Report on food aversion conditioning in sea lions. (*Zalophus californianis*)

by

Barbara A. Kuljis

49-139 Kam Hwy

Kaneohe, Hawaii 96744

Submitted to

National Marine Fisheries Service

Southwest Fisheries Center

8604 La Jolla Shores Dr.

La Jolla, California 92038

Work done under contract No. 84-ABC-00167

Through NMFS and California Fish and Game

INTRODUCTION.

Adverse interactions between marine mammals and fishermen which result in the loss of either bait or catch, occur in a variety of fisheries and involve a number of different species of marine mammals. Many fishermen feel that these interactions are seriously impacting the economics of their fisheries. One of the fisheries which is currently reporting an increased incidence of depredation of their catch by the California sea lion, Zalophus californianis, is the Southern California "party boat fishery" (DeMasters 1982). As a consequence of their opportunistic feeding habits California sea lions have become a serious pest to this fishery.

To date the methods used to reduce these interactions have been, at best, short lived. The sea lions quickly learn to habituate to novel but harmless stimuli (loud noises, seal bombs, firecrackers) and they learn to circumvent those that are harmful, (gunshots, capture nets etc.). In many instances these methods simply serve to challenge the animals to cleverly avoid these obstacles in order to get a tasty meal.

One possible method of ameliorating these interactions which has not been tested to date is conditioned food aversion. By using an emetic or aversive agent one can manipulate the food consumption of both vertebrate and invertebrate species(Gustavson 1977). When an animal ingests a specific food type and becomes nauseous and vomits it will subsequently associate the illness with the flavor of the ingested food and avoid that food upon later encounters (Garcia et al. 1955). This technique has been tested on a number of terrestrial

species as a means of wildlife pest management. These include: coyotes, (Gustavson 1974), wolves, (Gustavson, Kelly, Sweeney & Garcia , 1976), prairie dogs (Holzer & Gustavson 1980) and raccoons (Nicolaus 1982). Some opposition to the use of food aversion conditioning in pest management has arisen due to the varied results obtained in some coyote studies (Conover et al 1977, Burns 1980). One reason controlled food aversion has not gained wider acceptance as a management technique is due to the controversy surrounding these studies. There are a few critical variables in food aversion research which determine whether or not conditioning will occur (Gustavson, Kelly & Garcia). These are: 1) Time between consumption and illness. An aversive agent which has a fairly short interval between the time of ingestion and the onset of illness (60 minutes or less) is preferred. Although aversions can be developed with a delay of more than 1 hour, generally a long delay will result in a very weak aversion. 2) Flavor strength. Whatever emetic is used should be administered in such a way as to be undetectable by the animal. Detection of the flavor of an emetic by the animal could cause an aversion to the taste of the emetic rather than to the bait being used. In these cases the animal learns to avoid only those baits which taste like the emetic and does not develop a conditioned food aversion. The flavor of the bait should be distinct. 3) Illness intensity. The correct dosage of the emetic should cause the animal to become ill shortly after ingestion. A slightly prolonged illness is more effective than a very strong illness with a quick recovery time. Some of the field trials which were marked failures may have

been more successful had all three of these conditions been considered.

Another potential problem area in food aversion field research is in the collection of definitive data. That is data, in which a free ranging predator is first observed to consume live prey, then feeds upon bait treated with an emetic and then avoids the previously acceptable prey. Although this type of data is difficult to obtain in a field situation some factors which would facilitate the collection of this information are: 1) Identification of individual offending animals (by natural markings or tags), 2) prior knowledge of the incidence of predation, 3) documentation of the methods and frequency of depredations by the offending animals. Information of this nature will greatly contribute to the assessment of the successfulness of any food aversion field study.

The advantages of using a controlled food aversion program in predation control are numerous. The major one being that this method is a non-lethal means of pest control. The animal is only ill for a short period of time and experiences only a minimum amount of discomfort. Also, once shown to be effective, food aversion pest control programs should be inexpensive. The type of equipment and supplies necessary may vary from area to area but the overall costs are relatively low. Another advantage of this technique is that it elicits an internal response from the animal which cannot be avoided following the ingestion of a toxic substance. When consumption of a food produces nausea and/or vomiting the desireability of that food is subsequently reduced, and since the only way to avoid the aversive

reaction is to eliminate consumption of that food type there is a voluntary reduction in the rate and/or amount of that food consumed.

The intent of this study was to apply the technique of conditioned food aversion paired with a novel sound cue to a group of captive sea lions. Wilcoxin (1971) showed that an added visual cue paired with an ingested emetic agent produced a stronger aversion in quail than just an emetic alone. Sea lions have been shown to be relatively well adapted for effecient hearing in both water and air (Shusterman 1981). It is possible that hearing plays some role in foraging. Sound may somehow be used in the process of food selection in these animals as vision is used to aid in food selection in birds. If this is the case, then a sound stimulus paired with an emetic may be helpful in producing an aversion. The novelty of the sound may be of initial importance as it has been shown that when an animal first experiences a novel stimulus, that stimulus often causes withdrawal or avoidance (Testa and Ternes 1977). Using a novel sound cue paired with an emetic on sea lions may give the animal additional information with which to associate the illness with food consumption thereby enhancing the aversive response.

The objectives of this project were:

1. to develop an aversion to a specific food using an emetic, then pair a sound cue with that aversive agent as a means to enhance the aversive response.
2. to determine the extinction rate of the aversion.

METHODS.

The experimental animals were four yearling male California sea lions ranging in weight from 38 to 54 kilos. These animals had been

in captivity for over six months and were well adapted to a captive lifestyle. They were housed in a wire mesh kennel which contained an oblong salt water pool at one end. All four animals were marked with a coded numbering system. This was done by clipping the hair on the animals hind quarters using a previously established numbering system. The marking system made the immediate identification of individual animals (77,56,52 and 50) easy. All subjects were trained to station in front of a bucket and were hand fed twice daily, once in the morning and once in the afternoon. Two feeders were present at each feeding and fed two animals simultaneously. The feeders alternated which pairs of animals they fed each session in order to minimize any bias (the pairs were always the same 77 & 50 and 52 & 56).

A preliminary food study revealed that herring and mackeral were two highly preferred foods. Following this study the animals were maintained on a diet of four pounds of either herring or mackeral per feeding. These two fish types were alternated each feeding with herring being offered one feeding and mackeral being offered the next (i.e. herring am, mackeral pm, mackeral am, herring pm etc.). Feeding sessions were timed to determine the mean consumption time for both herring and mackeral. To measure food consumption, fish buckets were weighed to the nearest ounce before and after each feeding session.The animals were not restrained or confined during feeding sessions. During pre test period 1 no sound cue was used when feeding either mackeral or herring. Throughout the test period and during all subsequent mackeral feedings a pulsed, in air sound was used. A sonalert connected to a nine volt battery and housed in an

aluminum box was used to produce the sound. The sound cue was first introduced at the start of the mackeral feeding on test day 1.

The only emetic agent tested was lithium chloride (LiCl; Mallincrodt). LiCl was chosen as the test drug due to its fast acting emetic qualities and its limited side effects at fairly high doses. Due to its wide use in food aversion research and as an anti-depressant in humans there was a relatively large body of literature available on LiCl which was helpful in establishing an initial dose level. As LiCl has a strong salty flavor, the drug was administered via gelatin capsules. This eliminated the complication of the animals averting to the salty taste of lithium, rather than to the type of fish in which it was administered. The subject animals had all been given a vitamin capsule (pushed into the gut of a fish) daily prior to test day. These captive animals consumed their fish whole, head first,and never showed any sign of rejecting the fish on the basis of the capsules.

TEST.

Food consumption of all four animals was documented for a period of 21 days prior to the first test day. This time frame was considered pre-test period 1, and these data were used as baseline during data analysis. Analyses of these data revealed no significant difference between the amount of herring consumed over mackeral during a pre established time period. Therefore, mackeral was chosen as the test fish as it was a slightly larger fish and could accomodate more capsules per fish. On test day all animals were stationed as usual for feeding, however the pulsed tone was presented for the first time just as the animals consumed there first fish.

Animals 50 and 52 were fed mackeral with .5 g/kg of encapsulated LiCl stuffed in the guts. Animals 56 and 77 were control animals and received no lithium. Within thirty minutes of ingestion of the LiCl treated fish, animals 50 and 52 were experiencing diarrhea and within forty minutes emesis had occured. Emesis continued sporadically for the next twenty minutes. Both treated animals remained active throughout the illness phase of the test, either swimming or running on land with the control animals. At no time did either animal appear to be seriously debilitated. Immediately after the illness subsided (Aprox. 1 hour from time of ingestion to end of emesis), animal 50 was sunning himself on land and 52 was swimming with the control animals in the pool. The normal afternoon feeding regime was adhered to, and all animals (including 50 and 52) consumed their normal ration of herring without hesitation.

During post test period 2, animal 50 began consuming mackeral and was dosed again with .5 g/kg of LiCl. Food consumption of all four animals was monitored for 15 days during post test period 2. Pre test period 3 consisted of 7 days during which no animals were dosed and post test period 4 consisted of 2 days following a test day on which animals 50 and 56 were administered .35 g/kg and .4 g/kg of LiCl respectively.

RESULTS:

Figure 1 presents results by animal for both herring and mackeral consumption. During pre-test period 1 all animals consumed the same amount of mackeral each day. Following test day mackeral consumption decreased in all four animals. The two test animals took the first mackeral offered them in their mouths and immediately

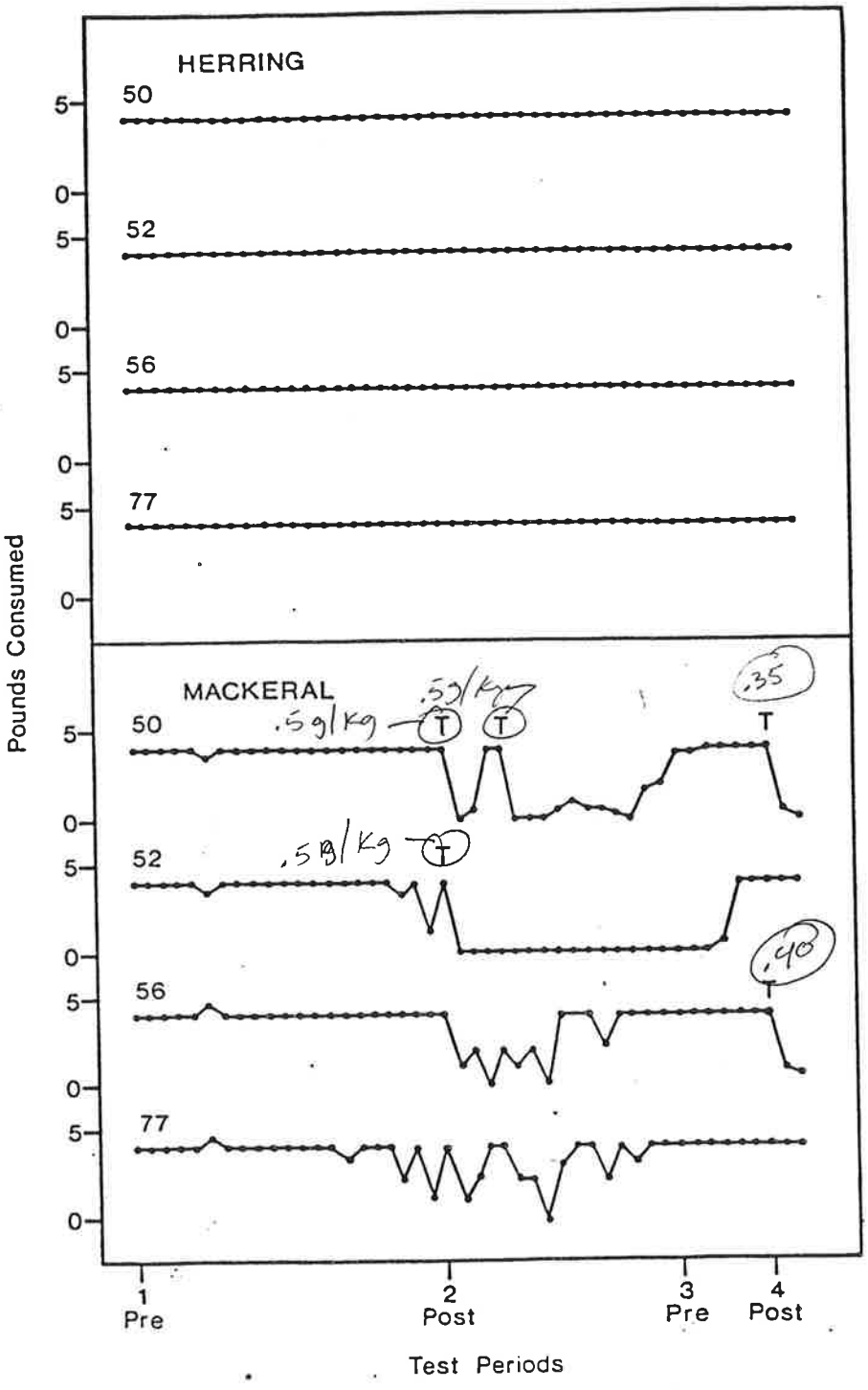

Figure 1 Consumption of both herring and mackeral by each animal for pre and post test periods.

dropped it. They left the stationing area and would not return for the entire six minute feeding period (this time period was established during baseline data collection by doubling the mean food consumption time). Both control animals slowly consumed one pound of mackeral each before leaving the stationing area and refusing to return to station during the feeding period. On the second day following dose day both control animals (77 and 56) consumed 2 pounds of mackeral each before leaving the stationing area. Test animal 52 stationed, was presented with a mackeral, rubbed his whiskers against the fish and left the stationing area for the rest of the feeding session. He continued to refuse all mackeral offered him for a period of eighteen days. Test animal 50 took one mackeral ripped the head off and slowly consumed the body. He then left the stationing area and would not return during the six minute feeding period. He began consuming 4 pounds of mackeral(the equivalent of the pre-test consumption level) 3 days after the first dosing. Lithium chloride was again administered to this animal (.5g/kg). Following this dosing the animal decreased its' consumption of mackeral by 85% for a period of eleven days during post test period 2. The control animals consumption of mackeral fluctuated throughout most of post test period 2 and leveled off to the normal 4 pounds per feeding by the last four days of the post test period. Herring consumption remained static during the entire experiment (pre and post test). Throughout the study, all animals were offered only herring and mackeral on an alternating schedule. This means that animal 52 and 50 were on self imposed half rations in order to avoid consuming mackeral.

A second pre-test was designated by a period of consumption equivalent to pre-test 1.The final test was run following the 7 day pre test period 3. During this test, animal 50 was given .35 g/kg of LiCl and 56 was given .4 g/kg of LiCl in mackeral. The following 2 days revealed an 80% decrease in their consumption of mackeral. The study had to be terminated at this point so only 2 days of post test 4 were documented.

Figure 2 shows the mean number of pounds of mackeral consumed for the control (undrugged) animals versus the experimental (drugged) animals. An analysis of variance for repeated measures showed a number of significant main effects and interactions. The most important being that the difference between the drugged groups consumption of mackeral for pre-test versus the post-test was significant [$F(4,341)=39.1$ $P>.01$]. There was a significant difference between herring and mackeral consumption for the post-test period for both the drugged and undrugged sugjects, however, the effect was smaller for the control group. Also, during the second test the control group showed no significant difference in consumption during the post-test period. Although the second post test period was unduly short, it should be noted that the effect on consumption within experimental groups was rapid in every instance. A summary of these analyses is presented in Table 1. Figure 3 shows the mean number of pounds of herring consumed by both groups. There was no difference between groups before or after testing when herring was consumed.

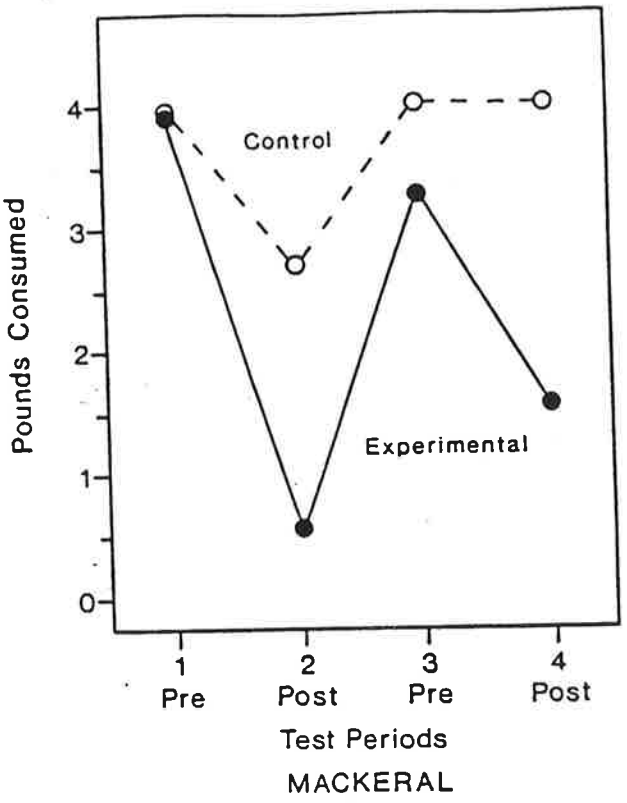

Figure 2 Mean number of pounds of mackeral consumed for drugged versus non drugged animals.

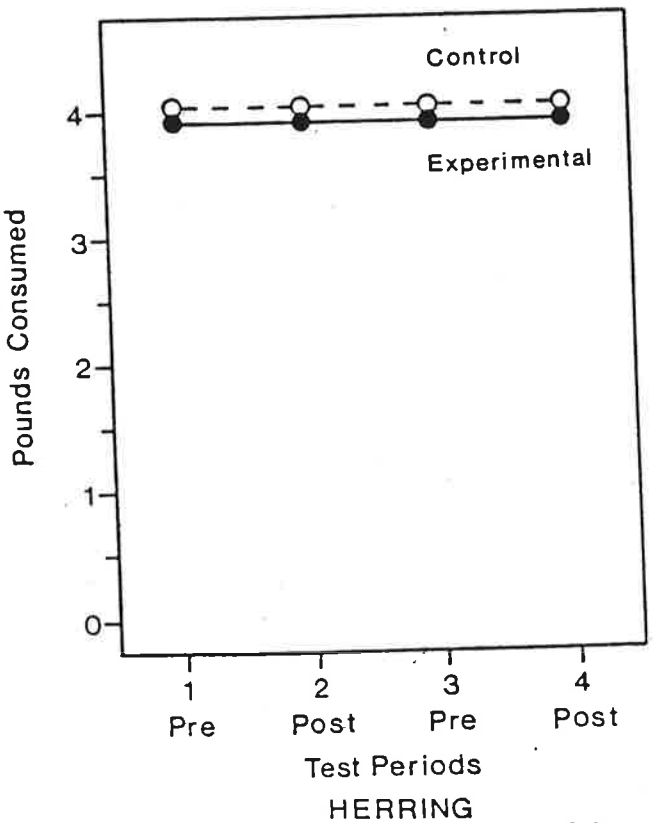

Figure 3 Mean number of pounds of herring consumed for drugged versus nondrugged animals.

Table 1. Summary of analysis of variance for consumption.

Source	DF	SS	F Value	PR > F
Drug	1	11.13980228	8.92	0.0583
Subj(drug)	3	3.74773015	2.25	0.0812
Prepost	3	90.80356851	54.45	0.0001
Drug*Prepost	3	21.00101993	12.59	0.0001
Fdtype	1	33.66233538	60.55	0.0001
Prepost*Fdtype	3	91.94731674	55.13	0.0001
Dr*Prpst*Fdtype	4	39.12636934	17.60	0.0001

Blood samples taken five days after the end of the study showed all animals to have blood counts within the normal range when compared with baseline samples taken one day prior to the start of this project.

DISCUSSION.

The intent of this study was to deterime if an emetic could be used to develop an aversion to a specific food type in California sea lions. The results clearly show that this is possible and in some cases after only one trial. In the case of animal 52 a 100% reduction of mackeral consumption was achieved for eighteen days after only one trial. This type of reduction could probably be prolonged if the animal had access to another food source and was not bound by the constraints of a controlled diet. Of course, in the wild the animals would have access to a variety of free ranging fish.

Some of the factors which make the results of this study exciting are: the short time period between ingestion of the LiCl dosed fish and the onset of illness, the rapid recovery following illness, the minimal disability of the animal during illness, and the immediacy of the conditioned response. All of these variables are favorable for the use of conditioned food aversion as a means of predation control in sea lions. The animals short response time to the drug LiCl indicates that this is a good drug to use in the aversive conditioning of sea lions. This short time frame may facilitate the animal in making the association between the illness and ingestion of a specific food type. The short duration of the LiCl induced illness is a very positive sign for use of this drug in the field. The animals would not be dibiliated for long periods of time and therefore vulnerable to predators. The fact that all the animals dosed decreased their consumption of mackeral after consuming LiCl leaves little doubt that captive California sea lions are capable of developing food aversions. Although it was not possible to establish how long the averions obtained in post test 4 would have lasted the important thing to look at here is that even with a low dose of LiCl the animals reduced their consumption of mackeral by more than 80% the next time they were presented with that fish type.

The significant changes during pre and post-test consumption of mackeral for the control groups presents some problems of interpretation. One interpretation is that there was inadvertant cueing by the feeders. Even if this were the case there was still a significant difference between the control and experimental groups. Therefore, if any cueing were occuring it at best produced only a

minor effect and does not compromise the results found for the experimental group. A more likely explanation would be observational learning. That is, learning that occurs when one animal watches the activities of another animal (Alcock 1969 , Galef 1977). The control animals witnessed the onset of illness in the test animals after they had ingested a specific food type that was paired with a novel sound. This observation then made them hesitant to consume that same food type in order to avoid illness. In a field situation a novel sound cue may play a role in warning off fellow fish thieves once they have witnessed the onset of illness in other sea lions. The act of stealing catch from fishermens lines is probably a learned behavior and so the avoidance of fish on lines may some day be a learned behavior as well. A detailed look at the food consumption of control animals which have been isolated from test animals would shed more light on the reasons for the control animals drop in consumption of mackeral.

Due to the necessity to end the project sooner than anticipated no determination was made as to the effectivness of a novel sound in enhancing conditioned food aversions. Evaluation of this aspect of the project had just begun and the only information obtained was that the novel sound cue used had no effect on the animals (all four) consumption of herring (the "safe" food).

Blood data collected prior to and at the end of this study revealed no signs of possible physiological problems associated with ingestion of the drug LiCl. This data is not conclusive and a more detailed look at sea lion blood profiles following ingestion of LiCl is necessary to evaluate any long term effects from the drug.

However, the short term gross examination of blood counts indicated no damage.

Successful aversive conditioning of captive California sea lions suggests that aversive conditioning may be a reasonable non-lethal means of ameliorating some of Southern Californias fishery problems. The robustness of the aversive response, even though short lived, indicates that sea lions are candidates to be considered for the use of conditioned food aversion as a means of pest control.

The implementation of aversive conditioning in a field situation should not be approached lightly. Background data should be collected prior to any attempts to alter the animals feeding habits. Extremely controlled implementation of this procedure is necessary if an accurate assessment of the technique in the field is to be obtained. A quick one trial shot in the dark attempt at chemically averting sea lions to fish on lines will only serve to further confuse the issue of predation control in sea lions.

The results obtained in this study indicate that further investigation during which a long hard look is taken at just how aversive conditioning can best be implemented in the field is warranted. From the strong response obtained in captive sea lions to aversive conditioning it appears obvious that this technique should not be put on the shelf due to its controversial nature, but rather should be examined more closely in order to ultimately answer the burning question, "Does it work in the field?".

ACKNOWLEDGEMENTS

I would like to thank Brad Andrews, Scott Rutherford and Terry Samansky of Marineland for all their help and cooperation during this project. I appreciate Doug DeMasters interest and participation in this study. I would also like to thank Doyle Hanan and California Fish and Game for there support of this project.

Alcock, J. Observational learning in three species of birds. Ibis 111 (3): 308-321 (1969).

Burns, R. J. Evaluation of conditioned predation aversion for controlling coyote predation. J. Wildlife Management 41: 938-942 (1980).

Conover, M. R., Francik, J. G., and Miller, D. E. An experimental evaluation of using taste aversion to control sheep loss due to coyote predation. J. Wildlife Management 41: 775-779 (1977).

DeMaster, D. P., Miller, D. J., Goodman, D., Delong, R. and Stewart B. Assessment of California sea lion fishery interactions. Proceed. 47 No. American Wildlife Conference (1982).

Garcia, J., Kimeldorf, D. J. and Koelling, R.A. Conditioned aversion to saccharin resulting from exposure to gamma radiation. Science 122, 157-158 (1955).

Galef, B. G. : Mechanisms for the soical transmission of acquired food preferences from adult to weanling rats. In L. M. Barker, M.R. Best, and M. Domjam, (Eds) Learning Mechanisms in Food Selection 123-148 (1977).

Gustavson, C. R., Garcia, J., Hankins, W. G. and Rusiniak, K. W.: Coyote Predation control by aversive conditioning. Science 184: 581-583 (1974).

Gustavson, C. R., Kelly, D. J., Sweeney, M. and Garcia, J.: Prey-lithium aversions I: coyotes and wolves. Behav. Biol. 17 : 61-72 (1976)

Holzer, G. A. and Gustavson, C. R. : Manipulation of wheat and oat preferences in black tailed prairie dogs: a field demonstration

using methiocarb as a taste aversion agent. Prairie Naturalist 12 (3,4) : 114-118 (1980).

Nicolaus, L. K., Hoffman, T. E., and Gustavson, C. R.: Taste aversion conditioning in free-ranging raccoons (Procyon lotor). Northwest Science 56(3) : 165-169 (1982).

Schusterman, R. J.: Behavioral capabilities of seals and sea lions: a review of their hearing, visual learning and diving skills. The Psychological Record 31: 125-143 (1981)

Testa, T. J. and Ternes, J. W. : Specificity of conditioning mechanisms in the modification of food preferences. In L. M. Barker, M.R.. Best, and M. Domjam, (Eds) Learning Mechanisms in Food Selection 229-253 (1977).

Wilcoxin, H., Dragoin, W. and Kral, P. : Illness induced aversions in rats and quail: Relative salience of visual and gustatory cues. Science 171, 826-828 (1971).