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An Investigation of Photo-Identification as an Application of Capture-recapture Methodology for Establishing Site Fidelity of Pinnipeds at Cupsogue Beach County Park, Long Island, New York

By Gabrielle Pacia

Problem

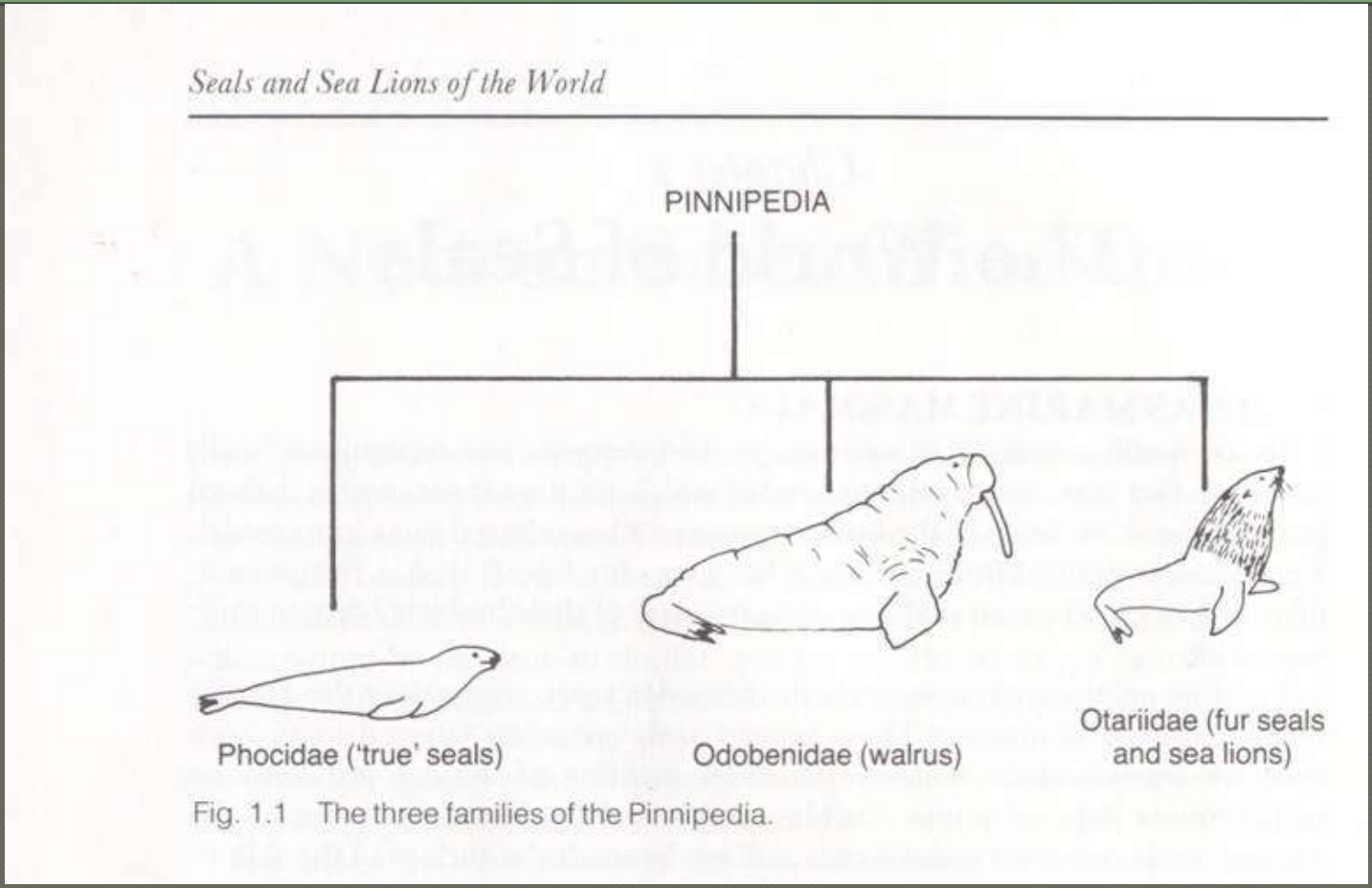
1) Site fidelity of seals is not well understood for Cupsogue Beach County Park, Long Island, New York

2) Methods for identifying pinniped site fidelity have not been well-established.

Purpose

- The purpose of this study is to identify seals observed and photographed at Cupsogue Beach County Park, Long Island, New York from 2007-2010 through photographic analysis (photo-ID) to establish a method for determining whether they return to the same haul-out location (site fidelity) through-out the season and between years.

Classification Chart



(Seals and Sea Lions of the World, Bonner, 1994)

Background- True Seals

True seals are from the Family Phocidae and are the only type known to visit Long Island. They are often called "earless" seals because they have no cartilaginous flap visible on the surface which makes them appear to be earless (CRESLI, 2008).

Five Types:

- Grey (*Halichoerus grypus)*
- Harbor *(Phoca vitulina)*
- Harp *(Pagophilus groenlandicus)*
- Hooded (Cystophora cristata)
- Ringed *(Phoca hispida)*

Grey Seal

Harbor Seal

Harp Seal

Hooded Seal

Ringed Seal

Study Location: Cupsogue Beach

Source: Google Earth retrieved on December 18, 2008 from: earth.google.com

Previous Studies- Cupsogue Beach County Park

Table 1: Number of seals spotted in previous years during CRESLI seal walks

Year	Seal Type	Number
2007	Grey Harbor Harp	147 369 4
2008	Grey Harbor Harp Hooded	20 587 4 1
2009	Grey Harbor Hooded Ringed	7 420 1 1

* Site fidelity was not a part of these studies.

(CRESLI, 2009)

MARK-RECAPTURE METHOD

- Seals are captured and marked with a brand or tag. Then, they are re-sighted or recaptured at a later time.

(Hastings, Small, Hiby, 2001)

CAPTURE-RECAPTURE METHOD

- Photo-Identification is a "capture-recapture" method that uses re-sighting events of seals with distinctive markings to study the movement patterns, site fidelity, and population size (Karlsson, Hiby, Lundberg, 2005).

Previous Study

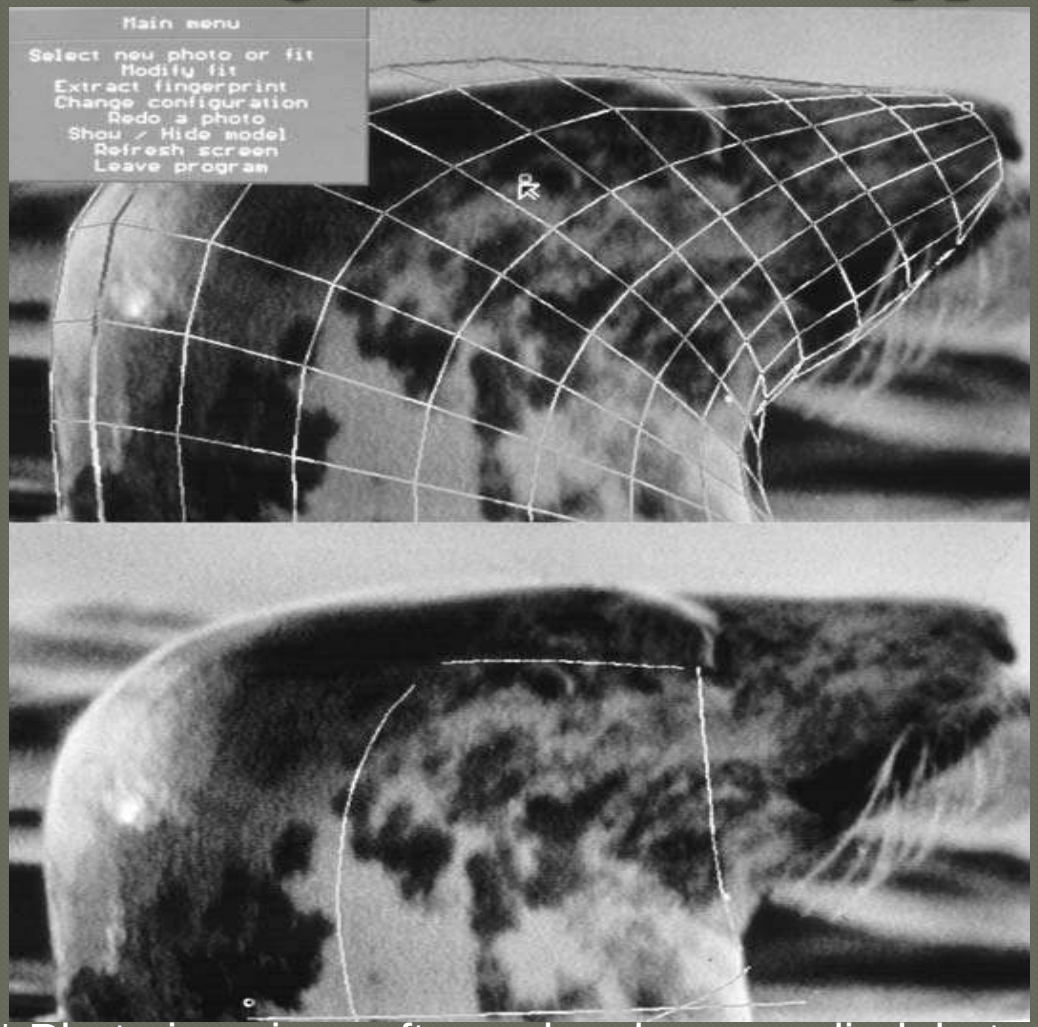
- In the Baltic Sea, movements and site fidelity of grey seals were studied by using mark-recapture methods and an analysis based on photo-identification of individuals.
- Seals were photographed at major summer haul-out sites each year from 1995-2000. Each major haul-out site was visited by boat two or three times each summer with a minimum of two weeks between successive trips to avoid photographing the same seal during the same haul-out occasions. Data shows that re-sightings frequently level off after approximately 10-14 days.

(Karlsson, Hiby, Lundberg, 2005).

Previous Study

- The photographs were then put into a computer software program that used complex calculations in order to match head and neck markings of an individual seal.
- The results of this experiment showed that grey seal exhibit strong site fidelity during the summer based on re-sightings of grey seals that could later be identified in the software program from previous years. Of 636 re-sightings 78% occurred in the area where the seals previously were and only 22% in another area. (Karlsson, Hiby, Lundberg, 2005).

Photo Imaging Software Application



* Photo imaging software has been applied, but does not meet the goals of this project which is to find an affordable means and rapid assessment method to analyze site fidelity.

Source: Karlsson et al. (2005)

I³S Manta version 2.1

- I³S is an acronym of Interactive Individual Identification System. I³S is an adaption that does not only take into account spot location, but spot size and shape.
- The user must point out the most distinguishing spots on each image and create three fixed reference points. Once the user annotates an image, I³S automatically matches an annotated image with all other annotated images on the database and shows a ranked list of images.
- This software was tested rigorously using data from ragged tooth shark database. The experiment to test I³S was repeated 100 times and revealed that images were ranked correctly 72% of the time or higher.

(den Hartog, Reijns, 2008)

Hypothesis

- H_{O1} -A minimum of five markings will not prove reliable for pinniped identification criteria.
- H_{A1} -A minimum of five markings will prove reliable for pinniped identification criteria.
- H_{O2-}Seals will not return to the same haul-out sites each year. (ANOVA)
- H_{A2-} Seals will return to the same haul-out sites each year.
- H_{O3-} Adult Photo-ID fingerprint will not match up between years.
- H_{A3-} Adult Photo-ID will match up between years.

Materials

Phase I & II- Software:

Adobe Lightroom I & II

I^3S Manta

Microsoft Excel ToolPak and/or SPSS

Experimental Photos from Dr. A. Koppelman, President, CRESLI.org

Control Photos from Riverhead Foundation

Methodology

Method I : Right Side Profile Fingerprint (RSPF)

- Experiment photographs: Collect and organize pinniped right side profile photos provided by CRESLI from Cupsogue Beach County Park for the years 2007-2010.
- Control photographs: Photograph right side profile of seals at different angles located at the Riverhead Foundation.
- Identify area polygons from three fixed reference points (eye to false ear to nape) for each photograph in the control and experimental group.
- Develop protocols based on control photos and repeated tests for Pinniped Fingerprint ID (PFID) using a minimum of five criteria markings. (Completed 2009)

Methodolgy

Method II: Interactive Individual Identification System (I^3S Manta)

- Identify area polygons from three fixed reference points (eye to false ear to nape) for each photograph in the control and experimental group.
- Apply I^3S Manta to both the experimental and control group photos to determine protocol feasibility for identifying site fidelity.

I^3S Manta Protocol

Two match values were used for both male and female. Match values are calculated by first finding corresponding match pairs. A spot pair is accepted as a good match if the nearest other candidate is at least twice the distance of the current match. Further, the spot sizes and the ratio between length and width of both ellipses should be similar. The green lines indicate whether two spots are considered a matching spot pair. From these pairs a distance metric is calculated to be able to rank each image in the database. The current metric is the sum of the distances between each spot pair, divided by the square of the number of spot pairs (den Hartog, Reijns, 2008).

Formula:

$d1 + d2/ \sqrt{s} = r$ d= metric distance between spot pairs

s= number of spot pairs

r= rank in database

Methodology

Method III: Name Game

- This method is based on the naming of humpback whales conducted by the Gulf of Maine group for the North Atlantic Humpback Whale Catalogue.
- Key characteristics are identified by committee and assigned names by each individual. A consensus vote by the committee determines the name of the individual humpback whale.
- These protocols were applied for the naming of seals from CBCP.

Preliminary Photo Data (Control)

Table 2: Preliminary Control Population Data

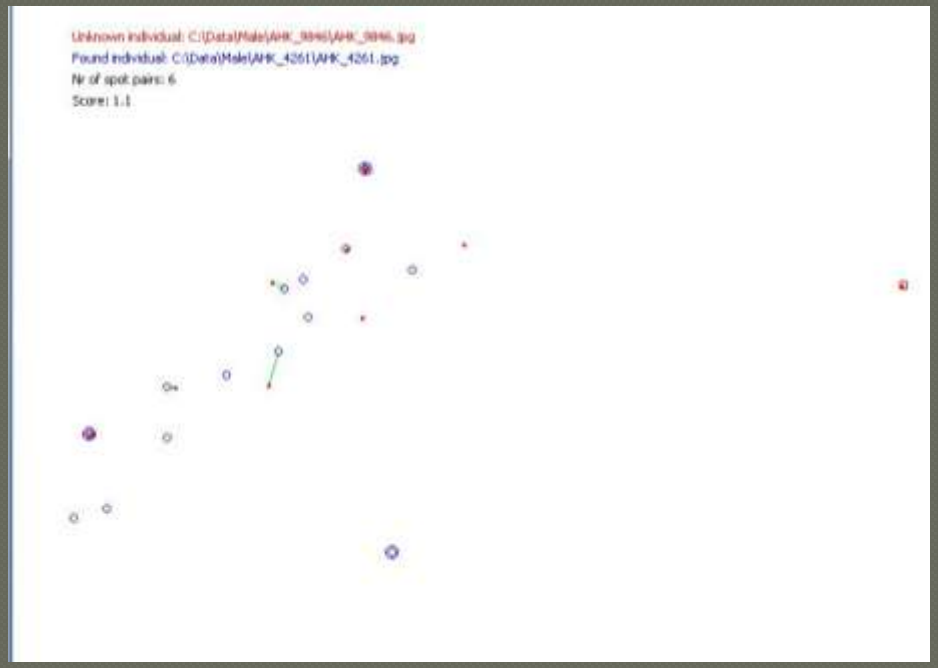
Common Name	Latin Name	Sex	Profile L/R	Number of confined markings view 1	Number of confined markings view 2	Lacerations	Special Notes	Photo
Harbor	*Phoca vitulina*	F	Right	5	8		2 views	
Grey	*Halichoerus grypus*	M	Left	8	7		2 views	
Grey	*Halichoerus grypus*	F	Left	11	12	✔		

RSPF Data

- Useful data could not be obtained due to image resizing problems.

I³S Manta

Spot Cloud



Annotated Seal

Seal Number/ Year	Distinguishing Marking	Additional Distinguishing Markings	Name
AHK_3626/2010, AHK_3468/2009	Three spots connected by lines on right ventral chest.	Spots make a "J" formation on right ventral chest.	Water Molecule
AHK_0654-2-2/2010, 0611-2-2/2009	Spots create an apple formation on left ventral chest.		Apple
AHK_3767/2010, AHK_3769/2009	Two separate formations of spots create images of a man on a segway. One located on left ventral chest the other located on right dorsal back.		Segway
AHK_4123/2010, AHK_4124/2009	Spot looks like a palm tree on right side of head.		Palm Tree
AHK_9886/2010, AHK_9899/2009	Fish on left side of neck.	Two different "V" formations on right head and right ventral chest.	Fishv[2]
AHK_3465/2010, AHK_3430-2/2009, AHK_3528/2008	Spot looks like Enterprise ship from Star Trek on ventral chest.		Enterprise

Discussion of Control Photos

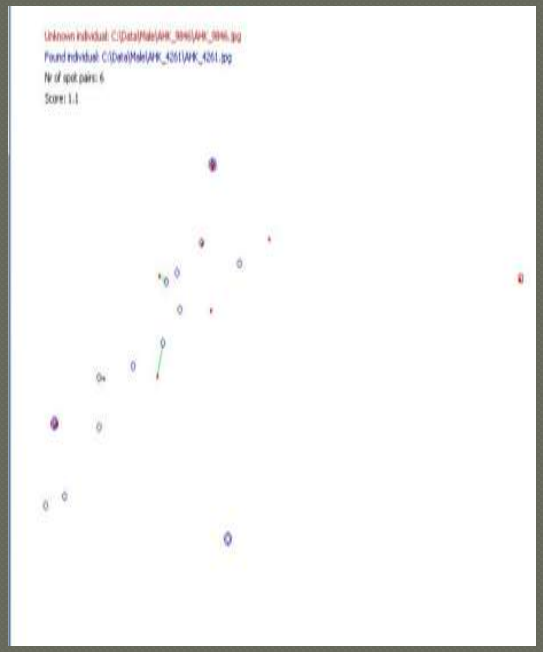
- Pinniped profiles of both harbor and grey seals support a criteria that a minimum of five different markings can be used to establish a right side profile fingerprint (RSPF).

Discussion of RSPF

- Experimental photographs, when scaled to a useful size for identification of distinguishing marks were too blurry to obtain reliable data.
- As a result, Genuine Fractals 6 was purchased for imagery sizing as it is marketed for increasing images 1000% without resolution loss. Reliable results could not be obtained.
- I3S Manta was pursued.

Discussion I3S Manta

A match value less than 4.0 was used as recommended by den Hartog, Reijns, 2008. The closer the value is to zero, the higher the confidence level for establishing site fidelity. Once the matches were identified a spot cloud was used to confirm relatedness of the sample in the population to those in the database. Spot cloud diagrams represents the model used by I³S Manta to calculate quality of the match between images.
Red dots = the spot centers of the unknown animal
Blue circles = Mantas from the database.
Green lines = matching pairs.
The more direction and length of the green lines are correlated locally, the higher the probability of relatedness (den Harog, Reijns, 2008).
At least one I³S Manta sample matched to a pinniped photo. This prompted more stringent valuation for matches whereby the database was re-evaluated using a criteria of 2.0 or less for I³S Manta. This new criteria failed as well.



Limitations of I3S Manta

- I³S Manta should be used to annotate animals with regular spots. Pinniped spots are very irregular; an ellipse cannot accurately show the shape of the spot, only the size and location.
- The database does not differentiate dark from light colored seals, only male or female. I³S Manta is a 2D model being used on 3D animals.
- Accuracy deteriorates considerably with angles larger than 40 degrees (den Hartog, Reijns, 2008).

Discussion of The Name Game

- The Name Game revealed that all six seals that have been named using this system have returned from the year 2009 to 2010.

Null Hypothesis Testing Table

Hypothesis	RSPF	Manta I^3S	The Name Game
Ho1	Reject	Accept	Reject
Ho2	Reject	Accept	Reject
Ho3	Accept	Reject	Accept

Future Work

- Continue evaluating experimental photography for key characteristics using Lightroom II to tag each photo.
- Naming committee should continue to meet for consensus naming of pinnipeds from CBCP to assess site fidelity.

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- Greg Kane, Photoshop support
- Jurgen den Hartog and Renate Reijns, I^3S Manta creators
- Pinniped Naming Committee (Dr. A. Kopelman, T. Bruno, J. Sergison, K. Tieman-Strauss)

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