Toxic Effect of the Explosive Depth Charge Chemicals from the Ship SANKISAN MARU on the Coral Reef Fish *Dascyllus aruanus (L)*[1]

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Abstract

The coral reef fish *Dascyllus aruanus* (damselfish) was subjected to various concentrations of explosive depth charge chemicals from the sunken Japanese cargo ship SANKISAN MARU to determine if the leaking of these chemicals into the waters of Truk Lagoon would pose a potential threat to marine organisms. Experiments using yellow powder (6% water, 83% ammonium picrate, 10% aluminum powder, and 1% benzene-soluble organics) resulted in a 48-hour TL_{50} value of 118 mg/1 and a 96-hour TL_{50} value of 95 mg/1. Experiments using black powder (34% water, 4% ammonium picrate, and 42% inert humic acid-type polymer containing an undetermined proportion of powdered aluminum and inorganic aluminum salts) resulted in a 48-hour TL_{50} value of 1200 mg/l and a 96-hour TL_{50} value of 1000 mg/l.

Introduction

Forty to sixty tons of depth charges, aboard the sunken Japanese cargo ship SANKISAN MARU, were discovered (Brewer, 1973) in 100—120 feet (30—36 m) of water in the Truk Lagoon, Eastern Carolines. The depth charge casings were beginning to deteriorate and leakage of their explosive chemicals was considered a potential threat to marine organisms. The purpose of this paper is to provide data as to the toxic effect of the depth charge chemicals on a common coral reef fish.

The depth charges were removed prior to the completion of this report and the explosives used to clear channels through coral reefs. The detonations were apparently incomplete on some occasions and much of the yellow chemical was found floating in the water after channel clearance. Freshly killed fish that could not have been killed by the actual explosions were found the day after the blasting (M. Falanruw, personal communication).

Materials and Methods

CHEMICALS

Chemical samples from two different depth charges were used for the bioassay experiments.

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Sample number I was a yellow-green crystalline material obtained from a depth charge with its casing still watertight. It consisted of 6% water, 83 % ammonium picrate, 10 % aluminum powder, and 1 % benzene-soluble organics. This chemical shall be referred to as yellow powder. It dissolved completely and immediately in filtered sea water and turned the water yellow.

Sample number II was a flat black-colored material of smoother texture obtained from a leaking depth charge. Analysis revealed it to contain 34% water, ammonium picrate, and 42 % inert, humic acid-type polymer (from decomposition of ammonium picrate) containing an undetermined proportion of powdered aluminum and inorganic aluminum salts. This chemical shall be referred to as black powder. It did not dissolve completely in filtered sea water as did sample number I; it did change the water to a yellow color, but a much lighter shade than sample number I. The undissolved portion was determined to be approximately 79 % and had a black carbon-like appearance. The residue was shaped in irregular chunks, with none larger than 2 mm and most being less than 1 mm. Some of this undissolved material floated at first but with time 90 % of it settled to the bottom of the experimental aquaria and remained undissolved there. Both chemicals were kept in a desiccator prior to the experimentation.

The chemical composition of the yellow and black powders were analysed by Professor Donald G. Crosby, University of California, Davis, Department of Environmental Toxicology.

TEST ANIMALS

The common coral reef fish *Dascyllus aruanus* (Linnaeus) or damselfish was used exclusively in all experiments. This fish was chosen because of its abundance in coral reef areas. Fish were caught by dip net and used in experiments one day after capture. This allowed time to eliminate specimens suffering from damage during capture and yet was soon enough to disregard effects of starvation on the experimental results. The size of fish used was between 2.2 and 3.2 cm in standard length.

BIOASSAY METHODS

Several small aquaria were used in the experiments, each filled with five liters of previously aerated filtered sea water. No filtering system or aeration was used during the experiments. The pH and dissolved oxygen of the water were determined before the introduction of fish and either after all the fish were dead or at the end of the experiment, whichever was appropriate. The temperature of the water during the experiments ranged from 26.1 to 29.0°C, which is within the ambient temperature range for Guam.

Fish were checked every 12 hours for number of deaths. They were observed very closely for the first 36 hours for reactions to the depth charge chemicals. After death, fish were removed from the aquarium and their standard length measured. From the data obtained, percent survivorship vs concentration is plotted on a semilog scale (Figs. 1 and 2) to obtain a 48-hour and 96-hour TL_{50} value, which is that con-

centration at which 50 % of the fish survive for the specified times.

After preliminary trials the following experiments were designed. Experiment I was designed with yellow-power concentrations of 75, 100, and 150 mg/1. Two aquaria with five fish per aquarium were used for each concentration. One aquarium containing five fish was used as a control. The size of the fish used ranged from 2.2 to 3.2 cm in length. The pH ranged from 8.0 at the start of the experiment to 7.7 at the end of the experiment. The dissolved oxygen ranged from 6.3 mg/1 at the start of the experiment to 4.0 mg/l at the end of the experiment.

Experiment II was designed with black-powder concentrations of 1,500 and 2,000 mg/l. One aquarium with 10 fish per aquarium was used for each concentration. One aquarium containing 10 fish was used as a control. The size of the fish used ranged from 2.2 to 2.8 cm in length. The pH ranged from 8.0 at the start of the experiment to 7.4 at the end of the experiment. The dissolved oxygen ranged from 6.2 mg/l at the start of the experiment to 3.6 mg/l at the end of the experiment.

Results and Discussion

Fish had the same pattern of behavior when subjected to either type of depth charge chemical. Those subjected to stronger concentrations displayed the pattern sooner than those subjected to lower concentrations. A generalized and typical behavior pattern will be given for fish subjected to 150 mg/l of yellow powder.

Upon introduction to toxic water, the fish proceed to swim in slow circles. After about one hour their visible respiration rate (determined by timing gill movements) increases and remains higher than normal until death. After two hours they become very sluggish. At about three hours most start losing their equilibrium. They swim or remain stationary in a lopsided manner. At this time some fish start to show color changes. *Dascyllus aruanus* in nature is a small, deep bodied tropical fish with black and white stripes, resembling a zebra in coloration. However after about three hours exposure to the yellow powder their white stripes show patches of brown. After about four hours they start to swim at the surface, most orientated in a nose-up position, struggling and spiraling. Some settled to the bottom and displayed behavior such as loss of fin movement, backwards swimming or swimming in very small circles, antagonism toward others, and periodic shaking. These two types of erratic behavior, whether at the surface or on the bottom, continue for five to thirty hours. After the fish have displayed one or possibly even both of these patterns for a time, they sink to the bottom, or if already there, they remain there in a stationary position, periodically displaying fast spasmodic swimming for a few seconds, then eventually dying.

When surviving fish were netted from the toxic water they showed no alarm to the approaching man or to the net in the water and appeared to be in a narcotized state. After being placed in fresh sea water, all of them recovered to normal activity within one hour.

From Fig. 1 a 48-hour TL_{50} value of 118 mg/l and a 96 hour TL_{50} value of 95 mg/

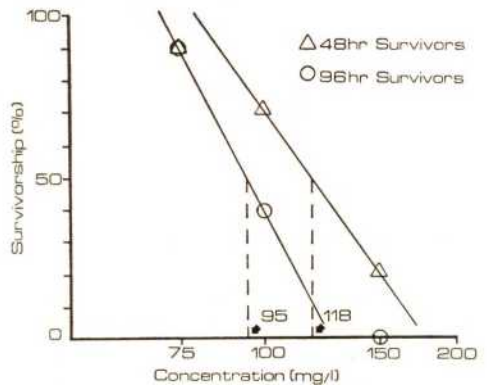

Fig. 1. The effect of various concentrations of yellow powder on the survivorship of *Dascyllus aruanus*. Results are plotted on a semilog scale.

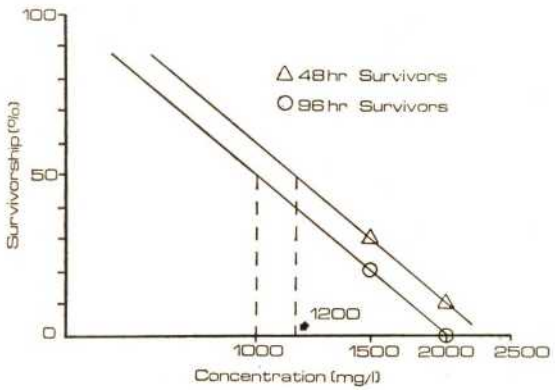

Fig. 2. The effect of various concentrations of black powder on the survivorship of *Dascyllus aruanus*. Results are plotted on a semilog scale.

1 are obtained, based on concentrations of 75, 100, and 150 mg/1 of yellow powder.

From Fig. 2 a 48-hour TL_{50} value of 1200 mg/l and a 96-hour TL_{50} value of 1000 mg/l are obtained using concentrations of 1500 and 2000 mg/l of black powder.

Since there is no linear relationship between size of fish and survival time in the two experiments, it is thought that each individual fish's physiological condition and metabolism was more of a factor in determining survival time in this narrow size range of fish tested.

In all experiments control animals remained healthy and active and in no way seemed abnormal. In addition, pH and dissolved oxygen never reached critical levels. The lower dissolved oxygen values after the death of all the fish or at the end of the experiment, whichever was appropriate, can be correlated in both Experiment I and II with the amount of time the fish were present in the water. Since in the control tanks there were no deaths and there were more fish to use up oxygen for the whole 96-hour time interval, their dissolved oxygen values were the lowest. It is

also worth noting that *Dascyllus aruanus* can survive in sea water for 96 hours with the dissolved oxygen as low as 3.6 mg/l without showing any signs of abnormal behavior.

This bioassay should only be considered valid for *Dascyllus aruanus* of the size range 2.2 to 3.2 cm and only for the time intervals used.

Conclusion

The toxicity of yellow powder and black powder were tested only for a maximum of 96 hours of exposure. The probability of the resultant TL_{50} concentration values ever occurring in Truk Lagoon would depend largely on the prevailing physical factors. Prolonged exposure to lower concentrations of yellow powder and black powder may produce a harmful environment and this should be considered in dealing with these toxic chemicals. Moreover, no consideration was given to possible sublethal effects such as reduced growth rate or reproductive potential. If the toxicity of yellow and black powder is to be gauged absolutely these sublethal effects should also be examined.

These facts being known, much care and consideration should therefore be used in dealing with other such toxic explosives that might be discovered in the future.

ACKNOWLEDGEMENTS

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Reference Cited

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