GENERAL

# an introduction to using gis in marine biology supplementary workbook four investigating home ranges of individual animals psls

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## Introduction

Marine ecosystems are dynamic, complex, and increasingly threatened by human activity and climate change. To protect these fragile habitats, scientists must understand how marine organisms move, use resources, and respond to environmental pressures. Geographic Information Systems (GIS) have become indispensable for marine biologists, providing powerful tools to map, analyze, and visualize spatial data. This article offers an **an introduction to using gis in marine biology supplementary workbook four investigating home ranges of individual animals psls**—a practical guide that blends theory, methodology, and real-world applications. Whether you are a student, a researcher, or an enthusiast, you will find actionable insights that help you harness GIS to unlock the mysteries of marine animal behavior.

## What Is GIS and Why It Matters in Marine Biology?

GIS is a technology that captures, stores, manipulates, analyzes, manages, and presents spatial or geographic data. In marine biology, GIS allows researchers to overlay biological data (e.g., animal sightings, tagging records) with environmental layers (e.g., bathymetry, temperature, salinity). This integration reveals patterns that would otherwise remain hidden.

Key benefits include:

- Spatial Visualization: Create intuitive maps that communicate complex data.
- Data Integration: Combine diverse datasets—satellite imagery, oceanographic models, and field observations.
- Quantitative Analysis: Perform statistical tests on spatial relationships.
- Decision Support: Inform conservation policy and marine spatial planning.

## Supplementary Workbook Four: Investigating Home Ranges of Individual Animals PSLS

Workbook Four is part of a broader educational series that guides students through practical GIS applications in marine biology. The focus of this module is the concept of *home range*—the area an animal routinely uses for feeding, breeding, and shelter. By studying home ranges, researchers can assess habitat quality, identify critical areas, and detect changes in animal behavior due to environmental stressors.

### Understanding Home Ranges and Their Significance

A home range is not a rigid boundary but a fluid zone that reflects an animal's movement ecology. Traditional methods such as the Minimum Convex Polygon (MCP) provide a simple outline, while modern techniques like Kernel Density Estimation (KDE) offer a probabilistic view of space use. In marine settings, home ranges help answer questions such as:

1. How far do fish or mammals travel during a season?

2. Which habitats are most critical for feeding or reproduction?
3. Are animals shifting their ranges in response to warming waters?

### Data Collection: Tracking Marine Animals

Accurate home range analysis starts with reliable tracking data. Common methods include:

- Satellite Telemetry: Tags transmit location data via satellites, ideal for large mammals like sea lions.
- Acoustic Telemetry: Receivers detect signals from underwater tags, suitable for fish and invertebrates.
- GPS Loggers: Handheld devices attached to animals, best for species that surface frequently.
- Drone-Based Photogrammetry: Aerial imagery captures surface movements of marine birds and mammals.

Each method has trade-offs in terms of spatial resolution, temporal frequency, and deployment cost. Selecting the appropriate technology is critical for producing robust home range estimates.

### Preparing Your GIS Dataset

Before analysis, raw tracking data must be cleaned and formatted for GIS software (e.g., ArcGIS, QGIS, or GRASS). Key steps include:

1. Data Validation: Check for outliers, missing timestamps, or unrealistic speeds.
2. Coordinate Transformation: Convert latitude/longitude to a suitable projected coordinate system (e.g., UTM Zone 10N for the Pacific).
3. Temporal Filtering: Exclude data outside the study period or during known anomalies (e.g., device malfunctions).
4. Data Integration: Merge tracking points with environmental layers like sea surface temperature (SST) or chlorophyll concentration.

Proper preparation ensures that subsequent spatial analyses are accurate and reproducible.

### Analyzing Home Ranges with GIS Tools

Once your dataset is ready, you can employ various GIS techniques to delineate and analyze home ranges:

- Minimum Convex Polygon (MCP): The simplest method that encloses all points.
- Kernel Density Estimation (KDE): Produces a smooth probability surface indicating core areas.
- Local Convex Hull (LoCoH): Generates non-convex polygons that capture irregular movement patterns.
- Dynamic Brownian Bridge Movement Models (dBBMM): Incorporate movement paths and time intervals to estimate utilization distributions.

Each approach offers different insights. For instance, dBBMM can highlight temporal changes in space use, while LoCoH is useful for species with strong site fidelity.

### Case Study: PSLS (Pacific Sea Lion Study)

The Pacific Sea Lion (PSLS) is a charismatic marine mammal that serves as an excellent model for home range analysis. In our supplementary workbook, students track PSLS individuals using satellite telemetry over a 12-month period. By applying KDE, they identify core feeding areas near kelp forests and breeding sites along coastal cliffs.

Key findings include:

- Male PSLS exhibit larger home ranges during the breeding season.
- Home range overlap decreases with increasing population density.
- Shifts in core area location correlate with changes in prey distribution.

These results demonstrate how GIS can reveal nuanced behavioral patterns and inform conservation strategies.

## Practical Step by Step Guide

Below is a concise workflow that mirrors the exercises in Supplementary Workbook Four. Follow these steps to replicate a home range analysis for any marine species.

### Step 1: Gather GPS Tracking Data

Acquire raw location data from your tracking platform. Ensure that each record contains a timestamp, latitude, and longitude. Export the data as a CSV or shapefile for ease of import.

### Step 2: Import Data into GIS Software

Open your chosen GIS application and create a new project. Import the tracking dataset as a point layer. Verify that the coordinate system matches your study area.

### Step 3: Clean and Preprocess Data

Use the data cleaning tools available in your GIS software to remove erroneous points, duplicate entries, and outliers. Apply a speed filter to eliminate biologically implausible movements (e.g., > 30 km/h for fish).

### Step 4: Generate Home Range Estimates

Choose an analysis method:

- For a quick overview, run the MCP tool.
- For a detailed utilization distribution, select KDE and set an appropriate bandwidth (e.g., 200 m).
- For species with irregular movement, apply LoCoH or dBBMM.

Export the resulting polygons or density surfaces for further analysis.

### Step 5: Visualize and Interpret Results

Create a map that overlays the home range polygons on environmental layers such as bathymetry, SST, or prey density. Add labels, a legend, and a scale bar. Interpret the spatial patterns: Are core areas aligned with high prey concentrations? Do ranges shift seasonally? Document your observations in a report.

## Common Pitfalls and How to Avoid Them

Even experienced researchers can encounter challenges when working with marine tracking data. Here are some pitfalls and recommended solutions:

- Inaccurate Coordinate Systems: Always double-check the projection. A misaligned coordinate system can distort distances and area calculations.
- Sparse Data: Low-frequency telemetry leads to large gaps in movement paths. Use interpolation cautiously and consider supplementing with higher-resolution data.
- Overlooking Temporal Dynamics: Static home range estimates may mask seasonal shifts. Incorporate time slices or dynamic models to capture temporal variability.
- Ignoring Environmental Context: Spatial patterns often depend on habitat features. Integrate environmental layers to provide ecological meaning.
- Assuming Uniform Movement: Animals rarely move at constant speeds. Incorporate movement models that account for variable velocity and direction.

## Advanced Techniques and Future Directions

As technology advances, new tools are emerging that deepen our understanding of marine animal space use.

### Integrating Remote Sensing Data

Satellite imagery provides high-resolution, near-real-time data on ocean color, sea surface temperature, and chlorophyll-a concentration. By overlaying these layers with animal tracking data, researchers can identify foraging hotspots and assess the impact of environmental changes.

### Machine Learning for Home Range Prediction

Supervised learning algorithms (e.g., random forests, support vector machines) can predict animal presence based on environmental covariates. Unsupervised clustering methods (e.g., k-means, DBSCAN) can detect natural movement patterns without pre-labeled data. These approaches enable predictive modeling of future space use under climate change scenarios.

### Collaborative GIS Platforms

Cloud-based GIS solutions (e.g., ArcGIS Online, Google Earth Engine) allow real-time collaboration across research teams. They also provide access to vast public datasets and computational resources, reducing the need for local hardware.

## Conclusion

Geographic Information Systems have revolutionized marine biology by turning raw movement data into actionable insights about animal behavior and ecosystem health. Supplementary Workbook Four provides a structured pathway—from data collection to advanced analysis—for investigating home ranges of individual marine animals, exemplified by the Pacific Sea Lion study. By mastering these GIS techniques, researchers can uncover spatial patterns that guide conservation, inform marine spatial planning, and ultimately contribute to the stewardship of our oceans. Whether you are new to GIS or looking to refine your skills, this guide offers the foundational knowledge and practical steps needed to explore the dynamic world of marine animal movement.


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