Evaluation Of A Dietary Alternative To Fish For California Sea Lions (*Zalophus c. californianus*)

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INTRODUCTION

Obtaining a suitable diversity of food fish for feeding marine mammals is a major challenge for zoological institutions and marine parks. In recent years, several species of fish, which were once considered staples in diets of captive marine mammals are no longer available due to over-harvesting [Davis, 1999]. Although government agencies have taken measures to address this decline in natural fish populations, it may take years before they can withstand regular harvesting [Davis, 1999]. Obviously, depleting natural populations of wildlife to feed captive specimens is in direct conflict with the goals of conservation organizations.

Recent advances in food science technology have led to the development of complete feeds that could be fed along with, or in place of fish. Currently, an experimental fish analog diet is manufactured by Purina Mills, Inc. Preliminary trials with earlier formulations of this diet with penguins (Sea World Florida) and pinnipeds (Denver Zoo) produced promising results and led to minor refinements in the product [Molitoris et al., 1998]. Currently, the revised product is being evaluated for use with cetaceans in the United States Navy Marine Mammal Program (San Diego, CA).

The trials were intended to facilitate the integration of a food item (fish analog) which, following the study, was added to the standard California sea lion diet used in conjunction with other fish and marine invertebrate species currently offered. The goal of the project was to evaluate criteria influencing the palatability of the fish analog diet (Mazuri #3492) with California sea lions when offered as a portion of the total diet to facilitate this introduction.

MATERIALS AND METHODS

Animals

Eight % California sea lions currently housed at the San Diego Zoo were included in the project. Six of these animals are housed in a show area (Wegeforth Bowl) and two animals are in an exhibit in the Sun Bear Forest area. Specific information for each specimen is provided in Table 1.

Husbandry

The diets and body weights of all six animals housed at the Wegeforth Bowl are tightly regulated as part of their standard husbandry practices. Body weights have been routinely (weekly) measured on these animals since 1995. Food intake, which is also regulated as a function of body mass, has been documented since 1996. This baseline data was used as benchmarks to assess animal status and response throughout the study. The two animals housed at Sun Bear Forest are weighed bi-monthly and total amounts of fish offered vary in accordance with seasonal changes in appetite.

Current husbandry practices, including monitoring food intake and body weight, were continued throughout this evaluation.

Test diet

The high moisture (75%), fish analog diet (Mazuri #3492) is formulated to mimic fish of average fat content fed to piscivorous animals in captivity (Table 2).

Preference trials

The fish analog was introduced in addition to the standard fish diet to all eight animals as a novel food in order to evaluate initial palatability. The quantity of fish offered maintained the pre-trial caloric levels, so that no caloric deprivation was used to encourage analog intake.

Animals were presented with the fish analog at one feeding each day over the eight-day trial. Presentation consisted of three pieces of the analog diet. Animal response to each piece offered was recorded. The diet was handled and offered to the animals in the same manner that is currently used for fish. Three factors that may influence observed palatability were evaluated in a full factorial design. These factors were:

1. Length of food item (short, 2.5" vs. long, 5")
2. Sequence in daily feeding progression (first feeding vs. last feeding)
3. Site of diet delivery (in mouth vs. in water).

Statistical analysis

The Wilcoxon matched-pairs signed-ranks test was designated for use to determine statistical significance of observations.

RESULTS

A total of 192 presentations of the fish analog were conducted over the study period. Overall acceptance was positive (59%), however, distinct differences in acceptance were noted between animals housed at Wegeforth Bowl (80% acceptance, *n*=6) and Sun Bear Forest (0%, *n*=2).

Acceptance of the fish analog was not influence by length of the particle, time of day offered, or mode of presentation (mouth or water). Seven of eight animals had identical responses to short and long pieces of fish analog. Five of eight animals had identical responses to the fish analog when offered at the first feeding (09:30-10:00) and last feeding (14:30-15:00). Five of eight animals also exhibited identical responses when the fish analog was delivered into the mouth or tossed into the water. Since the Wilcoxon matched-pairs signed-ranks test disregards pairs of observations of equal value it can be concluded that observed differences in palatability based on the three factors examined in the study were not significant.

In a prior study conducted at the Denver Zoo [Molitoris, et al., 1998] authors noted that acceptance of a fish analog seemed to be dependent on extent of hand-training and conditioning to accept food items from trainers= hands. These factors may have influenced the results of the present study. The two sea lions at Sun Bear Forest have been housed solely as exhibit animals, involved in minimal training as part of their daily routine. Additionally, one of the Sun Bear Forest animals displayed a general lack of interest in all fish offered during the course of the study, which unfortunately is a typical seasonal change in food intake that coincided with the study period.

CONCLUSIONS

1. Animal acceptance of the fish analog was not influence by length of the particle, time of day offered, or mode of presentation (mouth or water).
2. Level of overall training, and/or the routine participation in a training program, appeared to have a positive influence on introduction of this food item into the final diet.
3. The fish analog diet appears to be a viable option for those institutions seeking to increase the diversity of fish "species" to offer California sea lions, while offering the nutrient stability of a formulated diet.

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REFERENCES

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TABLE 1. Identification, gender, house name and location of eight California sea lions included in a study of dietary alternatives to fish

Accession No.	Gender	Date of birth	Location
M0170278	Male	Est. 1968	Wegeforth Bowl
M0181111	Male	10 Aug 1980	Wegeforth Bowl
M0587207	Male	07 Jun 1987	Wegeforth Bowl
M0587214	Male	09 Jun 1987	Wegeforth Bowl
M0587219	Male	14 Jun 1987	SBF
M0176144	Male	Est. 1975	SBF
M0594416	Male	Est. 1982	Wegeforth Bowl
M0599059	Male	04 Jun 1998	Wegeforth Bowl

TABLE 2. Select nutrient composition of fish analog diet expressed on an "as fed" and "dry matter basis" (DMB)[1]

Nutrient	as fed	DMB	Nutrient	as fed	DMB
Protein, %	13.0	52.0	Ca, %	0.55	2.19
Lysine, %	0.86	3.45	P, %	0.36	1.42
Fat, %	6.5	26.0	Na, %	0.13	0.50
Crude Fiber, %	0.85	1.10	Thiamin, ppm	23	90
Ash, %	2.7	10.8	Vitamin E, IU/kg	190	750

[1]data provided by PMI Nutrition International.