment, venues, etc.). Note that "Overheads" are not admissible. Add as many rows as you need to the table below.

Type	Detailed description	Cost in GB pounds
(1) Salaries (by person)	Cerchio, PI, salary for 3 months analysis and write up	16,400
(2) Travel/subsistence (by person or est. total for IPs)		
(3) Services (by item)		
(4) Reusable equipment		
(5) Consumables		
(6) Shipping (by Item)		
(7) Insurance (by item)		
(8) Co-funding		
(9) Other		
Total		

9. DATA ARCHIVING/SHARING

Please state your plans for data archiving and sharing. Note that data collected primarily under IWC grants are considered publicly available after an agreed period of time for publication of papers, usually about two years. The work of the IWC depends on the voluntary contribution of data to the various databases and catalogues IWC supports. Please consult the Secretariat (secretariat@iwc.int).

This project represents a collaborative effort and data sharing agreement among multiple independent groups from three different countries. In each case individuals and institutions have agreed to make data available for the purposes of the project and advancing the understanding and conservation of the Arabian Sea humpback whale. Data is archived by each of the respective contributing collaborators, and requests for further sharing agreements can be made to any individual collaborator.

10. PERMITS (PLEASE TICK)

Do you have the necessary permits to carry out the field work and have animal welfare considerations been appropriately considered?	n/a
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Do you have the appropriate permits (e.g. CITES) for the import/export of any samples?	n/a
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If 'Yes' please provide further details and enclose copies where appropriate:

References:

- CERCHIO S, JACOBSEN JK, NORRIS TF. 2001. Temporal and geographical variation in songs of humpback whales, *Megaptera novaeangliae*: synchronous change in Hawaiian and Mexican breeding assemblages. *Animal behaviour* 62(2):313-29.
- CERCHIO S, RASOLOARIJAO T, CHOLEWIAK D. 2018a. Progress Report: Acoustic monitoring of Blue Whales (*Balaenoptera musculus*) and other baleen whales in the Mozambique Channel off the Northwest Coast of Madagascar. Paper SC/67B/SH/14 presented to IWC Scientific Committee.
- CERCHIO S, WILLSON A, MUIRHEAD C, AL HARTHI S, BALDWIN R, BONATO M, COLLINS T, DI CLEMENTE J, DULAU V, ESTRADA V, LATHA G, MINTON G, SARROUF-WILLSON M. 2018b. Geographic variation in song indicates both isolation of Arabian Sea humpback whales and presence of Southern Hemisphere whales off Oman. *Paper SC/67B/CMP/19 presented to IWC Scientific Committee.*
- MAHANTY, M. M., LATHA, G., & THIRUNAVUKKARASU, A. 2015. Analysis of humpback whale sounds in shallow waters of the Southeastern Arabian Sea: An indication of breeding habitat. *Journal of Biosciences*, 40, 407-417.
- MADHUSUDHANA SK, CHAKRABORTY B, LATHA G. 2018. Humpback whale singing activity off the Goan coast in the Eastern Arabian Sea. *Bioacoustics*, DOI: 10.1080/09524622.2018.1458248
- MINTON, G., COLLINS, T. J. Q., FINDLAY, K. P., ERSTS, P. J., ROSENBAUM, H. C., BERGGREN, P. & BALDWIN, R. M. 2011. Seasonal distribution, abundance, habitat use and population identity of humpback whales in Oman. *Journal of Cetacean Research and Management, Special Issue on Southern Hemisphere Humpback Whales*, 185–198.
- POMILLA, C., AMARAL, A. R., COLLINS, T., MINTON, G., FINDLAY, K., LESLIE, M. S., PONNAMPALAM, L., BALDWIN, R. & ROSENBAUM, H. 2014. The World's Most Isolated and Distinct Whale Population? Humpback Whales of the Arabian Sea. *PLoS ONE*, 9, e114162.
- SUTARIA D. 2018. Baleen whale reports from the eastern Arabian Sea based on interview surveys and stranding reports - Update from India. *Paper SC/67B/CMP/15 presented to IWC Scientific Committee.*
- WILLSON ET AL. 2018. Update on satellite telemetry studies and first unoccupied aerial vehicle assisted health assessment studies of Arabian Sea humpback whales off the coast of Oman. *Paper SC/67B/CMP/13 presented to IWC Scientific Committee.*

Appendix 2 – DRAFT SCORING SHEET

If a project presents multiple primary objectives which are achieved using sub-projects, a sheet should be used to evaluate each single sub-project. Note that not all criteria are equally applicable depending on the nature of the project (e.g. field work versus workshops).

IWC SCIENTIFIC COMMITTEE PROPOSALS FOR FUNDING - REVIEW CRITERIA - TEST			
TITLE OF THE PROJECT/sub-projects:			
PRINCIPAL INVESTIGATOR:			
Key criteria	Explanation of scoring	Score	Supporting Remarks
<i>Relevance to Scientific Committee priorities</i>			
1	How well aligned are the scientific outcomes of the project/activity with the current SC priority areas?	1 - Not aligned/poorly aligned (e.g. too vague or generic reference to general SC priorities) 2 - Reasonably aligned (e.g. some aspects may be vague or links are not clear) 3 - Well aligned (e.g. outcomes clearly deliver in the most part on priority areas, may also address longer term or potential future issues). 4 - Closely aligned (e.g. of interest for multiple sub-groups or delivers on specific SC high priority topics/recommendations in the immediate or short term).	
2	To what extent will the outcomes of the project/activity contribute to improvements in the conservation and management of cetaceans?	1 - Not at all 2 - Poorly 3 - Reasonably or over the longer term 4 - Well or over the medium term 5 - Excellently or to almost immediate effect	
Note: if in each of the two above key criteria under this section the project does not score singularly at least 2 points, do not proceed in further evaluation. Of course, proposals within a sub-group would only be developed if in their estimation scores were of 4 or above.			
<i>Approach and methodology</i>			
3	What degree of scientific merit/value is there in carrying out the work?	1 - Not demonstrated or of low scientific value 2 - Useful/basic scientific value 3 - Very good scientific value 4 - Excellent/innovative scientific value	
4	Is the proposed methodology scientifically sound and feasible in terms of field and analytical methods?	1 - Feasibility unrealistic & poor methodology or not properly addressed 2 - Feasibility & methodology acceptable but would benefit from some substantial amendments	

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		3 - Feasibility & methodology good, some small changes beneficial 4 - Feasibility & methodology excellent or a highly promising innovative approach to an important question facing the Committee		
5	What is the likelihood of success based on the proposed overall approach and methodology?	1 - No chance of success 2 - Low chance of success/better approaches available 3 - Medium chance of success/some changes to the approach necessary 4 - High chance of success/little or no changes to the approach necessary		
5a	Are objectives of the research likely to be achieved within the proposed time-frame?	1 - No or unlikely 2 - Partially or potentially ambitious 3 - Yes with some minor suggestions 4 - Yes		
5b	Are any proposed intermediary targets timely and achievable?	1 - No or unlikely 2 - Partially 3 - Probably 4 - Yes		
5c	Is the proposed time-frame/work necessary (e.g. can the project produce results in a shorter time period)?	1 - No or unlikely 2 - Partially 3 - Probably 4 - Yes		
5d	Is the sample size adequate to achieve the stated objectives?	1 - Not demonstrated/not properly addressed 2 - No or unlikely (too low/too high) 3 - Probably (additional analysis needed) 4 - Yes		
6	Is the project likely to affect adversely the population(s) involved?	1 - Not properly addressed/ unknown 2 - Yes severely 3 - Possibly at a low level 4 - No		
6a	IF YES , are analyses provided on simulations of the effects using different time-frames for the project if applicable?	1 - No 2 - Partially 3 - Yes		
<p>Note: if in each of the above key criteria under this section the project does not score singularly at least 2 points, do not proceed in further evaluation. Of course, proposals within a sub-group would only be developed if in their estimation scores were of 3 or above.</p>				
<p>Project team and Project management</p>				

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7	To what extent does the team have the relevant expertise, experience, and balance?	1 – Poor or not demonstrated 2 – Sufficient 3 - Very good 4 - Excellent		
8	Contingency plan: To what extent have potential problems/risks been considered and appropriate mitigation proposed?	1 – Poor or not demonstrated 2 – Sufficient but could be improved 3 - Fully or requiring only minor suggestions or not applicable		
<i>Value for Money</i>				
10	Does the project represent good value for money?	1 – No or significant amendments would be needed 2 – Yes but with some minor amendments 3 – Yes		
11	Have sufficient links been made to the wider research community/other organisations/capacity building.	1 – No 2 – Some but significant amendments needed 3 – Yes but with some minor additions 4 – Yes or not applicable		