Exploration of trophic levels of North Pacific humpback whales through analysis of stable isotopes: implications on prey selection and resource quality

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ABSTRACT: The analysis of stable carbon (δ13C) and nitrogen (δ15N) isotope ratios has become an efficient method for exploring feeding origins, diet and trophic position for migratory animals. Previous analysis of stable isotope ratios from 1105 samples of humpback whale skin collected as part of the Structure of Populations, Levels of Abundance and Status of Humpback whales (SPLASH) project described six isotypically distinct feeding grounds and identified migratory links between these groups and breeding areas. In this study, trophic levels of individual whales within the six feeding groups were calculated using δ15N of humpback whales and of regional primary consumers, such as copepods and scallops, and then averaged to determine relative trophic levels of the feeding groups. The overall mean trophic level for North Pacific humpback whales was 3.6 ± 0.02. This value is indicative of a diet of both fish and zooplankton species, supporting assumptions of humpback whales as generalist predators that exploit both prey categories. The highest mean trophic level was calculated for the north Gulf of Alaska feeding group (4.0 ± 0.03), while the lowest was found for the group feeding near Russia and the westernmost Aleutian Islands (3.3 ± 0.08). Differences in mean trophic levels suggest some groups have a more piscivorous diet, while others feed on a mixed diet or one higher in zooplankton. Results may be used to determine if differences in diet composition between feeding groups result in differences in accrued nutritional benefits, and, in turn, impact reproductive success and survival. Previous studies have shown that prey choice and diet can have significant impact on life history factors, such as adult and calf survival and fecundity. With data on life history parameters for North Pacific humpback whales, correlations between these parameters and dietary differences between feeding groups can be explored.

ESTIMATING RELATIVE TROPHIC LEVELS

The relative trophic level of each of the six feeding groups were calculated as:

\[ TL = 2 + \frac{\delta^{15}N_{\text{consumer}} - \delta^{15}N_{\text{top level}}}{2.4} \]

Where, 2 = trophic level of 1° of primary consumer
2.4 = average enrichment in δ15N per trophic level for marine mammals.

Mean TL = 3.6 supports humpback whales as generalist predators. Regional differences suggest that COW and NGOA target a higher percentage of fish in their diets than the remaining groups who appear to target a more mixed diet likely higher in zooplankton. Letters indicate feeding groups with similar means.

WHAT ARE THE IMPACTS OF TROPHIC LEVEL AND PREY CHOICE?

Data on population parameters and specific regional diet compositions are needed to determine the potential impacts of prey choice and trophic level. If yes, strongest impacts would be expected in WEST feeding areas and corresponding breeding grounds.

ADJUSTING FOR REGIONAL DIFFERENCES IN δ15N

Failing to account for regional differences in the δ15N values of 1° consumers may lead to false assumptions about the relative trophic level of foraging humpback whales within feeding groups.

REGIONAL DIFFERENCES IN TROPHIC LEVELS

<table>
<thead>
<tr>
<th>Group</th>
<th>δ15N (Mean ± SD)</th>
<th>δ15N (Median)</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEST</td>
<td>12.3 ± 0.19</td>
<td>3.3 ± 0.08</td>
<td>Neocalanus spp., Calanus sp.</td>
</tr>
<tr>
<td>CENT</td>
<td>12.0 ± 0.01</td>
<td>3.5 ± 0.03</td>
<td>P. acus, B. acus</td>
</tr>
<tr>
<td>NGOA</td>
<td>13.6 ± 0.07</td>
<td>4.0 ± 0.03</td>
<td>P. acus, B. acus</td>
</tr>
<tr>
<td>SEAK</td>
<td>12.7 ± 0.06</td>
<td>3.4 ± 0.03</td>
<td>P. acus, B. acus</td>
</tr>
<tr>
<td>NWC</td>
<td>13.0 ± 0.08</td>
<td>3.6 ± 0.03</td>
<td>M. californiana, Calanus sp.</td>
</tr>
<tr>
<td>COW</td>
<td>14.7 ± 0.07</td>
<td>3.9 ± 0.03</td>
<td>Salpidae, Copepoda</td>
</tr>
</tbody>
</table>

* No 1° consumers were available for WEST, so CENT values were used.

TABLE 2: Mean δ15N values of humpback whale skin for each feeding group and 1° consumers used.

OBJECTIVES

Determine the relative trophic level of six previously defined feeding groups by comparing δ15N values of humpback whale skin to the base of regional food webs

Explore differences in trophic positions and discuss them as potential indicators of survival and reproductive success

SAMPLE COLLECTION & STABLE ISOTOPE ANALYSIS

Samples for isotopic analysis were collected from free-ranging humpback whales throughout the North Pacific basin as a part of the SPLASH project using a hollow-tip biopsy dart fired by either a crossbow or pneumatic rifle.

FIELD METHODS

Skin samples were analyzed for δ13C and δ15N isotope ratios and were reported as per mil (‰) from the equation:

\[ \delta = \left( \frac{R_{\text{sample}} - R_{\text{standard}}}{} \right) \times 10^{3} \]

DIFFERENCES IN δ13C AND δ15N ISOTOPE RATIOS FOR THE SIX TROPHIC LANDSCAPES

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Less energy in prey
Poorer body condition?
Lower adult/calf survival?
Reduced reproductive success?

Higher TL
More energy in prey
Better body condition?
Higher adult/calf survival?
Improved reproductive success?