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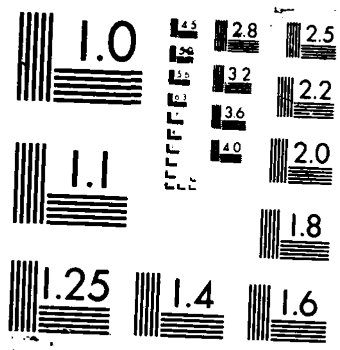

ROCOPY RESOLUTION TEST CHART

NUSC Technical Report 7479
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Experimental Studies of the Survival of Zooplankton: Effects of Net Capture and Artificial Control of Population Densities

Albert L. Brooks
Charles L. Brown
Surface Ship Sonar Department

Naval Underwater Systems Center
Newport, Rhode Island / New London, Connecticut

Preface

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The technical reviewer for this report was J. M. Monti, Code 3331.

Reviewed and Approved: 27 August 1985

L. Freeman
Head, Surface Ship Sonar Department

The authors of this report are located at the
New London Laboratory, Naval Underwater Systems Center,
New London, Connecticut 06320.

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Field and laboratory experiments were performed to determine the effects of capture, transportation and various conditions of crowding in an artificial environment on the survival of zooplanktonic organisms.

Mortality due to net capture was estimated to be 36 percent. Results indicate that this mortality can be significantly reduced by (1) using a net with a large mouth diameter (e.g., 1 meter), (2) restricting duration of each net tow to 4-5 minutes, and (3) towing at speeds not exceeding 3 knots.

Experimental data suggest that a concentration equivalent to 18.6×10^6 zooplankters per m^3 is highly detrimental to their survival but at concentrations equivalent to 2, 4, and $6 \times 10^6/m^3$ the ability of the zooplankton to survive is good and appears to be

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independent of concentration. At a concentration of $6 \times 10^4/m^3$ survival decreases only slightly over an 8-day period.

As was expected, between-sample variability was relatively high. The data suggest that this variability can be reduced by (1) judicious choice of the sampling site and time of year (2) conducting all net towing at the same speed, in the same direction and at the same depth and (3) when samples are collected on different days they should be taken on the same stage of the tide.

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INTRODUCTION

The objective of the Improved Performance Undersea Vehicle (IPUV) Program at the Naval Underwater Systems Center (NUSC) is to determine the applicability of laminar flow technology to small undersea vehicles. Vehicle tests in the ocean have indicated that impacts with plankton and fecal pellets are detrimental to laminar flow.

In order to further develop laminar flow technology, NUSC has refurbished the Langley Air Force Base Sea Water Tow Tank. The objective of this refurbishment was to provide the Navy with a full scale sea water facility in which to conduct high speed laminar flow experiments. The tank is 2880 feet long, 24 feet wide and 12 feet deep and holds 5.4 million gallons of water.

The tow tank is located on the Back River, an estuary of the Chesapeake Bay in Hampton, Virginia. Initial studies of the salt water in the Back River indicated that the suspended particulates are not representative of those found in a typical ocean environment. Most of the particles were found to be silt-sized terrigenous material and detritus (dead organic material). Since the size and density of these particles can be considerably different from oceanic plankton it was decided to develop techniques to simulate a typical ocean environment in the tow tank.

The concept that is being considered for simulation of the ocean environment is to fill the tow tank with filtered salt water from the Back River, collect live plankton from a typical marine environment and seed the tow tank with the plankton. An exhaustive literature search indicated that the ocean environment has not been previously simulated on such a large scale. Initial efforts have been directed towards developing plankton collecting and handling techniques.

In the oceanic environment the most common particles with size attributes and population densities in the range of concern are comprised of the zooplankton. These organisms may range in length from 100 to 2000 μm (0.1 - 2.0mm) and, depending on the productivity of the waters in which they occur, may range in concentration from 1 to 10^6 individuals m^{-3}.

Clearly, to successfully seed a tank of this size with living zooplankton of known size distribution and particle concentration requires answers to a multitude of questions of a biological nature. In an attempt to answer these questions this investigation was designed as a three-phase experiment.

Phase I was designed (1) to establish the most efficacious methods and procedures for at-sea collecting, handling and maintenance of live zooplankton (2) to develop laboratory procedures for the microscopic examination and counting of live and dead organisms (3) to provide samples of the total plankton for a qualitative determination of the size characteristics and species composition of the population and a preliminary estimate of the zooplankton concentration at the sampling site and (4) to provide an estimate of the mortality due to net capture.

Phase II was designed to determine the survivability of organisms over time when subjected to conditions of crowding simulating those which might be expected during transportation from the collection site to the tow tank.

Finally, Phase III experiments were designed to determine the survivability of organisms over a period of 8 days under environmental conditions as close to those of the tow tank as was practical to achieve. Experiments were performed on local planktonic populations during March and April, 1982.

This report presents results of this preliminary investigation.

METHODS

Net tows taken during Phase I and Phase II were collected from an area in Fishers Island Sound off Noank, Connecticut using the University of Connecticut research vessel, "Libinia." Phase III samples were collected from water off the NUSC/NL south pier. With the exception of preliminary trial collections made with a 1/2 meter diameter, number 20 mesh (mesh opening 80 μm) net, all samples were collected with a 1-foot diameter, number 10 mesh (mesh opening 153 μm) net. The net cod end was fitted with a stainless steel cup of approximately 1 liter capacity and a General Oceanics flow meter was suspended in the outer quarter of the net mouth diameter. The volume of water filtered during each net tow was calculated from the duration of the tow and the number of revolutions recorded by this calibrated flow meter.

At the completion of each net tow the contents of the net were washed into the cod-end cup and transferred to a holding container appropriate for the experimental phase being conducted. For the most part, holding containers consisted of covered insulated plastic picnic coolers of about 48 quart (45 liter) capacity.

In the laboratory, contents of the holding containers were gently stirred to create a homogeneous mixture and subsamples were collected using a Stempel pipette. These samples were transferred to a plexiglass tray 4.1 in. (10.5 cms) long by 2.4 in. (6 cms) wide by 0.4 in (1 cm) deep (total volume, 3.8 in ^{3} (63 cm^3)) and organisms were examined at a magnification of 15x. To insure that the entire sample was included in the microscopic examination, the tray was marked with a series of parallel lines. The width of each path thereby created was equal to just slightly less than the diameter of the microscope's field of view. Live organisms in the subsamples were quite active and often moved in and out of the field of view during the counting process. To eliminate the possibility that a living individual might be counted more than once only the dead specimens were counted on the first pass over the tray.

A few drops of formalin were then added and after all individuals had died and settled to the bottom a count of the total number of specimens was obtained. The number of living individuals was then calculated by subtracting the number of dead from the total.

RESULTS AND DISCUSSION

Phase I

On March 23, 1982, a series of trial net tows was taken off Noank using a 1/2 meter diameter, number 20 mesh net. This is one of the smallest net mesh sizes available and will capture the whole range of zooplankton sizes plus a high percentage of the larger phytoplankton. The primary purpose of these tows was to obtain samples of the total plankton for a general qualitative determination of the size characteristics and species composition of the population at the collecting site. These tows were also helpful in establishing methodological procedures for the efficient handling and processing of the captured organisms. From the character of the samples it soon became evident that a far greater number of small particles (e.g. < 100 μm), consisting mainly of phytoplankton, was captured than was desirable for tow tank seeding. It was also evident that the filtering efficiency of this fine-meshed net was rapidly eroded as the phytoplankton cells clogged the net mesh. Based on these results it was concluded that this particular planktonic population would be more advantageously sampled using a number 10 mesh (mesh opening 153 μm) net. A net with this mesh opening would allow most of the phytoplankton to pass through while still retaining zooplankton with the desired dimensional composition.

On the following morning (24 March 1982) several additional trial net tows were made using a 1-foot diameter, number 10 mesh net. The nets were placed well astern of the "Libinia" and towed at a depth of about 3 meters to avoid the turbulent zone in the vessel's wake. After some experimentation it was found that a "low idle" throttle setting and a duration of tow of two to five minutes provided what appeared to be satisfactory samples containing actively-swimming organisms. The combination of slow speed and short duration of tow appeared to reduce to a minimum, physical damage and physiological stress in the captured organisms. To obtain a quantitative estimate of net mortality, however, a microscopic examination of the net contents was required as soon after capture as possible. With everything in readiness, one more net tow was collected. As soon as the net was on board, the vessel headed back to the Noank laboratory. During transit the net contents were washed into a one gallon jar and the volume of water in the jar was brought up to 3000 ml with filtered water taken from the collecting site. The jar was then capped and placed in an insulated 48 quart picnic cooler which had been filled with collecting-site water. The relatively large volume of water in the cooler helped to maintain the captured organisms at the temperature of their natural environment. Within 40 minutes from the time of capture the first of seven replicate samples was being examined and counted in the laboratory. The last of these counts was completed in slightly more than two hours after the organisms were captured. Table 1 presents the results of these counts and reveals a mean total (i.e., alive and dead) number of organisms of slightly more than 6500 individuals per cubic meter of water

TABLE 1
PHASE I - ZOOPLANKTON COUNTS FOR DETERMINATION OF NET MORTALITY, 24 MARCH 1982

TOW NO.	VOLUME FILTERED (m^3)	TOTAL SAMPLE VOLUME (ml)	REPLICATE COUNT NO.	TIME OF COUNT (HRS.)	NO. DEAD	NO. ALIVE	TOTAL NO.	MORTALITY (Δ)	TOTAL NO./m^3 AT SAMPLE SITE	ELAPSED TIME-SAMPLE COLL'N TO SAMPLE COUNT (HRS:MIN)
1	8.6	1	1	1030	3	7	10	30	3488	0:40
1	8.6	1	2	1055	7	9	16	44	5581	1:05
1	8.6	1	3	1059	10	11	21	48	7325	1:09
1	8.6	1	4	1110	7	16	23	30	8023	1:20
1	8.6	1	5	1125	6	17	23	26	8023	1:45
1	8.6	1	6	1140	10	11	21	48	7325	1:50
1	8.6	1	7	1156	4	13	17	24	5930	2:06
			MEANS		6.7	12.0	18.7	36	6528	

and a mean net mortality of 36 percent. It was assumed that all of these organisms were alive in the waters of the collecting site and that the observed mortality was caused by the trauma of capture and/or the extreme conditions of crowding (equivalent to 18.6 X $10^6/m^3$) experienced by the organisms during their brief period of residence in the gallon jar.

Phase II

Upon completion of Phase I counts we again boarded the R/V Libinia and returned to the original sampling site. Within the next hour and one-half, seven more individual net tows were collected (see Table 2). The purpose of this phase of the experiments was to determine the effect on survival of varying concentrations to which organisms might be subjected during transportation from a collecting site to the tow tank for subsequent seeding. Samples were collected with the same 1-foot diameter, number 10 mesh net used earlier for the Phase I collections. It was assumed that the concentration of zooplankton at the sampling site during this second set of net tows would be approximately the same as that determined for the morning collections (i.e., ≈ $6500/m^3$). Though this assumption was subsequently shown to be incorrect it was the best estimate available at the time. Based on this estimate the duration of each net tow (except the last) was adjusted so that approximately 9 m^3 of water was filtered thus theoretically yielding about 60,000 zooplankters in each net sample. Just prior to these net tows each of three insulated coolers was filled with 30 liters of filtered water collected from the sampling site. As soon as net tow number 1 was on board its contents were washed into cooler number 1. In like manner the contents of tows 2 and 3 were washed into cooler number 2. By the time net tows 4, 5 and 6 were on board the cumulative total number of revolutions on the flow meter indicated that the desired 27 m^3 of water for these three tows had not been filtered. This was undoubtedly due to a gradual clogging of the net mesh with a resultant decrease in volume of water filtered. To make up this deficit one additional net tow (i.e. number 7) was made. Contents of net tows 4, 5, 6, and 7 were placed in cooler number 3. Based on the expected number of individuals in each collection it was anticipated that the total number (i.e., living and dead) of individuals in containers 1, 2, and 3 would be 60,000, 120,000, and 180,000 respectively or, equivalent to 300, 600, and 900, times (i.e., 2, 4, and 6 X $10^6/m^3$) the natural population density prevailing at the sampling site. Insulated lids were placed on all containers and the samples were transported back to the laboratory for periodic examination and counting.

At approximately 5, 8, 21, and 45 hours after the three containers were seeded, sub-samples were removed and examined under a microscope for content of living and dead zooplankton. The results of these counts are shown in Table 3. From a summary of these data, shown in Table 4, several interesting facts become apparent. The overall mean total number of individuals (i.e., alive plus dead) in each container was only about one-half the anticipated totals of 60,000, 120,000, and 180,000 and indicated a population density at the sampling site of about 3000 individuals/m^3. As mentioned previously these anticipated totals were based on an estimated population density of about 6500 zooplankters/m^3 derived from collections made during mid-morning. The discrepancy between

TABLE 2

PHASE II - NET TOW LOG, 24 MARCH 1982

TOW NO.	NET DEPTH (m)	NET DIAM. (cm)	NET MESH	DURATION OF TOW (sec)	FLOW METER COUNTS	COUNTS PER SEC	DISTANCE (m)	CM PER SEC	VOL FILTERED (m^3)	CONTAINER NO.
1	3	32	10	280	4253	15.2	114	41	9.1	1
2	3	32	10	250	4107	16.4	110	44	8.8	2
3	3	32	10	365	4500	12.3	120	33	9.6	2
4	3	32	10	393	4340	11.0	116	29	9.3	3
5	3	32	10	210	3706	17.6	99	47	7.9	3
6	3	32	10	197	3165	16.1	84	43	6.7	3
7	3	32	10	95	2360	24.8	63	66	5.0	3

TABLE 3
PHASE III - ZOOPLANKTON COUNTS FOR DETERMINATION OF SURVIVAL RATE DURING TRANSPORTATION

CONTAINER NUMBER 1

ELASPSED TIME (HRS) SAMPLE COLLECTION TO SAMPLE COUNT	REPLICATE NO.	NUMBER DEAD	NUMBER ALIVE	TOTAL NUMBER	Δ SURVIVAL	EST'D TOTAL NO. IN 30 L (ALIVE PLUS DEAD)	EST'D TOTAL NO. IN 30 L (ALIVE ONLY)
5	1	3	7	10	70	30,000	21,000
	2	2	6	8	67	24,000	16,080
8	1	3	6	9	67	27,000	18,090
	2	3	7	10	70	30,000	21,000
	3	0	9	9	100	27,000	27,000
21	1	4	2	6	33	18,000	5,940
	2	2	10	12	83	36,000	29,880
	3	3	5	8	63	24,000	15,120
	4	1	13	14	93	42,000	39,060
45	1	5	5	10	50	30,000	15,000
	2	4	5	9	56	27,000	15,120
	3	5	4	9	44	27,000	11,880

TABLE 3
PHASE III - ZOOPLANKTON COUNTS FOR DETERMINATION OF SURVIVAL RATE DURING TRANSPORTATION

CONTAINER NUMBER 2

ELASPSED TIME (HRS) SAMPLE COLLECTION TO SAMPLE COUNT	REPLICATE NO.	NUMBER DEAD	NUMBER ALIVE	TOTAL NUMBER	Δ SURVIVAL	EST'D TOTAL NO. IN 30 L (ALIVE PLUS DEAD)	EST'D TOTAL NO. IN 30 L (ALIVE ONLY)
5	1	7	12	19	63	57,000	35,910
	2	7	17	24	71	72,000	51,120
8	1	8	10	18	56	54,000	30,240
	2	9	11	20	55	60,000	33,000
	3	6	10	16	63	48,000	30,240
	4	5	12	17	71	51,000	36,210
21	1	9	12	21	57	63,000	35,910
	2	14	8	22	36	66,000	23,760
	3	2	11	13	85	39,000	33,150
	4	4	9	13	69	39,000	26,910
45	1	6	7	13	54	39,000	21,060
	2	7	11	18	61	54,000	32,940
	3	3	8	11	73	33,000	24,090
	4	9	13	22	59	66,000	38,940

TABLE 3
PHASE III - ZOOPLANKTON COUNTS FOR DETERMINATION OF SURVIVAL RATE DURING TRANSPORTATION

CONTAINER NUMBER 3

ELASPSED TIME (HRS) SAMPLE COLLECTION TO SAMPLE COUNT	REPLICATE NO.	NUMBER DEAD	NUMBER ALIVE	TOTAL NUMBER	Δ SURVIVAL	EST'D TOTAL NO. IN 30 L (ALIVE PLUS DEAD)	EST'D TOTAL NO. IN 30 L (ALIVE ONLY)
5	1	7	15	22	68	132,000	89,760
	2	3	8	11	73	66,000	48,180
8	1	5	17	22	77	132,000	101,640
	2	2	12	14	86	84,000	72,240
	3	3	11	14	79	84,000	66,360
	4	3	15	18	83	108,000	89,640
21	1	2	16	18	89	108,000	96,120
	2	6	13	19	68	114,000	77,520
	3	7	17	24	71	144,000	102,240
	4	7	4	11	36	66,000	23,760
45	1	8	2	10	20	60,000	12,000
	2	11	5	16	31	96,000	29,760
	3	8	4	12	33	72,000	23,760
	4	13	1	14	7	84,000	5,880

TABLE 4
PHASE II - SURVIVAL RATE DURING TRANSPORTATION - A DATA SUMMARY

	EST'D MEAN TOTAL NO/30L (ALIVE PLUS DEAD)				OVERALL MEAN (ALIVE AND DEAD)	EST'D MEAN TOTAL NO/30L (ALIVE ONLY) AND MEAN PERCENT SURVIVAL				OVERALL MEAN (ALIVE ONLY)
	5HRS	8HRS	21HRS	45HRS		5HRS	8HRS	21HRS	45HRS	
CONTAINER NUMBER 1	27,000	28,000	30,000	28,000	28,500	18,540 69Δ	22,030 79Δ	22,500 68Δ	14,000 50Δ	19,598
CONTAINER NUMBER 2	64,500	53,250	51,750	48,000	52,929	43,515 67Δ	32,422 61Δ	29,932 62Δ	29,257 62Δ	32,391
CONTAINER NUMBER 3	99,000	102,000	108,000	78,000	96,429	68,965 71Δ	82,470 81Δ	74,910 66Δ	17,850 23Δ	59,918

actual and expected totals may be accounted for by the fact that morning collections coincided with the approximate time of high tide. Afternoon net tows were made between 4 and 5 hours later during the latter part of the ebb tide. Since the sampling site was located in fairly shallow water (about 15 feet) and about one mile southwest of the mouth of the Mystic River, a high potential existed for a change in water characteristics and particulate content due to tidal flushing. The relevance of this observation bears directly on the choice of future sampling sites in support of actual vehicle testing and tow tank seeding operations.

Data resulting from studies of natural marine zooplanktonic populations are notoriously variable and these Phase II experiments are no exception, as is evident from perusal of Tables 3 and 4. Part of this variability results from horizontal and vertical patchiness occurring in the distribution of zooplankton assemblages. In the present case additional variability is surely introduced as a result of statistical vagaries associated with the sub-sampling process. In spite of these shortcomings the estimates of mean percent survival shown in Table 4 are reasonably consistent and are interpreted as follows:

(1) Despite concentration in containers 1, 2, and 3 of factors about 300, 600, and 900 times the concentration of individuals at the sampling site the mean percent survival was roughly the same in all three containers and remained so for a period of 21 hours after initial inoculation.

(2) Survivability appeared only slightly reduced after 21 hours though replicate counts increased noticeably in variance.

(3) For the most part, there was an appreciable decrease in the number of survivors when the final counts were taken 45 hours after net capture. An important factor contributing to this decrease was the rise in temperature from 2.8°C (37°F) at the time of net tow collections to 13.7°C (56.7°F) over the 45 hour period. Also during this time, whatever phytoplankton was originally present was undoubtedly exhausted by zooplankton feeding activity with a concurrent accumulation of metabolic waste products and perhaps a reduction in O_2 content of the water.

(4) During Phase I experiments a mortality due to net capture was estimated at 36 percent, or conversely, a percent survival of 64 percent. Because of the nature of Phase II experiments the resultant estimates of mean percent survival in the three containers represent the combined effects on the organisms of mortality and stress due to net capture as well as effects due to confinement within their respective artificial environments. It is interesting to note from Table 4 that if the final counts (i.e., counts made 45 hours after the start of Phase II) are disregarded most of the estimated means of percent survival for all containers over a 21 hour period exceed survivability expected immediately following net capture. These differences between Phase I and Phase II estimated mean percent survival are relatively small and may simply be an artifact of statistical variability. On the other hand, the lower survivability observed during Phase I may have resulted from the extreme crowding experienced by the organisms while being transported to the laboratory in a water volume of only 3000 ml. Whatever the correct interpretation may be, mean survival percentages shown in Table 4 suggest that most of the mortality observed

occurs during net capture and handling with little evidence for additional mortality attributable to these different population densities at least for a duration of time approaching 21 hours.

Phase III

As originally planned, this phase of the experiments was to have determined the ability of organisms to survive over a relatively long period (i.e., eight days) when maintained under conditions simulating those anticipated in the tow tank during actual vehicle testing. The desired concentration of particles during these tests will be about 15,000 per m^3, which approximates average concentration levels found at the Dabob Bay test range. (Brown, 1982). This concentration, when translated to the coolers currently being used, would mean a total number of organisms in each container of only about 570 individuals. Small subsamples of such a dilution, obtained for microscopic examination, would contain so few organisms, resulting in such high relative variability, that the degree of experimental error introduced would probably be unacceptable. To overcome this difficulty, two of the previously described coolers were filled with 37.85 liters of filtered water from the collecting site and inoculated with living zooplankton at a concentration considerably in excess of that found in Dabob Bay. These organisms were collected from water adjacent to the NUSC/NL south pier using the same 1-foot, number 10 mesh net as used for Phase I and Phase II experiments. Examination of trial net tows taken just two hours prior to cooler inoculation indicated a population density of 1660 zooplankters/m^3. Using this estimate, and a 36 percent net mortality estimate, the towing distance of two final net tows was adjusted to provide a total number of organisms captured in each net of about 2200. This total, when placed in each container, would create a population density roughly equivalent to 4 times (i.e., 60,000/m^3) that found in Dabob Bay. As soon as the contents of these two net tows were washed into their respective containers the coolers were covered and transported to the laboratory.

Subsamples for microscopic counting were collected (after gentle stirring of the water in each container) by removing a 1-liter (1000 ml) volume of water. The volume of this sample was then reduced to 80 ml by pouring it through a container fitted with a stainless steel screen of the same mesh size as the collecting net. The water passing through the screen was returned to the cooler from which it was removed. This process effectively concentrated all of the organisms in the initial 1-liter sample by a factor of 12.5. From this concentrate, 3-10 ml samples, taken with a Stempel pipette, were each added to the microscope counting tray and counted in the manner previously described. The 50 ml of concentrate remaining in the screened container was then returned to its original cooler. Thus for each sample removed the volume of water in each cooler was reduced by 30 ml for a total of 240 ml over the test period. This amounts to such an insignificant reduction in total volume in each container (0.6 percent) that it was disregarded in subsequent adjustments of the raw counts. This was not the case, however when it came to the reduction in number of organisms which resulted when each 1-liter sample was removed. In this case, assuming a uniform distribution of particles, a number of particles equivalent to 1/37.85 X 30/80 or 1 percent of the total was removed from each cooler each time a 1-liter sample was taken. This resulted in a cumulative total reduction of 8 percent per container over the duration of the test period. The actual particle counts for each subsample taken during this experimental phase are shown in Table 5. A correction factor, appropriate to each subsample, was applied to these counts to derive the adjusted mean total number per liter and number per container shown in Table 6. These figures give the mean values "adjusted back" to a population density existing prior to the removal of any organisms and thus render the means in Table 6 directly comparable to one another. For container number 1, the adjusted mean total numbers per liter are remarkably consistent. The expected total number of zooplankters per container (i.e., about 2200) as well as the desired population density of about 60,000/m^3 was achieved within quite acceptable limits. The mean survival percentages, which are independent of any changes in population density caused by subsampling and thus require no adjustment, are considerably higher than expected and suggest only a slight increase in mortality over the last half of the test period. Results from Phase I and Phase II have indicated that mortality may be influenced by the speed and duration of a net tow. The low mortality observed in container number 1 may be due to the fact that these organisms were captured in a net towed very slowly for a period of just one minute.

Counts shown in Table 6 for zooplankters residing in container number 2 indicate an initial concentration which is almost twice what had been expected. The habit of zooplankton to occur in vertically stratified bands of concentration is well known and although great care was taken to position both net tows at the same depth the possibility exists that the second tow sampled one of these stratified bands of concentration. The adjusted mean total numbers per liter in container number 2 decreased steadily over the test period. Since these are the means of the total (i.e., living and dead) number of organisms they should remain the same, except for normal statistical variation, throughout the experiment. The regular nature and amount of decrease observed suggests that the decrease was real and that something other than statistical variation was operative. It is now reasonably certain that this decrease was caused by the feeding activities of two small jellyfish which, due to their transparency were not noticed until well along in the experiment. Zooplankton is the natural prey of these organisms and they are known to have voracious appetites. In addition, the ability of these organisms to decimate a population of zooplankton may have been enhanced because of the relatively high population density in the container. The mean rate of survival of organisms in container number 2 was similar to that observed in container number 1 and indicate only a slight increase in mortality over the duration of the experiment.

TABLE 5
PHASE III - ZOOPLANKTON COUNTS FOR 8-DAY SURVIVABILITY EXPERIMENT

DATE	CON-TAINER NO.	REPLI-CATE COUNT NO.	NO. DEAD	NO. ALIVE	TOTAL NO.	SURVIVAL RATE (Δ)	TIME OF COUNT	TIME ELAPSED-COLL'N TO COUNT HRS:MIN	TOTAL NO. PER LITER	CORR-ECTION FACTOR
4/4/82	1	1	2	18	20	90	1220	49:50	53	0
	"	2	1	19	20	95	1245	50:15	53	1.01
	2	1	3	44	47	94	1323	50:53	125	0
	"	2	1	33	34	97	1355	51:25	91	1.01
4/6/82	1	1	1	14	15	93	0906	94:46	40	1.02
	"	2	2	22	24	92	0931	95:01	64	1.03
	2	1	4	21	25	84	0958	95:28	67	1.02
	"	2	7	40	47	85	1022	95:52	125	1.03
4/8/82	1	1	5	20	25	80	1035	144:05	67	1.04
	"	2	1	18	19	95	1135	145:05	51	1.05
	2	1	3	25	28	89	1108	144:38	75	1.04
	"	2	4	21	25	84	1159	145:29	67	1.05
4/10/82	1	1	5	16	21	76	0943	191:13	56	1.06
	"	2	1	20	21	95	1001	191:31	56	1.07
	2	1	4	15	19	79	1003	191:33	51	1.06
	"	2	1	27	28	96	1036	192:06	75	1.07

TABLE 6
PHASE III - SURVIVAL RATE DURING 8-DAY PERIOD - A DATA SUMMARY

DATE	4/4/82		4/6/82		4/8/82		4/10/82	
	CON-TAINER NO.1	CON-TAINER NO.2	CON-TAINER NO.1	CON-TAINER NO.2	CON-TAINER NO.1	CON-TAINER NO.2	CON-TAINER NO.1	CON-TAINER NO.2
ADJUSTED MEAN TOTAL NO./LITER	53	109	54	99	62	74	60	67
ADJUSTED MEAN TOTAL NO./CONTAINER	2006	4126	2044	3747	2347	2801	2271	2536
ADJUSTED EQUIVALENT CONCENTRATION/M^3	53,000	109,000	54,000	99,000	62,000	74,000	60,000	67,000
MEAN RATE OF SURVIVAL (Δ)	93	96	93	85	88	87	86	88

CONCLUSIONS

1. A no. 10 mesh (mesh opening 153 µm) net will retain zooplankton with the desired dimensional composition for tow tank seeding.

2. A combination of slow speed and short duration of tow appears to reduce to a minimum, physical damage and physiological stress in the captured organisms.

3. The mean mortality due to net capture was estimated to be 36 percent. It is believed that part of this high mortality was due to extreme crowding of the live zooplankton while being transported from the field to the laboratory for microscopic examination.

4. At concentrations equivalent to 2, 4 and 6 x 10^6 individuals per m^3, such as might be experienced during transportation of live organisms from the field to the tow tank, there was a neglible effect on mortality for periods up to 21 hours.

5. At concentrations equivalent to 6 x 10^4 individuals per m^3, (a population density four times the concentration anticipated during final tow tank tests), survival was good throughout the entire 8 day test period.

6. The data suggest that the trauma of net capture and handling immediately following net capture account for most of the overall mortality observed.

RECOMMENDATIONS

1. The use of a large (e.g. 1 m. diameter) net of no. 10 mesh (mesh opening 153 µm) towed slowly for periods not exceeding 4-5 minutes should reduce mortality of the captured organisms.

2. Considerable care must be exercised in the choice of a zooplankton collecting site. Important factors to be examined include effects of tidal flushing, vertical and horizontal patchiness, accessibility, temperature and salinity differential between collecting and experimental residence sites and occurrence in net samples of highly efficient predators such as jelly fish, arrow worms and others.

3. Wherever possible, any changes in temperature must be kept to a minimum.

REFERENCES

Brown, C. L. 1982. Particle Sampling and Analysis in Dabob Bay, Washington. NUSC TR6733. 18 p.

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