Toxic Phytoplankton Blooms in the Sea
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VARIATION IN LEVELS OF PARALYTIC SHELLFISH TOXINS AMONG INDIVIDUAL SHELLFISH

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ABSTRACT

Monitoring studies of paralytic shellfish toxin levels in Georges Bank shellfish during 1990 and 1991 included 48 sets of assays of individual animals collected at six stations in the vicinity of Cultivator Shoal and Georges Shoal. At each station, 5 to 40 shellfish were taken at random from dredge hauls covering 200 to 700 m of ocean bottom. Mouse bioassay tests were conducted on individual, whole surfclams, ocean quahogs, moonsnails and sea scallops. Mean toxin levels of the data sets ranged from 71 to 3356 μg STX equiv./100 g tissue. The coefficient of variation of the sets ranged from 19 to 99%. The overall mean coefficient of variation was 48.5%, which is consistent with the few reports of toxin levels in individuals of other shellfish species. There was a tendency for the degree of variation among individual surfclams to decrease as toxin levels increased. There was no significant correlation between toxin level and shell length of surfclams over the size range tested. Results indicate there are substantial differences in toxin levels among individual shellfish in the same area, emphasizing the need for including a large number of animals in composite samples.

INTRODUCTION

A knowledge of the variation in biotoxin levels among individual shellfish in the same area is important for ecological and physiological considerations and is necessary for developing statistically sound testing protocols for fisheries management and public health protection purposes. Yet in regard to paralytic shellfish toxins there is little information on the variation among individual animals, largely because the standard mouse bioassay specifies use of 100 g of shellfish meat, which requires the use of more than one individual for most shellfish species.

Since 1989, shellfish from some areas of Georges Bank in the Gulf of Maine have contained high levels of paralytic shellfish toxins, necessitating closure of this offshore area to shellfishing for the first time (see White et al., this volume). The large size of the animals contaminated with the toxins enabled the performance of mouse bioassay tests on individual shellfish.

MATERIALS AND METHODS

Atlantic surfclams, ocean quahogs, and northern moonsnails were collected at six stations (Fig. 1) between August 1990 and August 1991. Sea scallops were collected from two other locations in the Gulf of Maine (Table 1). Animals were collected from a commercial surfclam vessel using a hydraulic clam dredge or, for scallops, using a scallop dredge. Tows at each station lasted 5 to 10 min at between 2 and 2.5 knots and thus covered about 650 to 2300 ft (200 to 700 m) of ocean bottom. Individual animals were selected at random from the catch. They

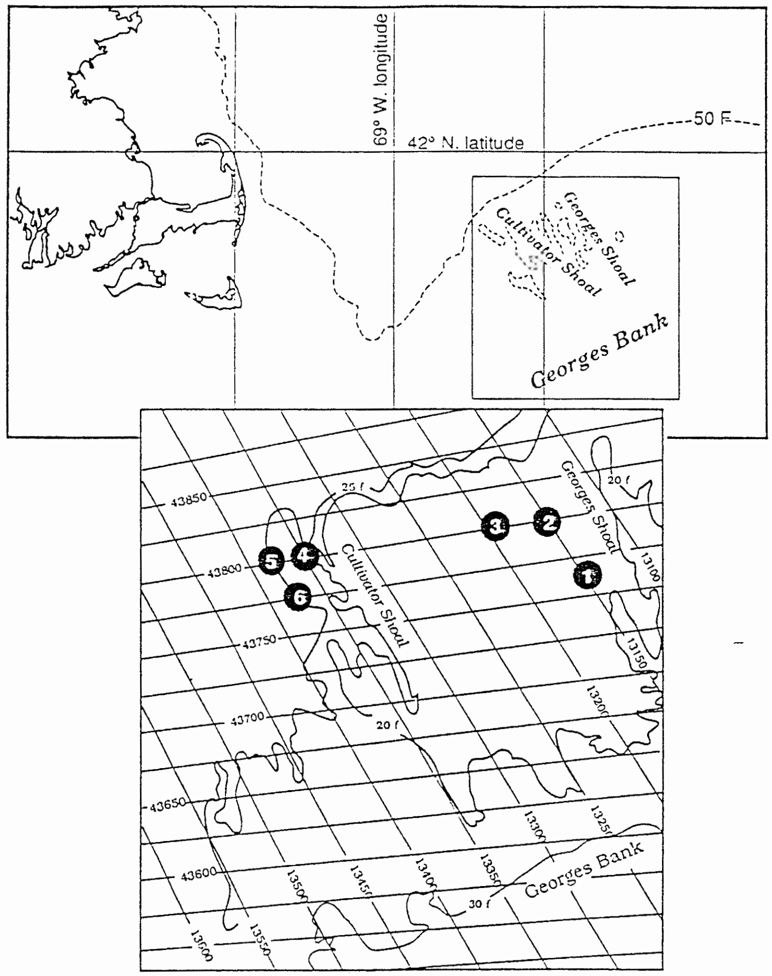

FIG. 1. Location of sampling stations on Georges Bank off the northeastern coast of the United States. Grid lines in bottom part of figure are Loran C lines.

were maintained in seawater wells on the ship and reached the laboratory from 1 to 1.5 days after collection. At the laboratory, 5 to 40 (typically 10) animals from each station were measured and a standard, 3-mouse bioassay test [1] was performed on each individual animal. Shell length ranges of the animals tested were as follows: surfclams, 11-17 cm; ocean quahogs, 7.5-10 cm; moonsnails, 9.0-12.0 cm; sea scallops, 9.7-14.2 cm.

RESULTS

Forty-eight sets of data were accumulated; 42 for Atlantic surfclams (*Spisula solidissima*), 2 for ocean quahogs (*Arctica islandica*), 2 for northern moonsnails (*Euspira heros*, formerly *Polinices*), and 2 for sea scallops (*Placopecten magellanicus*). Results are summarized in Table I.

There was a large variation in toxin levels among individual animals. The coefficient of variation (CV) of each data set ranged from 19 to 99%. Examples of the degree of variation are depicted graphically in Fig. 2, showing actual toxin levels of all the individuals in selected sets. The mean CV for the 42 surfclam data sets was 48.6%, for the ocean quahogs it was 56%; for the moonsnails it was 47.5%; and for the sea scallops it was 43.5% (Table 1). The overall mean CV for all four species was 48.5%.

For surfclams, there was a tendency for the degree of variation among individuals to decrease as toxin levels increased (Fig. 3).

Analysis of toxin level versus shell length of surfclams showed no significant correlation over the size range tested.

DISCUSSION

Part of the variation in toxin levels among individuals reported here is, of course, attributable to the mouse bioassay test, the reproducibility of which is generally accepted to be ± 20% [2]. The overall mean CV for all four shellfish species studied here was more than twice this (48.5%), and in many data sets at low toxin levels was much greater, reaching 99% in one instance (Fig. 3). Thus there is considerable variation among individual shellfish beyond that accounted for by the mouse bioassay. That the animals within each data set occurred near each other (over a span of just several hundred meters) suggests substantial, small-scale differences in the exposure of shellfish to the toxic dinoflagellates (i.e., bloom patchiness and turbulence), in the feeding behavior of the animals, or in the kinetics of their uptake and elimination of the toxins. Shumway and Cucci [6] have demonstrated species-specific feeding and behavioral responses of shellfish exposed to toxic dinoflagellates.

The offshore shellfish reached peak toxin loads during the late spring and early summer of 1990, probably from a bloom of *Alexandrium tamarense* (see White et al., this volume). The variation in toxin levels among surfclams was least in the first samples taken for this purpose in August and September 1990, when the toxins were recently acquired and toxin levels were high (Table I and Fig. 3). No toxic bloom was observed in 1991, and as toxin levels gradually decreased in these shellfish, the amount of variation in toxin levels among individuals appears to have increased (Fig. 3).

There is limited information on the variation in paralytic shellfish toxin levels among individual shellfish. Available information is, however, in general agreement with the results reported here. Ten blue mussels (*Mytilus edulis*) taken from the same sample in the Bay of Fundy (Canada) showed a CV of 35% [3]. Seven softshell clams (*Mya arenaria*) taken from a 10-ft square area also in the Bay of Fundy showed a CV of 49% [3]. The CV for 41 butter clams (*Saxidomus giganteus*) taken from an area of a few square yards in British Columbia (Canada) was 51% [4]. The overall CV for 10 data sets (n = 10) of Pacific geoducks (*Panopea abrupta*) in Alaska was 41% [5].

In summary, past and present results indicate substantial variation in amounts of paralytic shellfish toxins among individual shellfish in the same area. It appears that the overall variation among shellfish in the same area can be characterized generally as having a CV of about 50%, as measured by mouse bioassay.

TABLE I. Variation in levels of paralytic shellfish toxins among individual, whole animals.

Organism	Date	Sta.	n	Range (μg/100g)	Mean ± SD	CV (%)	Mean CV (%)
Spisula solidissima	8/3/90	*	10	454 - 4211	2759 ± 1131	41	
	"	3	10	1882 - 4400	3356 ± 932	28	
	9/13/90	1	10	1257 - 4560	2432 ± 968	40	
	"	2	10	1860 - 4066	2806 ± 687	25	
	"	3	10	2120 - 3696	2657 ± 504	19	
	"	3	10	1824 - 4584	2971 ± 800	27	
	"	4	10	952 - 2907	1930 ± 499	26	
	"	4	10	40 - 3213	1661 ± 1024	62	
	10/9/90	4	40	212 - 1978	812 ± 357	44	
	4/4/91	1	10	246 - 813	513 ± 225	44	
	"	2	10	339 - 2003	766 ± 466	61	
	"	3	10	544 - 1809	1028 ± 382	37	
	"	6	8	459 - 1583	778 ± 377	48	
	4/30/91	1	10	191 - 880	437 ± 209	48	
	"	2	10	351 - 1166	625 ± 216	35	
	"	3	10	344 - 1066	649 ± 219	34	
	5/23/91	1	7	147 - 608	340 ± 192	57	
	"	2	8	350 - 1284	607 ± 292	48	
	"	3	6	426 - 1246	864 ± 294	34	
	"	4	6	123 - 755	442 ± 259	59	
	"	5	7	130 - 528	366 ± 171	47	
	6/4/91	1	10	244 - 657	485 ± 143	29	
	"	2	6	240 - 764	394 ± 188	48	
	"	3	10	40 - 1417	809 ± 472	58	
	"	4	6	241 - 688	465 ± 188	40	
	"	5	9	177 - 1194	469 ± 327	70	
	"	6	10	336 - 2082	828 ± 511	62	
	6/18/91	1	6	127 - 960	325 ± 318	99	
	"	2	8	132 - 595	423 ± 170	40	
	"	3	8	70 - 562	381 ± 160	42	
	"	4	9	40 -783	334 ± 265	79	
	"	5	8	68 - 333	226 ± 83	37	
	7/2/91	1	10	45 - 157	71 ± 35	49	
	"	2	7	83 - 654	240 ± 192	80	
	"	3	6	124 - 322	200 ± 79	40	
	"	4	8	52 - 384	168 ± 114	68	
	7/16/91	1	9	97 - 680	201 ± 183	91	
	"	2	6	136 - 492	334 ± 150	45	
	"	3	10	53 - 901	368 ± 255	69	
	"	4	6	146 - 1092	528 ± 387	73	
	"	6	5	349 - 628	454 ± 106	23	
	8/30/91	2	6	171 - 871	362 ± 265	73	48.6
Arctica islandica	8/3/90	6	10	333 - 1803	868 ± 493	57	
	9/13/90	6	10	57 - 573	314 ± 174	55	56.0
Euspira heros	7/2/91	3	10	43 - 1406	695 ± 448	64	
	7/16/91	6	9	1043 - 2922	1803 ± 556	31	47.5
Placopecten magellanicus	8/26/91	**	10	66 - 407	217 ± 121	56	
	"	***	10	40 - 132	94 ± 29	31	43.5

*Loran C location 13175-43825, ** 11961-25754, *** 11947-25752

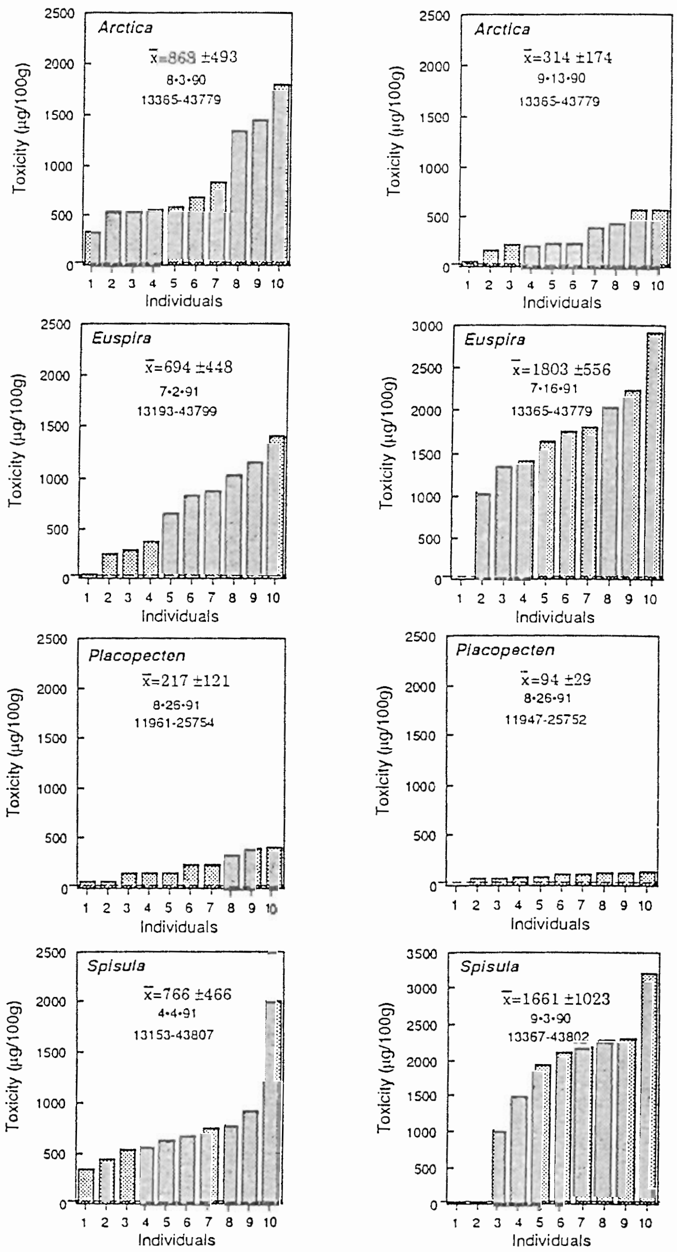

FIG. 2. Toxin levels of the individual animals described in Table I. Only two of the 42 surfclam data sets are shown. Shown on each graph is the mean toxin level, standard deviation, date of collection and Loran C coordinates of the collection site.

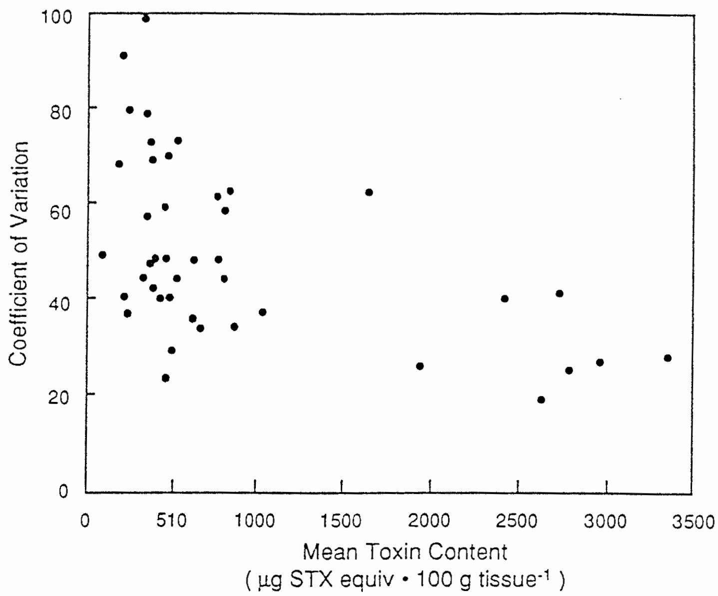

FIG. 3. Mean toxin level of the surfclam data sets from Table I versus the coefficient of variation of each set.

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