Fidelity to natal social groups and mating within and between social groups in an endangered false killer whale population

Karen K. Martien*, Barbara L. Taylor, Susan J. Chivers, Sabre D. Mahaffy, Antoinette M. Gorgone, Robin W. Baird

*Corresponding author: karen.martien@noaa.gov

Endangered Species Research 40: 219–230 (2019)

Age-class determination

All individuals are given an identification (ID) number in the catalog regardless of distinctiveness or photo quality; however, analyses are usually restricted to individuals that are distinctive and sightings with good or excellent photo quality. Re-sightings of individuals are based on natural markings on the body such as scars or notches on the dorsal fin. Dorsal fin notch acquisitions or changes for this population have been estimated to occur on average every 6.9 to 8.8 years (Baird et al. 2008); thus, individuals with notches are typically at least a year old. To avoid falsely excluding a true parent from the candidate pool, we purposely erred on the late side when determining the latest year the individual could possibly have been born (birth_year) and on the early side when determining the earliest year the individual could possibly have reproduced (repro_year). An individual was deemed an adult once eight years had passed since it was first identified (either genetically or photographically). If eight years had not passed since it was first identified, all photographs of the individual when other individuals were visible in the photo were assessed to determine relative size (e.g., whether the individual was approximately the same size as other known adults or smaller indicating it may be a sub-adult or juvenile). Given the slow acquisition of notches, the number of notches on the dorsal fin was also considered, with individuals with few or no notches and small relative size categorized as juveniles. For individuals classified as juveniles or sub-adults the first year in which they were sighted, birth_year equaled the year they were first identified. For those identified as adults in their first sighting, birth_year equaled 10 years prior to first sighting for females and 15 years prior to first sighting for males, as females and males are thought to reach physical maturity at ages 10 and 15, respectively (Ferreira et al. 2014). For individuals classified as juveniles, repro_year was defined as the year after they were last seen as a juvenile. The earliest possible year of reproduction could not be confidently determined for any individuals that were first sighted as adults or sub-adults. Females were deemed adults due to having a small calf in close proximity only when photos clearly showed a calf in infant position relative to the identified mother during surfacing. In these instances, calves could not reliably photographically-identified due to lack of body scars and dorsal fin notches.
Figure S1. Distribution of pairwise relatedness values for all individuals in the data set.
Table S1. Stage categories of individuals based on photo-identification data collected through 2013. Categories are A=adult, SA=sub-adult and J=juvenile. Stages prefaced with P are probable categories. Stage categories given are for the most recent year seen, unless a year is noted in parentheses. The column labeled ‘Basis’ indicates the data on which the age determination is based. IC=in catalog more than eight years, M=markings, RS=Relative size in photographs with other individuals present, and W/C means with calf (year seen with calf in parentheses). Distinctiveness of the individual was rated as 4=very distinctive, 3=distinctive, 2=slightly distinctive, 1=not distinctive.

| ID     | First seen | Last seen | # years seen | # times seen | Distinctiveness | Stage category | Basis          |
|--------|------------|-----------|--------------|--------------|----------------|----------------|----------------|
| 18945  | 1988       | 2010      | 9            | 21           | 4              | A              | IC             |
| 18946  | 2000       | 2010      | 7            | 10           | 4              | A              | IC             |
| 18954  | 2000       | 2000      | 1            | 1            | 2              | P A            | M              |
| 18955  | 2000       | 2008      | 2            | 3            | 3              | A              | IC             |
| 23316  | 2001       | 2010      | 7            | 16           | 4              | A              | M / IC         |
| 23317  | 2001       | 2010      | 6            | 8            | 4              | A              | IC             |
| 23318  | 2000       | 2010      | 5            | 13           | 2              | A              | IC, W/C (2008) |
| 23319  | 1990       | 2010      | 10           | 15           | 4              | A              | IC             |
| 23320  | 1999       | 2008      | 6            | 10           | 4              | A              | IC             |
| 23321  | 2001       | 2010      | 6            | 15           | 4              | A              | M, W/C (2006)  |
| 27453  | 2002       | 2010      | 3            | 3            | 1              | P A            | RS, W/C        |
| 30073  | 2002       | 2004      | 2            | 2            | 4              | A              | M              |
| 33885  | 2003       | 2010      | 4            | 7            | 4              | A              | M/RS           |
| 33886  | 2003       | 2003      | 1            | 1            | 4              | A              | M              |
| 33887  | 2003       | 2010      | 5            | 7            | 4              | A              | RS, M          |
| 33888  | 2003       | 2010      | 4            | 6            | 3              | P SA           | RS, M          |
| 33890  | 2002       | 2003      | 2            | 2            | 1              | P SA           | M              |
| 33892  | 2002       | 2003      | 2            | 2            | 4              | A              | M              |
| 33895  | 2003       | 2010      | 5            | 7            | 3              | A              | W/C (2009)     |
| 33898  | 2003       | 2010      | 5            | 8            | 3              | P A            | RS, M          |
| 33899  | 2003       | 2007      | 3            | 4            | 3              | A              | W/C (2007)     |
| 33902  | 2003       | 2008      | 3            | 4            | 3              | P SA           | M              |
| 33903  | 2003       | 2010      | 5            | 6            | 4              | A              | M/RS           |
| 33905  | 2003       | 2010      | 4            | 4            | 3              | P A            | RS             |
| 33906  | 2003       | 2009      | 4            | 5            | 3              | A              | M              |
| 33907  | 2003       | 2004      | 2            | 2            | 3              | A              | M              |
| 33908  | 2003       | 2010      | 5            | 9            | 4              | A              | RS, M          |
| 33909  | 2003       | 2004      | 2            | 2            | 4              | P A            | M              |
| 41286  | 2001       | 2010      | 7            | 10           | 4              | A              | IC             |
| 45925  | 1986       | 2010      | 6            | 6            | 4              | A              | IC             |
| 45928  | 2003       | 2010      | 4            | 5            | 4              | A              | RS, M          |
| 45932  | 2003       | 2003      | 2            | 2            | 4              | P A            | M              |
| 49043  | 2005       | 2010      | 2            | 2            | 4              | P A            | M              |
| 49046  | 2005       | 2010      | 2            | 2            | 4              | A              | RS, M          |
| 49048  | 2002       | 2009      | 3            | 3            | 3              | P J            | M              |
| 49050  | 2004       | 2008      | 3            | 3            | 4              | A              | M              |
| 49051  | 2005       | 2010      | 2            | 2            | 3              | A              | M              |
| 49052  | 2005       | 2005      | 1            | 1            | 3              | A              | M              |
| 71016  | 2005       | 2010      | 5            | 14           | 3              | P A            | RS             |
| ID    | Start Year | End Year | Type | IC/RS/M   |
|-------|------------|----------|------|-----------|
| 4049  | 2000       | 2010     | 8    | 4         | A       |
| 73895 | 2008       | 2008     | 1    | 3         | P A M   |
| 75660 | 2003       | 2010     | 6    | 3         | P A RS, M |
| 75661 | 2008       | 2008     | 1    | 3         | P A M   |
| 75662 | 1990       | 2010     | 9    | 4         | A IC    |
| 75663 | 2000       | 2010     | 7    | 4         | A IC    |
| 75665 | 1991       | 2010     | 12   | 4         | A IC    |
| 75676 | 2005       | 2010     | 6    | 3         | P A RS  |
| 75677 | 2008       | 2010     | 3    | 1         | J (2008) RS |
| 75678 | 2007       | 2010     | 4    | 2         | P J (2007) M |
| 75679 | 2005       | 2010     | 6    | 3         | P J M   |
| 75680 | 2006       | 2009     | 2    | 2         | P SA RS, M |
| 75681 | 2009       | 2009     | 1    | 3         | A W/C   |
| 75682 | 2009       | 2009     | 1    | 4         | A IC, M |
| 75683 | 2009       | 2009     | 1    | 4         | A M     |
| 75684 | 2009       | 2009     | 1    | 1         | J RS    |
| 75685 | 2009       | 2009     | 1    | 3         | A W/C   |
| 75686 | 2010       | 2010     | 1    | 1         | J RS    |
| 75687 | 2010       | 2010     | 1    | 2         | P A M   |
| 75688 | 2009       | 2009     | 1    | 3         | J RS    |
| 75689 | 2008       | 2011     | 4    | 1         | J (2008) M/RS |
| 75690 | 2009       | 2010     | 2    | 6         | P J M   |
| 75691 | 2007       | 2010     | 4    | 3         | P J (2007) M |
| 75692 | 2004       | 2010     | 7    | 3         | P A RS  |
| 75693 | 2005       | 2010     | 3    | 4         | A M     |
| 75694 | 1995       | 2010     | 10   | 4         | A IC    |
| 75695 | 2004       | 2010     | 7    | 4         | A M/RS  |
| 75696 | 2008       | 2011     | 5    | 1         | P J (2008) M |
| 75697 | 1999       | 2010     | 10   | 4         | A IC    |
| 75698 | 2000       | 2010     | 6    | 3         | A M, IC |
| 75699 | 2010       | 2010     | 1    | 2         | P J RS, M |
| 75700 | 2010       | 2010     | 1    | 3         | P SA M   |
| 75701 | 2009       | 2009     | 1    | 2         | P SA M   |
| 75702 | 2005       | 2010     | 4    | 3         | P A M   |
| 75703 | 2008       | 2010     | 2    | 4         | J (2008) RS |
| 75704 | 2004       | 2010     | 3    | 5         | A M     |
| 75705 | 2005       | 2010     | 6    | 3         | A RS    |
| 75706 | 2010       | 2010     | 4    | 3         | P A M   |

4
Table S2. Parent/offspring pairs identified with high confidence by CERVUS. For those pairs in which the relative ages of the individuals could be determined from photographic and sighting data, the ID of the individual identified as the parent is in bold. The first six columns provide the sample identification numbers, sex, and haplotype for the two individuals in the pair. The columns labeled ‘Soc1’ and ‘Soc2’ give the social group for MHI individuals. A blank indicates that the social group affiliation is unknown, while ‘NWHI’ indicates the individual is from the NWHI population. ‘Loci’ indicates the number of microsatellite loci at which both individuals were scored and could therefore be compared and ‘Mis-match’ indicates the number of loci at which the two individuals do not share at least one allele. Mismatches can occur due to mutation, genotyping error, or incorrect assignment of parentage.

| ID1  | ID2   | Sex1 | Sex2 | Hap1 | Hap2 | Soc1 | Soc2 | Loci | Mis-match |
|------|-------|------|------|------|------|------|------|------|-----------|
| 18945| 75677 | F    | F    | 2    | 2    | 1    | 1    | 13   | 1         |
| 18954| 33907 | M    | M    | 1    | 1    | P    | 3    | 16   | 0         |
| 18955| 91083 | F    | M    | 1    | 1    | P    | P    | 16   | 0         |
| 23316| 23321 | M    | F    | 1    | 1    | 1    | 1    | 16   | 0         |
| 23316| 98746 | M    | M    | 1    | 2    | 1    | 2    | 16   | 0         |
| 23317| 91277 | M    | F    | 1    | 1    | 1    | P    | 13   | 0         |
| 23317| 92256 | M    | M    | 1    | 1    | 1    | 1    | 15   | 0         |
| 23318| 30078 | F    | M    | 2    | 2    | 1    | 1    | 15   | 0         |
| 23318| 75666 | F    | F    | 2    | 2    | 1    | 1    | 16   | 0         |
| 23320| 98738 | F    | M    | 2    | 2    | 1    | 1    | 16   | 0         |
| 27453| 27454 | F    | F    | 1    | 1    | 1    | 3    | 16   | 0         |
| 30072| 98743 | F    | F    | 1    | 1    | 2    | 2    | 16   | 0         |
| 30073| 23321 | M    | F    | 1    | 1    | 2    | 1    | 16   | 1         |
| 30077| 49054 | M    | F    | 1    | 1    | 2    | 1    | 15   | 1         |
| 30077| 102483| M    | M    | 1    | 1    | 3    | 14   | 0         |
| 30081| 49049 | F    | M    | 1    | 1    | 2    | 1    | 13   | 0         |
| 33886| 45932 | M    | M    | 1    | 1    | 3    | 3    | 16   | 0         |
| 33886| 75666 | M    | F    | 1    | 2    | 3    | 1    | 16   | 1         |
| 33887| 123188| F    | F    | 1    | 1    | 3    | 3    | 12   | 2         |
| 33888| 30078 | F    | M    | 1    | 2    | 3    | 1    | 14   | 0         |
| 33890| 30078 | F    | M    | 1    | 2    | 3    | 1    | 15   | 0         |
| 33890| 123188| F    | F    | 1    | 1    | 3    | 3    | 15   | 0         |
| 33892| 33909 | F    | M    | 1    | 1    | 3    | 3    | 14   | 0         |
| 33895| 45932 | F    | M    | 1    | 1    | 3    | 3    | 16   | 0         |
| 33902| 33908 | F    | M    | 1    | 1    | 3    | 3    | 16   | 2         |
| 33902| 45928 | F    | F    | 1    | 1    | 3    | 3    | 15   | 0         |
| 33903| 33904 | F    | M    | 1    | 1    | 3    | 3    | 14   | 0         |
| 33907| 98736 | M    | F    | 1    | 2    | 3    | 1    | 16   | 0         |
| 45925| 75666 | M    | F    | 2    | 2    | 2    | 1    | 14   | 0         |
| 49044| 30072 | F    | F    | 1    | 1    | 2    | 1    | 13   | 1         |
| 49046| 49051 | F    | F    | 2    | 2    | 2    | 2    | 15   | 1         |
| 49047| 30078 | F    | M    | 2    | 2    | 2    | 2    | 14   | 0         |
| 49047| 49051 | F    | F    | 2    | 2    | 2    | 2    | 14   | 1         |
| ID   | Age | Gender | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 |
|------|-----|--------|--------|--------|--------|--------|--------|--------|
| 49051 | 98746 | F  | M  | 2 | 2 | 2 | 2 | 15 | 0 |
| 49052 | 98745 | M  | M  | 5 | 2 | 2 | 2 | 13 | 0 |
| 71016 | 71017 | M  | F  | 2 | 2 | 1 | 1 | 16 | 0 |
| 75661 | 33886 | M  | M  | 1 | 1 | 1 | 3 | 16 | 1 |
| 75663 | 30078 | M  | M  | 2 | 2 | 1 | 15 | 1 |
| 75666 | 75677 | F  | F  | 2 | 2 | 1 | 1 | 16 | 0 |
| 75676 | 75679 | F  | F  | 1 | 1 | 1 | 1 | 16 | 0 |
| 75678 | 75679 | F  | F  | 1 | 1 | 1 | 1 | 16 | 0 |
| 75679 | 92256 | F  | M  | 1 | 1 | 1 | 1 | 16 | 0 |
| 91276 | 91277 | F  | F  | 1 | 1 | P | P | 14 | 0 |
| 91284 | 18938 | M  | F  | 1 | 1 | P | 14 | 1 |
| 91284 | 23317 | M  | M  | 1 | 1 | P | 1 | 14 | 0 |
| 98732 | 98737 | F  | F  | 2 | 2 | 1 | 1 | 16 | 0 |
| 98740 | 30078 | F  | M  | 1 | 2 | 1 | 15 | 0 |
| 98743 | 102485 | F  | M  | 1 | 1 | 2 | 3 | 16 | 0 |
| 98744 | 30078 | M  | M  | 1 | 2 | 2 | 15 | 0 |
| 102500 | 23318 | M  | F  | 1 | 2 | 1 | 1 | 16 | 1 |
| 102500 | 30078 | M  | M  | 1 | 2 | 1 | 15 | 0 |
| 123188 | 33907 | F  | M  | 1 | 1 | 3 | 3 | 15 | 1 |
LITERATURE CITED

Baird RW, Gorgone AM, McSweeney DJ, Webster DL and others (2008) False killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands: long-term site fidelity, inter-island movements, and association patterns. Mar Mamm Sci 24:591–612