Global variation in shape and size of orca (*Orcinus orca*) saddle patches

Pirjo H. Mäkeläinen[1,2], Ingrid N. Visser[1], Tracy E. Cooper[1], Mathieu Cusson[3]

[1] Orca Research Trust, Tutukaka, Northland, New Zealand,

[2] Faculty of Biological and Environmental Sciences, University of Helsinki, Helsinki, Finland,

[3] Département des sciences fondamentales, Université du Québec à Chicoutimi, Chicoutimi, Québec, Canada

Introduction

Orca (killer whale) distribution around the world is widespread and populations have adapted to a range of habitats and differentiated into ecotypes. By the 1970's, saddle patches of orca were recognised as unique to each individual and by the 1980's researchers began to establish that there were differences in general saddle patch shapes between populations and ecotypes. More recently, with data-sharing and identification catalogues readily available online, comparisons of populations and ecotypes at a global level are potentially more robust. Despite previous research, it appears that the variation of the saddle patch sizes between ecotypes or populations has been limited to descriptions (e.g., Evans & Yablokov, 1978; Sugarman, 1984) and they have not been used extensively to delimited ecotypes in the peer-reviewed literature.

OBJECTIVES: The main goal of our study was to find out how differentiated the orca saddle patch shapes and sizes are among orca groups around the globe.

Methods : Saddle patch shape

We compiled photographs of orca from various sources (published articles, catalogues, data from research centres, field researchers, citizen scientists, NGO's, whale watching companies and from our own collections). We collated the saddle patches of >3,900 orca, from 48 geographically or ecologically divided groups (Figure 1), using six known shape variants (Figure 2).

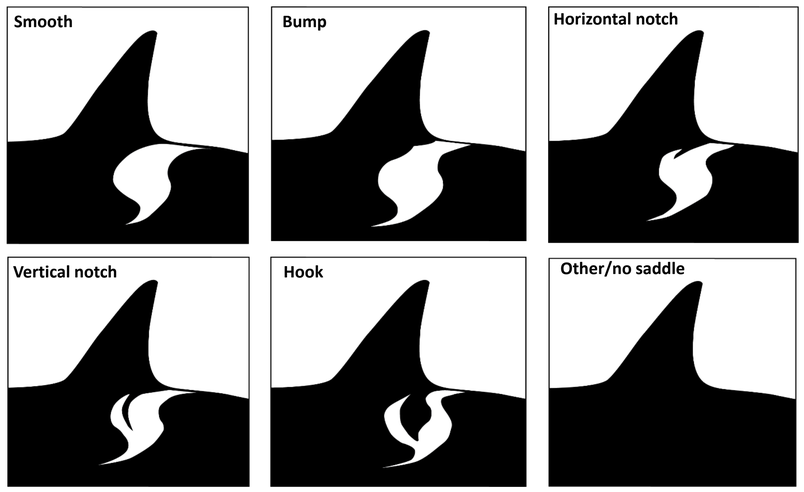
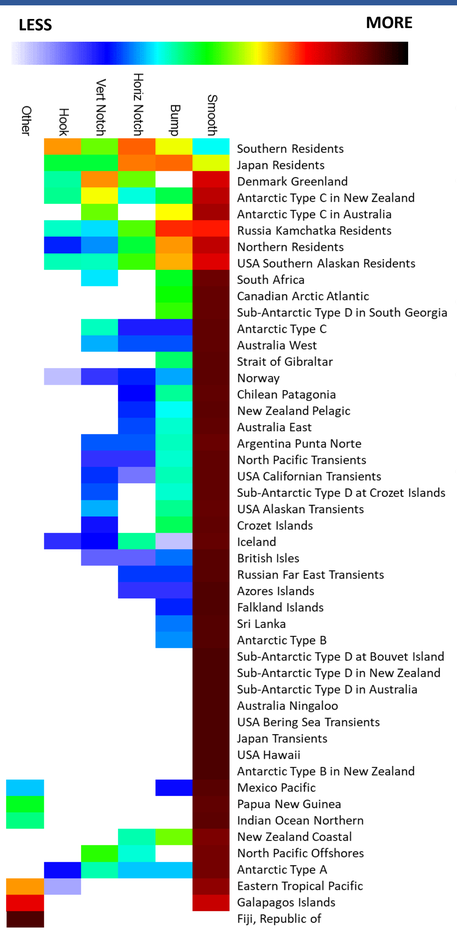


Figure 2. Shape of saddle patches: Saddle patches were categorised into five standardized shape variations or allocated to a sixth variant which included those which were too dark to define or had no saddle patch visible, (Drawings P. H. Mäkeläinen & S. Remes, modified from Sugarman, 1984).

Results : Saddle patch shape



HIGHLIGHTS

- The smooth patch type is the most common while Fiji has no visible saddle patches.
- All five Pacific Resident ecotype groups, Antarctic Type C groups in New Zealand and Australian waters as well Greenland group had most variable saddle patches.
- All six Transient groups had much less variation in saddle shapes than the Resident ecotypes.
- From Antarctic ecotypes, Type C had more variation than Type A, while Type B had mainly smooth saddle patches.
- Groups from Galapagos, Eastern Tropical Pacific, Mexico Pacific, Papua New Guinea and Indian Ocean Northern had individuals with normal and darker coloured saddle patches as well as individuals without visible saddle patches ('Other' category).

Figure 3. Percentage occurrence (log scale standardised by total occurrence) of saddle patch shape in each geographical/ecotype group ordered by a cluster analysis (average cluster mode).

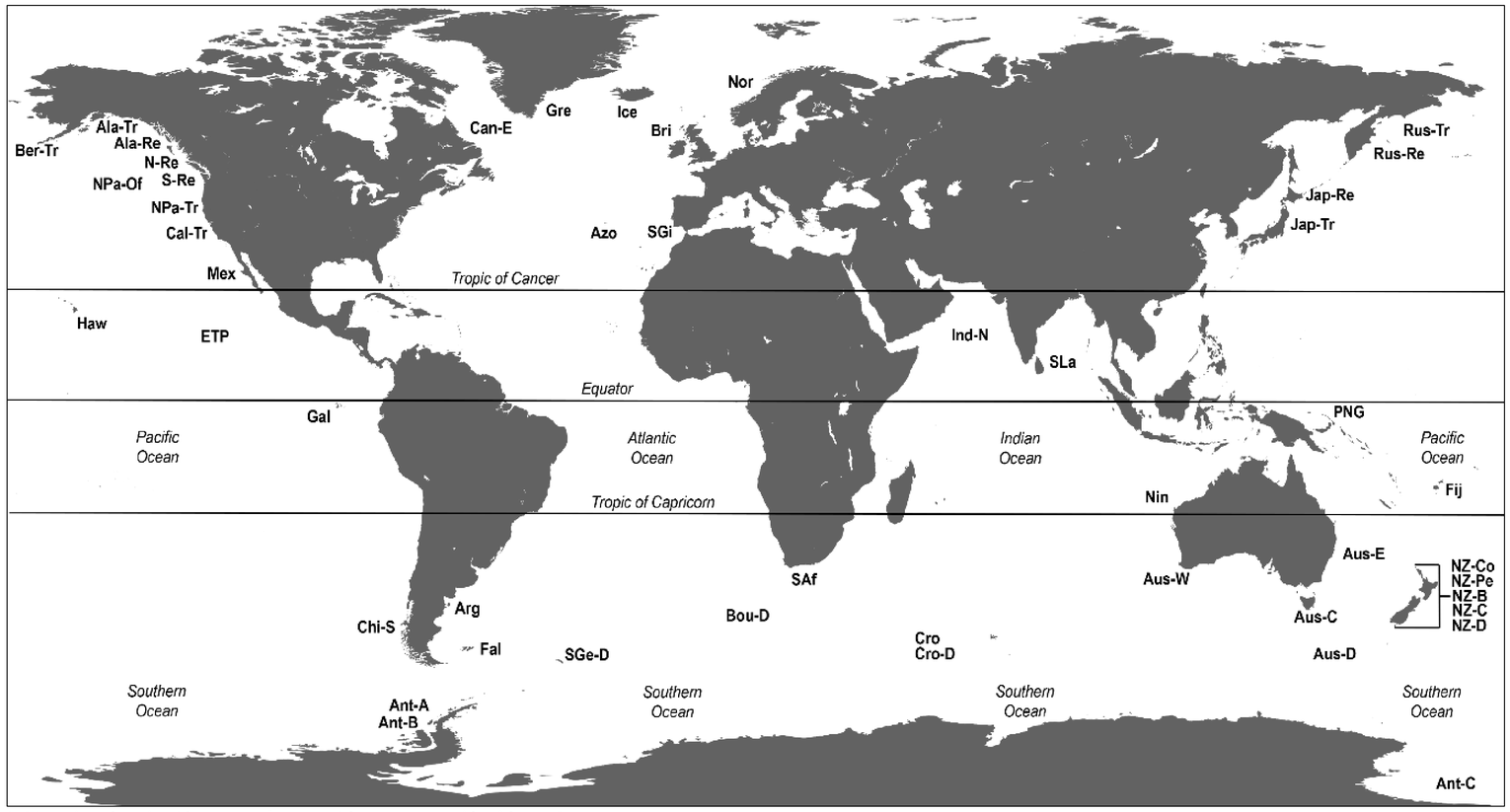


Figure 1. Map showing the 48 ecotype/geographic groups used in this study. Ant-A = Antarctic Type A, Ant-B = Antarctic Type B, NZ-B = Antarctic Type B in New Zealand, Ant-C = Antarctic Type C, Aus-C = Antarctic Type C in Australia, NZ-C = Antarctic Type C in New Zealand, Arg = Argentina Punta Norte, Aus-E = Australia East, Nin = Australia Ningaloo, Aus-W = Australia West, Azo = Azores Islands, Bri = British Isles, Can-E = Canadian Arctic Atlantic, Chi-S = Chilean Patagonia, Cro = Crozet Islands, Gre = Denmark Greenland, ETP = Eastern Tropical Pacific, Fal = Falkland Islands, Fij = Fiji, Republic of, Gal = Galapagos Islands, Ice = Iceland, Ind-N = Indian Ocean Northern, Jap-Re = Japan Residents, Jap-Tr = Japan Transients, Mex = Mexico Pacific, NZ-Co = New Zealand Coastal, NZ-Pe = New Zealand Pelagic, NPa-Of = North Pacific Offshores, NPa-Tr = North Pacific Transients, N-Re = Northern Residents, Nor = Norway, PNG = Papua New Guinea, Rus-Re = Russia Kamchatka Residents, Rus-Tr = Russian Far East Transients, SAf = South Africa, S-Re = Southern Residents, SLa = Sri Lanka, SGi = Strait of Gibraltar , Bou-D = Sub-Antarctic Type D at Bouvet Island, Cro-D = Sub-Antarctic Type D at Crozet Islands, Aus-D = Sub-Antarctic Type D in Australia, NZ-D = Sub-Antarctic Type D in New Zealand, SGe-D = Sub-Antarctic Type D in South Georgia, Ala-Tr = USA Alaskan Transients, Ber-Tr = USA Bering Sea Transients, Cal-Tr = USA Californian Transients, Haw = USA Hawaii, Ala-Re = USA Southern Alaskan Residents.

Methods : Saddle patch size

We used a new method to compare saddle patch sizes, with a ratio of the saddle patch width at its widest compared to dorsal fin width at its base. We measured over >3,000 individuals from 47 groups (Fiji was excluded, since no visible saddle patches) and three size ratio variants (Fig. 4).

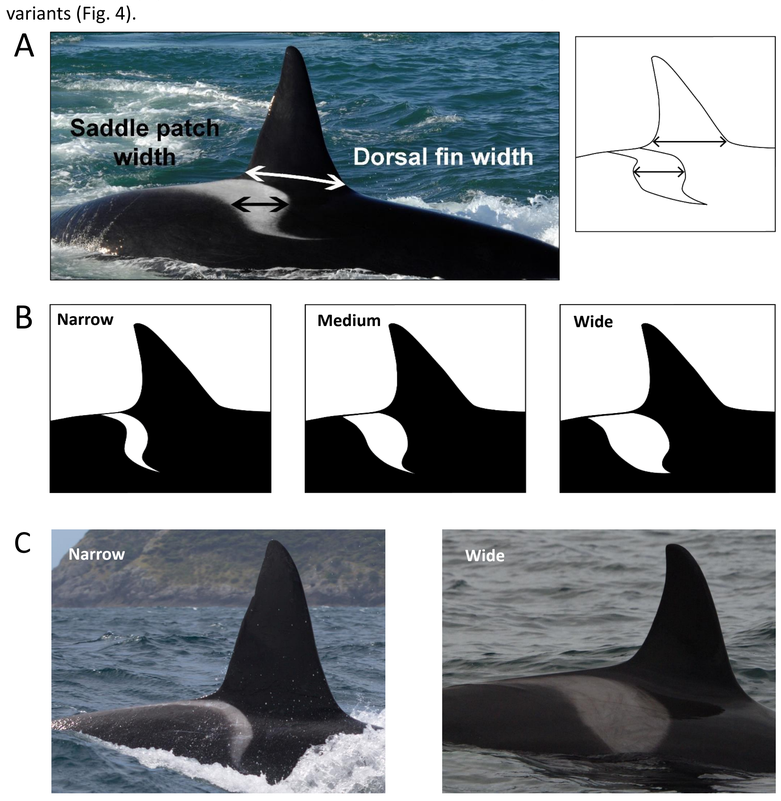


Figure 4. A) Example of how the ratio was measured. B) Three saddle patch size variants: narrow, medium and wide. C) Two individuals in the New Zealand Coastal ecotype illustrate variations in saddle patch size. (Photos I. N. Visser, , Drawings P. H. Mäkeläinen & S. Remes).

Results : Saddle patch size ratio

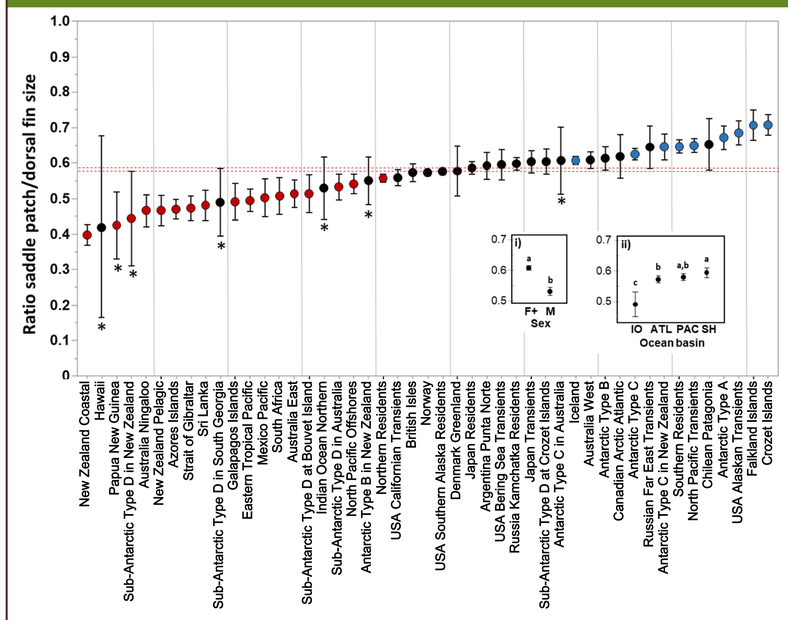


Figure 5. Average ratio (±CI 95%) of saddle patch size to dorsal fin width for each group. Red bracket line show the ±CI 95% of the overall average. Groups with blue or red point average show ratio values greater or lower than the overall average. Inset graphs: average (±CI 95%) ratio i) between sex (F+ = female including juvenile and unsexed individuals) and ii) among Ocean basins where different letters above average show significant differences ($p < 0.05$). Points marked with stars, have small sample size ($n < 8$).

HIGHLIGHTS

- New Zealand Coastal & Pelagic ecotypes as well Australia Ningaloo have the lowest ratio averages.
- North Atlantic Azores islands and Strait of Gibraltar orca have narrower averages than the more northerly groups in the Atlantic Ocean.
- The largest averages can be found at Crozet Islands, Falkland Islands, Antarctic Type A, Chilean waters and among Transient groups.
- The ratio was higher in the Southern hemisphere and in the Pacific Ocean basin, whilst orca from the Indian Ocean showed a lower ratio.

Acknowledgements

We want to warmly thank all the orca researchers, photographers and helpful volunteers who provided materials for our study.

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Conclusions

- **Differences can be found in orca saddle patch shape and size between the geographic/ecotype groups.**
- **This may provide a non-invasive method to identify undescribed ecotypes, or more clearly differentiate sympatric ecotypes.**
- **Such results may help assessments for marine Management Authorities and policy makers in the creation of recovery or conservation plans**

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By the 1970's, saddle patches of *Orcinus orca* (killer whale / orca) were recognised as unique to each individual and by the 1980's, researchers began to establish that there were also differences in general saddle patch shapes between populations and ecotypes. More recently, with data-sharing and identification catalogues readily available online, comparisons of populations and ecotypes at a global level are potentially more robust. We compared the saddle patches of > 3,900 orca, from 48 geographically or ecologically divided groups, using six variants. For the first time, we assessed saddle patch width on a global scale, using a ratio measurement (comparing the width of the saddle patch to the width of the dorsal fin). We found global differences in saddle patch shape, however there were certain shapes that were more prevalent than others. One shape ('Smooth') was found worldwide in all but one group (from Fiji, in the Pacific Ocean) and eight groups exhibited only 'Smooth' saddle patches. In contrast, nine groups exhibited all five saddle patch types. Size ratios differed across Ocean basins with the highest variability observed in the Southern Hemisphere. When size was compared across geographic groups, the narrowest saddle patches were found on New Zealand Coastal orca and the widest on the Crozet Islands. Our study may help researchers to identify undescribed ecotypes, or more clearly differentiate sympatric ecotypes, and thereby help assessments for marine Management Authorities and policy makers in the creation of recovery or conservation plans.

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[1]Orca Research Trust, Tutukaka , Northland, New
[2] Faculty of Biological and Environmental Sciences, University of Helsinki, Helsinki, Finland,
[3] Département des sciences fondamentales, Université du Québec à Chicoutimi, Chicoutimi, Québec, Canada

TWEET:
orca saddle patches vary between groups; using >3,700 orca, from 48 groups, 4 the 1st time we assessed width on a global scale: narrowest saddle patches on NZ Coastal orca & widest on Crozet Islands, findings can also help researchers identify undescribed ecotypes