Distance Sampling and Animal Movement

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Assumption: Objects are detected at their *initial* location.
**Assume**: Objects are detected at their *initial* location.
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Violate: Move in response to observer.
**Assume:** Objects are detected at their *initial* location.

**Violate:** Move in response to observer.

**Mitigate:**

- Survey Protocol
- Left truncation
- Double Observer Methods
**Assume:** Objects are detected at their *initial* location.

**Violate:** Move in response to observer.

**Mitigate:**
- Survey Protocol
- Left truncation
- Double Observer Methods

---


Assume: Objects are detected at their *initial* location.

Violate: Move *independently* of the observer.
Assume: Objects are detected at their initial location.

Violate: Move independently of the observer.
**Assume:** Objects are detected at their *initial* location.

**Violate:** Move *independently* of the observer.

**Mitigate:** ?
\hat{N} = \frac{n}{\hat{p}}
Increasing total number of detections

Increasing animal speed

\[ \hat{N} = \frac{n}{\hat{p}} \]
\[ \hat{N} = \frac{n}{\hat{p}} \]
Increasing animal speed

Decreasing estimated detection probability

\[ \hat{N} = \frac{n}{\hat{p}} \]
\[ \hat{N} = \frac{n}{\hat{p}} \]
SIMULATION

Line transects

DS

Relative Bias (%) vs. Animal Speed (as % of Observer Speed)
SIMULATION

**Line transects**

![Graph showing relative bias vs. animal speed for line transects.]

**Point transects**

![Graph showing relative bias vs. animal speed for point transects.]

- **DS**: Indicates a specific data series or condition.
Assume: Objects are detected at their initial location.

Violate: Move independently of the observer.

Mitigate:

◦ Survey Protocol
Survey Protocol

Increasing total number of detections

Increasing animal speed
1. Search further.
Survey Protocol

1. Search further.

2. Ignore overtaking animals.
Survey Protocol

1. Search further.
2. Ignore overtaking animals.
3. Take a snapshot.
1. Search further.

2. Ignore overtaking animals.

3. Take a snapshot.

**Assume:** Objects are detected at their *initial* location.

**Violate:**  Move *independently* of the observer.

**Mitigate:**

- Survey Protocol
- Truncate?
**Assume**: Objects are detected at their *initial* location.

**Violate**: Move *independently* of the observer.

**Mitigate**:
- Survey Protocol
- Truncate?
Assume: Objects are detected at their *initial* location.

Violate: Move *independently* of the observer.

Mitigate:

- Survey Protocol
- Model?
\[ g(x) = \mathbb{P}(\text{detected} \mid \text{located at } x) \]
Distance Sampling

Observer \[ \Rightarrow x \Rightarrow \text{Animal} \]

\[ g(x) = \mathbb{P}(\text{detected} \mid \text{located at } x) \]

\[ f(x) = \frac{g(x)\pi(x)}{\int g(x)\pi(x) \, dx} \]
Distance Sampling

Observer \( X \) \rightarrow \text{Animal}

\( g(x) = \mathbb{P}(\text{detected} \mid \text{located at} \ x) \)

\[ f(x) = \frac{g(x)\pi(x)}{\int g(x)\pi(x) \, dx} \]

\( \hat{p} = \int \hat{g}(x)\pi(x) \, dx \)
Distance Sampling

Observer → $\mathcal{X}$ → Animal

$g(x) = \mathbb{P}(\text{detected} \mid \text{located at } x)$

$f(x) = \frac{g(x) \pi(x)}{\int g(x) \pi(x) \, dx}$

$\hat{p} = \int \hat{g}(x) \pi(x) \, dx$
Distance Sampling

Observer \rightarrow \mathcal{X} \rightarrow \text{Animal}

\[ g(x) = \mathbb{P}(\text{detected} \mid \text{located at } x) \]

\[ f(x) = \frac{g(x) \pi(x)}{\int g(x) \pi(x) \, dx} \]

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\[ \hat{p} = \int \hat{g}(x)\pi(x) \, dx \]
Distance Sampling

Observer \( \xrightarrow[]{} \)Animal

\[ g(x) = \mathbb{P}(\text{detected} \mid \text{located at } x) \]

\[ f(x) = \frac{g(x) \pi(x)}{\int g(x) \pi(x) \, dx} \]

\[ \hat{p} = \int \hat{g}(x) \pi(x) \, dx \]

\[ \lambda(r) = \frac{\alpha}{r^\beta} \]

\[ g(\vec{x}, t) = \lambda(\vec{x}_t) \exp \left( -\int_0^t \lambda(\vec{x}_s) \, ds \right) \]
Observer \xrightarrow{\mathcal{X}} \text{Animal}

\[ g(x) = \mathbb{P}(\text{detected} \mid \text{located at } x) \]

\[ f(x) = \frac{g(x)\pi(x)}{\int g(x)\pi(x) \, dx} \]

\[ \hat{p} = \int \hat{g}(x)\pi(x) \, dx \]

\[ \lambda(r) = \frac{\alpha}{r^\beta} \]

\[ g(\vec{x}, t) = \lambda(\vec{x}_t) \exp \left( -\int_0^t \lambda(\vec{x}_s) \, ds \right) \]

\[ \hat{p} = \int \int \hat{g}(\vec{x}, t)\pi(\vec{x}) \, dt \, d\vec{x} \]
Distance Sampling

Observer \rightarrow \mathcal{X} \rightarrow \text{Animal}

\[ g(x) = \mathbb{P}(\text{detected} \mid \text{located at } x) \]

\[ f(x) = \frac{g(x)\pi(x)}{\int g(x)\pi(x) \, dx} \]

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MDS

\[ \mathbf{x} \]

\[ \lambda(r) = \frac{\alpha}{r^\beta} \]

\[ g(\mathbf{x}, t) = \lambda(\mathbf{x}_t) \exp \left( -\int_0^t \lambda(\mathbf{x}_s) \, ds \right) \]

\[ \hat{p} = \int \int \hat{g}(\mathbf{x}, t)\pi(\mathbf{x}) \, dt \, d\mathbf{x} \]
**SIMULATION**

**Line transects**

**Point transects**
Applied to Spotted Dolphins in the Eastern Tropical Pacific.
• Applied to Spotted Dolphins in the Eastern Tropical Pacific.

• Use tag data on 19 individuals to estimates movement speed using a Brownian motion movement model.
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- Use tag data on 19 individuals to estimates movement speed using a Brownian motion movement model.

- Animal speed was around 40-50% observer speed.
- Applied to Spotted Dolphins in the Eastern Tropical Pacific.

- Use tag data on 19 individuals to estimates movement speed using a Brownian motion movement model.

- Animal speed was around 40-50% observer speed.

<table>
<thead>
<tr>
<th>Year</th>
<th>Est.</th>
<th>CV</th>
<th>95% CI</th>
<th>Est.</th>
<th>CV</th>
<th>95% CI</th>
<th>Est.</th>
<th>CV</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>1073</td>
<td>22%</td>
<td>(700, 1644)</td>
<td>1166</td>
<td>18%</td>
<td>(750, 1581)</td>
<td>918</td>
<td>18%</td>
<td>(588, 1248)</td>
</tr>
<tr>
<td>2000</td>
<td>947</td>
<td>23%</td>
<td>(601, 1493)</td>
<td>999</td>
<td>19%</td>
<td>(627, 1372)</td>
<td>787</td>
<td>19%</td>
<td>(492, 1082)</td>
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<tr>
<td>2003</td>
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<td>19%</td>
<td>(1053, 2189)</td>
<td>1550</td>
<td>15%</td>
<td>(1087, 2013)</td>
<td>1223</td>
<td>15%</td>
<td>(854, 1592)</td>
</tr>
<tr>
<td>2006</td>
<td>1213</td>
<td>24%</td>
<td>(755, 1947)</td>
<td>1342</td>
<td>20%</td>
<td>(809, 1874)</td>
<td>1059</td>
<td>20%</td>
<td>(636, 1481)</td>
</tr>
</tbody>
</table>
• Applied to Spotted Dolphins in the Eastern Tropical Pacific.

• Use tag data on 19 individuals to estimate movement speed using a Brownian motion movement model.

• Animal speed was around 40-50% observer speed.
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• Animal speed was around 40-50% observer speed.

Assume: Objects are detected at their initial location.

Violate: Move independently of the observer.

Mitigate:

- Survey Protocol
- Model
1. Need Detection Times and 2d locations.
Need Detection Times and 2d locations.

Need information on movement.
FURTHER DEVELOPMENTS
FURTHER DEVELOPMENTS

1. Cameras and Gliders
FURTHER DEVELOPMENTS

1. Cameras and Gliders

2. Responsive Movement

FURTHER DEVELOPMENTS

1. Cameras and Gliders

2. Responsive Movement

3. Behaviour-Switching Movement

**Distance Sampling and Animal Movement**

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**moveds**

Fits models that account for non-responsive, Brownian motion of individuals during distance sampling surveys.

**Install**

In R, the latest release can be installed using the `devtools` package with command

```
devtools::install_github("r-glenlie/moveds@v0.1.0", build_vignettes = TRUE)
```

The package requires you have a C compiler installed on your system. Windows users may need to install R-tools for this reason. It is assumed Linux and Mac users have a compiler installed.

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