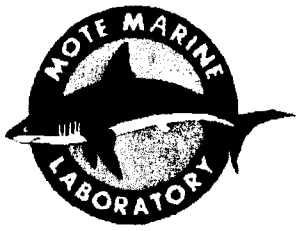

EFFECTS OF MOSQUITO CONTROL MEASURES ON NON-TARGETED ORGANISMS IN THE FLORIDA KEYS NATIONAL MARINE SANCTUARY

DRAFT FINAL

FOR THE PERIOD
October 1, 1997 through December 21, 1998

SUBMITTED TO:

US ENVIRONMENTAL PROTECTION AGENCY
FLORIDA KEYS NATIONAL MARINE SANCTUARY
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INTRODUCTION/PROJECT SUMMARY

This project was undertaken to determine if mosquito adulticides used in Monroe County cause adverse ecological effects in the Florida Keys National Marine Sanctuary (FKNMS). Previous studies of thermal fog applications showed drift of naled and fenthion into non-targeted (no-spray) terrestrial habitats in the Florida Keys, (Hennessey *et al.*, 1992). Pesticide residues collected on cellulose pads exhibited up to 90 $\mu g/m^2$ naled at 15 m inside a pineland no-spray zone, with naled drift detected up to 750 meters into the no-spray zone. At 6 hours (hrs.) after application, naled concentrations on the pads diminished to about 50% that observed at 1.5 hours. Fenthion was detected in about the same concentrations 50 meters into a wildlife refuge, but none was detected at 500 m. No persistence data were obtained for fenthion. These results show the potential for ecological hazard resulting from drift from mosquito adulticide applications.

Dibrom-14, also known as Naled (1,2-dibromo-2,2-dichloroethyl dimethyl ester, phosphoric acid) is a fast acting, short residual organophosphate insecticide (U.S.EPA, 1984). Naled hydrolyses in water (half life @ 70^0F and pH 7 = 16 hours, decreases with increasing pH). Although hydrolysis occurs fairly rapidly in seawater (pH = 8) the primary degradation product, DDVP (2,2-dichlorovinyl dimethyl phosphate), is much more toxic than dibrom. The toxicity of dibrom (rat, acute oral LC-50) is 250 mg/kg, where as the LC-50 for DDVP is 89 mg/kg (Chevron, 1985). Therefore, environmental assessment of the effects of dibrom must also include analyses and toxicological testing for DDVP as well. Permethrin is an organochlorine, contact insecticide, consisting of a mixture of cis and trans isomers. The cis isomer is highly toxic (mouse LC-50, 85 mg/kg),however, the commercial mixture has a lower mammalian toxicity (LC-50 of 410 mg/kg). Permethrin is applied with a synergist, piperonyl butoxide (PBO), that inhibits the insect's natural metabolic defense against pyrethroids, greatly enhancing its insecticidal effectiveness (U.S. EPA, 1984).

A study of both permethrin and naled/DDVP was conducted in a mangrove community and residential water collection systems on Grand Cayman Island, CI. following applications over residential areas as well as coastal mangrove forests (Pierce and Henry, 1988). These results showed persistence of permethrin in mangrove tree leaves and in association with suspended sediment in the water cisterns, but none was detected in saltmarsh water pools. Although no naled or DDVP were detected in the mangrove community following application, residues of both were recovered from cistern water up to 16 hours after application (Pierce and Henry, 1988), exhibiting the potential for exposure to coastal aquatic organisms as well as to potential public health problem in potable drinking water.

The acute toxicity of permethrin for non-target estuarine organisms, assessed in a flow-through system, reported the 96 hr. acute toxicity to be 0.02 $\mu g/l$ for mysid shrimp, 0.2 $\mu g/l$ for penead shrimp and 2.2 $\mu g/l$ for the silverside minnow, menidia (Schimmel *et al.*, 1984). The half-life pf permethrin in water and sediment was found to be <2.5 days, and was dependent upon photolysis in water and on microbial degradation in sediments (Schimmel, *et al.*, 1984; Miller, 1998).

Results of aerial ULV applications of 1 fl oz/acre and 2 fl oz/acre dibrom over an estuarine environment exhibited no observable effects on caged non-target organisms; Paneus shrimp (post-larvae), Callinectes crabs (adult) and adult Fundulus up to 48 hours after application (Chevron, 1980). Sublethal and chronic effects, however, have not been established and are of concern for repeated applications of ULV that may drift considerable distances into restricted flow areas in bays and estuaries within the Florida Keys.

This one year study was designed to monitor the distribution and persistence of the two mosquito adulticides most commonly applied in Monroe County, permethrin and dibrom (naled). Permethrin is routinely applied in the evening as an ultra low volume (ULV) product from trucks, to pinpoint specific mosquito problem areas. Dibrom is applied early morning as ULV from C-47 aircraft to reach a broader mosquito infested area. The amount of pesticide entering the FKNMS by way of aerial drift and tidal current transport was monitored on three occasions, (6/16-6/18; 7/28-7/29; and 9/22-9/23). The results show aerial drift into the leeward side of the application area, with some tidal transport out of canals into the adjacent waters of the National Marine Sanctuary. Concentrations of naled in the water column were below the toxicity threshold. However, the naled degradation product, dichlorvos (DDVP), was found in some of the water column samples in quantities exceeding the acute toxicity threshold (no observable effects level, NOEL), indicating a potential ecological hazard. Permethrin was not detected in water samples, however, the lower limit of detection (0.07 μg/L) in water is very close to the acute NOEL for some marine invertebrates, (Miller, 1998).

METHODS AND MATERIALS:

The Monroe County Mosquito Control District (MCMCD) provided both permanone as well as dibrom applications within the same area of Key Largo (between MM #89 and MM # 91). Dibrom was applied as ultra low volume (ULV) technical product dibrom-14 (Valent USA Corp.), 0.75 oz/acre using C-47 aircraft. Permethrin was applied as the technical product, Permanone (4% cis + trans permethrin / 8% PBO, Agrivo Corp.) from trucks as ground ULV applied at 5.5 fl oz/acre. Prior to each test application , a grid of nine (9) sampling sites covering an area of approximately 1.5 Km along shore to 1 Km offshore, was established in both the Florida Bay side as well as the Atlantic side of Key Largo to provide a control (windward) and a drift (leeward) sampling area, depending on the direction of the wind.

Samples collected at each of the eighteen (18)sampling sites consisted of:

- Filter pads to determine pesticide deposition as a result of aerial drift (placed on floating platforms above the water surface to avoid water splashing on to the filter surface,

- water surface microlayer to determine if the pesticides accumulated from deposition onto the water surface, and

- water subsurface (about 20 cm depth) to determine the amount of pesticide in the water column to which marine organisms would be exposed.

Samples were collected just prior to each pesticide application to monitor for residual pesticides, and again at 2 to 4 hours (hr.) after each application. Persistence in the aqueous environment was monitored by collection of surface and subsurface water samples again at 12 hour intervals post application as deemed necessary for each study according to the procedures of Pierce *et al.*, 1996.

Water quality and field parameters were collected for each site, including temperature, dissolved oxygen, pH, salinity, conductivity and depth. A strict quality control program was followed including field blanks, spiked standard recoveries and surrogate recovery standards added to each sample. Sample custody samples were maintained and samples processed according to the written standard operating procedure, as approved by the Environmental Protection Agency, (EPA). Samples were processed immediately in the field with the addition of dichloromethane solvent to initiate extraction and to reduce degradation of the parent compounds. Samples were brought back to Mote Marine Laboratory (MML) for further processing and gas chromatography- mass spectrometry (GC-MS) analysis.

GC-MS analyses were performed using a Varian Instruments (Sugar Land, TX) Saturn II ion-trap Mass Spectrometer coupled with a Varian 3400 gas chromatograph. GC separations were performed on a 30 m glass capillary DB-5 MS column.

Pre-application samples for the first study, **June 16, 1998**, were collected simultaneously from the Atlantic and Bay sites at 17:00 to 18:40. The permanone was applied by ground ULV starting at 20:00, with the first series of filters, surface and sub-surface water samples collected from 22:00 to 01:00. Dibrom was subsequently applied by air ULV at 07:00 on 6/17/98, with the post application sampling occurring from 09:00 to 11:30. The 24-hour permanone (coincident with the 12 hour dibrom) sampling occurred from 17:00 to 18:30 on 6/17/98. One final sampling was performed on 6/18/98 from 08:30 to 10:00 on both the Bay and Atlantic sites.

The second study **(7/28/98)** pre-application samples were collected from 15:00 to 17:00 hours on both the Bay and Atlantic sides simultaneously, with the permanone application following at 20:00. The post-application samples were collected from 22:00 to 00:45 on both the Bay and Atlantic sides concurrently. Dibrom was applied the next morning at 07:00. The first pre-application sampling for the Bay side was obtained from 9:45 to 11:15, however, due to boat problems, the Atlantic side was not sampled until 12:38 to 14:00, delaying the post-application samples for that area. The second dibrom sample collection, simultaneous with the third permanone sampling was obtained from the Bay side from 14:00 to 15:30. No further samples were collected from the Atlantic side.

The third study **(9/22/98)** pre-application samples were collected from 16:20 to 17:30 in the bay and Atlantic and canal sites simultaneously, with permanone application initiated at 20:00.

Dibrom was not applied during this study due to evacuation of aircraft from the impending hurricane, Georges. The 12-hour post permanone application sampling was performed from 8:40 to 10:00 on 9/22/98.

RESULTS AND DISCUSSION:

FIRST APPLICATION: JUNE 16-18, 1998

Pesticide concentrations collected on the **filter** pads are given in **Table 1A** and **B**, showing some drift of permanone in to the Florida Bay side of the application area, with none detected on the Atlantic side. This is consistent with the wind direction out of the ESE at 5 kts. (**Figure 1**). Standard recoveries for spiked filter samples are shown in **Table 1C**.

Lower limits of detection were (Miller, 1998) were:

	Naled/DDVP	CIS + Trans Permethrin
Water	0.05 μg/L	0.07 μg/L
Filter	0.1 $\mu g/m^2$	0.2 $\mu g/m^2$

Surface water microlayer samples collected from the Atlantic and Bay sides (**Table 2A** and **B**) show no permethrin or dibrom in the surface water, with DDVP (breakdown product of dibrom) found at only one site. Standard recoveries from surface water samples are shown in **Table 2C**. These results show that although some permethrin was deposited onto the filter papers, none was detected in the surface water microlayer, indicating rapid dispersion-dissolution into the water, and/or rapid degradation by hydrolysis and photolysis.

Results of the **subsurface water** samples (collected about 20 cm below the surface) are given in **Table 3A** and **B** for the Atlantic and Bay side respectively. These results show no pesticide residues on the Bay side (except a small amount of DDVP at one site 24 hr. after application), yet DDVP was observed in 50% of the Atlantic samples 14-16 hr. after application and in 3 of 9 sites during the 22 to 24 hr sampling period (**Table 3A** and **B**). This would suggest that the breakdown product of dibrom (DDVP) was transported to these sites in the water column as well as by degradation of dibrom deposited into the water by aerial drift. The most likely source would be tidal movement out of the canal systems of the residential area where the pesticides were applied. Water quality data for the June application monitoring episode are given in **Table 4A** and **B**.

SECOND APPLICATION: JULY 28-29, 1998

Results of the second application monitoring episode are similar to the first, with no permethrin found on filter pads on the Atlantic side (**Table 5A**), and all filter samples in the Bay side exhibiting permethrin at 3-6 hr. after application (**Table 5B**), showing permethrin drift into the Buttonwood sound area of Florida Bay, consistent with the wind speed and direction as. ESE at 12 kts (**Figure 2**). Standard recovery for the filter pad QA is given in **Table 5C**.

Consistent with the first application, the surface water samples showed no permethrin, or dibrom or DDVP, indicating no accumulation at the water surface microlayer (**Tables 6A, B** and **C**). Sub-surface water samples exhibited much lower amounts of DDVP than were observed from the first application, yet three out of nine sites did indicate amounts just above detection limits. It is possible that the low DDVP concentrations resulted from the delayed sampling time (3 hours late due to boat problems) and that higher wind velocity dispersed the aerially applied pesticides, reducing the amount deposited in any given area of the FKNMS and the canal water (**Table 7 A** and **B**). The QA standard recovery data are given in **Table 7C** for sub-surface water samples. Water quality data for the July sampling are shown in **Table 8.**

THIRD APPLICATION: SEPTEMBER 22-23, 1998

The sampling regime for the third application was changed to include samples of water from the residential canals opening to the Atlantic side of the study area. This sampling episode was scheduled to occur just as hurricane "Georges" was bearing down on the Keys, so it was terminated prematurely. Fortunately, we were able to collect filter and water from both the Bay and Atlantic sides and from the canals before and after the evening permanone application. The 12 hr. post sampling collection also was obtained the following morning, prior to evacuating from the hurricane. The wind direction during the permanone application was opposite that of the two previous sampling episodes, this time from the north at 5-10 kts.

Temephos concentrations found on the **filters** are given in **Table 9A** for the Atlantic side, including the canal system leading out to the Atlantic, and **9B** for the Bay side **(Figure 3).** These show permanone collected on the filters in all except one of the Atlantic sites, with up to 51 $\mu g/m^2$ cis + trans permethrin collected on a filter in the canal. Filters on the Bay side exhibited permanone deposition on 4 out of 10 filters. **Surface water** was collected only from the canals. These results (**Table 10**) show permanone in all of the surface water microlayer samples 2-4 hr. after application. Dibrom was not applied during this period because the airplanes were evacuated due to the pending hurricane.

Sub-surface water samples also were collected at each site 2-4 hours after application and again at 12 hours after. No permethrin was detected in any of the subsurface samples, which is consistent with the previous two applications (**Tables 11A and 11B**). Water quality field data are given in **Tables 12A and 12B**

ECOLOGICAL HAZARD ASSESSMENT:

The toxicity of **permethrin, dibrom** and **DDVP** to representative marine invertebrates is shown in **Table 13** (EPA 1985; Miller 1998). Comparisons of the toxicity thresholds in **Table 13** with pesticide concentrations found in sub-surface water are used to assess the potential for an ecological hazard from that pesticide.

PERMETHRIN - Although cis and trans permethrin were found in most of the leeward-side filter samples, concentrations exceeding quantifiable amounts in water were found only in the

canal surface water samples. It is important to note that the acute NOEL for permethrin is approximately equal to the detection limit of the GC-MS method used. Therefore, it is possible that concentrations of permethrin approaching the toxicity threshold were present, yet not detected. This problem can be resolved by processing larger volumes of water for permethrin analysis, and by the use of GC-ECD to provide a more sensitive analytical technique.

NALED - Naled was not detected on filter pads, nor in the surface water samples. The only instance of detectable amounts of naled was in one sub-surface water sample on the Atlantic side on 6/17/98. This concentration was less than the acute NOEL for marine invertebrates, indicating no ecological hazard from dibrom. The amount of dibrom in canal water was not assessed and should be a priority for future studies.

DDVP - The primary degradation product of dibrom, DDVP, was found in sufficient quantities and for a sufficient time period to be considered as a potential ecological hazard to sensitive marine invertebrates. Although DDVP in the subsurface water could result from degradation of dibrom from aerial deposition, the most likely source would appear to be from tidal flushing of the pesticide residues from the residential canal systems, over which the mosquito control pesticides were applied. Recommendations are that studies be implemented to assess the concentration, distribution and persistence of dibrom and DDVP in the canals and adjacent waters of the FKNMS.

CONCLUSIONS

These results show permethrin drift into the FKNMS from ground (truck) permanone applications as deposition on to glass fiber filters held above the water surface, yet none was detected in the surface or subsurface water samples. Neither Dibrom nor its more toxic degradation product, DDVP, were detected as drift on the filter pads, however, DDVP was found in some subsurface samples several hours after application, indicating aqueous transport from residential canals to the National Marine Sanctuary. The DDVP concentrations were of sufficient intensity to be considered a potential ecological hazard to sensitive marine invertebrates, depending on the duration and mode of exposure.

Although these results do not show high concentrations of the mosquito adulticides impacting the FKNMS as aerial drift, a toxic degradation product was detected in subsurface water samples, probably as a result parent compound drift and as aqueous transport in the Sanctuary. Water and filter samples collected from the canal system show greater deposition of aerially applied pesticides in the canals, relative to the out side waters. Deposition of high amounts of pesticide into the canals suggests the importance of more closely monitoring the amount of pesticides deposited into residential canals and partially enclosed embayments, with subsequent tidal transport and distribution into the sanctuary.

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Table 1A. Keys Filter Data: June 16-18, Atlantic

Station	Date	Time	DDVP µg/M²	Naled µg/M²	Cis Perm µg/M²	rans Per µg/M²
PRE APPLICATION						
A1	6/16/98	16:47	<	<	<	<
A5	6/16/98	17:15	<	<	<	<
A9	6/16/98	18:35	<	<	<	<
3-6 HOUR PERMANONE						
A1	6/16/98	22:19	<	<	<	<
A2	6/16/98	22:40	<	<	<	<
A3	6/16/98	22:53	<	<	<	<
A4	6/17/98	0:03	<	<	<	<
A5	6/16/98	23:32	<	<	<	<
A5 dup	6/16/98	23:32	<	<	<	<
A6	6/16/98	23:09	<	<	<	<
A7	6/17/98	0:22	<	<	<	<
A8	6/17/98	0:50	<	<	<	<
A9	6/17/98	1:08	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
A1	6/17/98	9:15	<	<	<	<
A2	6/17/98	9:28	<	<	<	<
A3	6/17/98	9:48	<	<	<	<
A4	6/17/98	10:46	<	<	<	<
A5	6/17/98	10:26	<	<	<	<
A5 dup	6/17/98	10:26	<	<	<	<
A6	6/17/98	10:05	<	<	<	<
A7	6/17/98	11:00		LOST AT SEA		
A8	6/17/98	11:17	<	<	<	<
A9	6/17/98	11:28	<	<	<	<

Table 1B. Keys Filter Data, June 16-18, Bayside

Station	Date	Time	DDVP µg/M²	Naled µg/M²	Cis Perm µg/M²	rans Per µg/M²
PRE APPLICATION						
B1	6/16/98	17:09	<	<	<	<
B5	6/16/98	17:57	<	<	<	<
B9	6/16/98	18:40	<	<	<	<
3-6 HOUR PERMANONE						
B1	6/16/98	22:20	<	<	2.50	5.41
B2	6/16/98	22:40	<	<	1.38	14.37
B3	6/16/98	23:01	<	<	3.43	5.86
B4	6/17/98	0:18	<	<	2.09	3.62
B5	6/16/98	23:59	<	<	2.98	5.08
B5 dup	6/16/98	23:59	<	<	3.06	4.11
B6	6/16/98	23:28	<	<	3.14	5.19
B7	6/17/98	0:41	<	<	1.76	3.88
B8	6/17/98	1:01	<	<	1.76	2.83
B9	6/17/98	1:23	<	<	1.53	3.10
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
B1	6/17/98	9:15	na	na	na	na
B2	6/17/98	9:33	<	<	<	<
B3	6/17/98	9:47	<	<	<	<
B4	6/17/98	10:37	<	<	<	<
B5	6/17/98	10:21	<	<	<	<
B5 dup	6/17/98	10:21	<	<	<	<
B6	6/17/98	10:01	<	1.60	<	<
B7	6/17/98	10:47	<	<	<	<
B8	6/17/98	10:59	0.16	<	<	<
B9	6/17/98	11:13	<	<	<	<

Table 1C. Spiked Glass Fiber Filter Recoveries (%REC)

			DDVP	Naled	Cis Perm	Trans Per
A5 sp	6/16/98	17:15	58.26	58.17	84.30	101.90
A5 sp	6/16/98	23:32	47.01	71.28	103.30	108.37
A5 sp	6/17/98	10:26	5.89	65.26	94.58	112.33
B5 sp	6/16/98	17:57	7.23	80.81	117.12	144.17
B5 sp	6/16/98	23:59	0.00	67.26	97.48	128.03
B5 sp	6/17/98	10:21	1.93	72.83	105.55	111.10
		average	20.1	69.3	100.4	117.7
		stddev	25.6	7.7	11.1	15.6

Figure 1.

Deposition of (cis + trans) permethrin to the FL Keys National Marine Sanctuary following ground (truck) application of Permonone at Key Largo, FL. Filter pads recovered 2 to 4 hrs after application: 6/17/98.

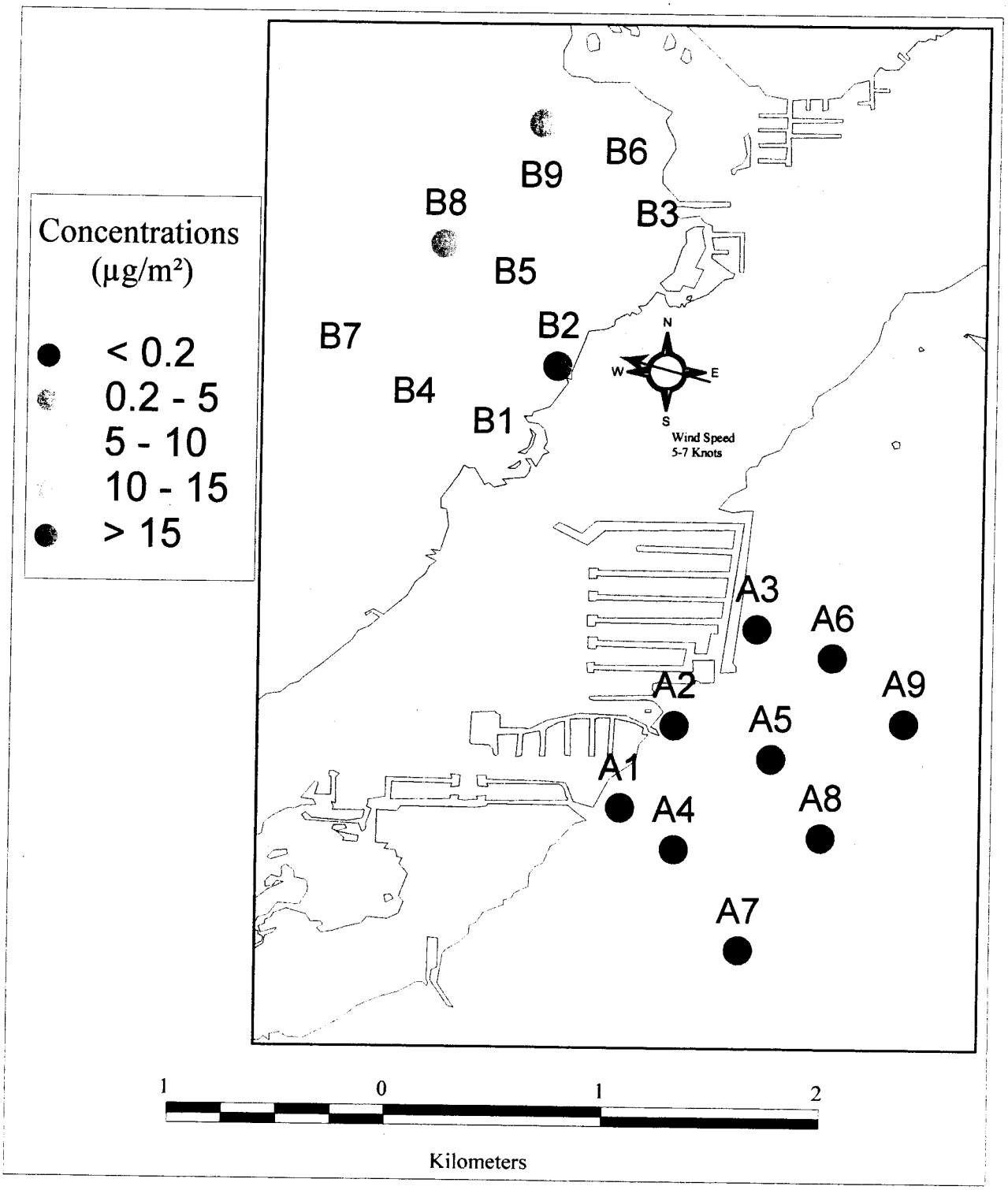

Table 2A. Keys Surface Water Data: June 16-18, Atlantic.

Station	Date	Time	DDVP µg/L	Naled µg/L	Cis Perm µg/L	rans Per µg/L
PRE APPLICATION						
A1	6/16/98	16:47	<	<	<	<
A5	6/16/98	17:15	<	<	<	<
A9	6/16/98	18:35	<	<	<	<
3-6 HOUR PERMANONE						
A1	6/16/98	22:19	<	<	<	<
A2	6/16/98	22:40	<	<	<	<
A3	6/16/98	22:53	<	<	<	<
A4	6/17/98	0:03	<	<	<	<
A5	6/16/98	23:32	<	<	<	<
A5 dup	6/16/98	23:32	<	<	<	<
A6	6/16/98	23:09	<	<	<	<
A7	6/17/98	0:22	<	<	<	<
A8	6/17/98	0:50	<	<	<	<
A9	6/17/98	1:08	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
A1	6/17/98	9:15	<	<	<	<
A2	6/17/98	9:28	<	<	<	<
A3	6/17/98	9:48	1.30	<	<	<
A4	6/17/98	10:46	<	<	<	<
A5	6/17/98	10:26	<	<	<	<
A5 dup	6/17/98	10:26	<	<	<	<
A6	6/17/98	10:05	<	<	<	<
A7	6/17/98	11:00	<	<	<	<
A8	6/17/98	11:17	<	<	<	<
A9	6/17/98	11:28	<	<	<	<
22-24 HOUR PERMANONE 10-11 HOUR DIBROM						
A1	6/17/98	17:09	<	<	<	<
A2	6/17/98	17:18	<	<	<	<
A3	6/17/98	17:28	<	<	<	<
A4	6/17/98	17:59	<	<	<	<
A5	6/17/98	17:47	<	<	<	<
A5 dup	6/17/98	17:47	<	<	<	<
A6	6/17/98	17:37	<	<	<	<
A7	6/17/98	18:08	<	<	<	<
A8	6/17/98	18:18	<	<	<	<
A9	6/17/98	18:29	<	<	<	<
37-39 HOUR PERMANONE 23-24 HOUR DIBROM						
A1	6/18/98	8:22	<	<	<	<
A2	6/18/98	8:32	<	<	<	<
A3	6/18/98	8:48	<	<	<	<
A4	6/18/98	9:18	<	<	<	<
A5	6/18/98	9:09	<	<	<	<
A5 dup	6/18/98	9:09	<	<	<	<
A6	6/18/98	8:57	<	<	<	<
A7	6/18/98	9:27	<	<	<	<
A8	6/18/98	9:35	<	<	<	<
A9	6/18/98	9:44	<	<	<	<

Table 2B. Keys Surface Water Data: June 16-18, Bayside

Station	Date	Time	DDVP µg/L	Naled µg/L	Cis Perm µg/L	rans Per µg/L
PRE APPLICATION						
B1	6/16/98	17:09	<	<	<	<
B5	6/16/98	17:57	<	<	<	<
B9	6/16/98	18:40	<	<	<	<
3-6 HOUR PERMANONE						
B1	6/16/98	22:20	<	<	<	<
B2	6/16/98	22:40	<	<	<	<
B3	6/16/98	23:01	<	<	<	<
B4	6/17/98	0:18	<	<	<	<
B5	6/16/98	23:59	<	<	<	<
B5 dup	6/16/98	23:59	<	<	<	<
B6	6/16/98	23:28	<	<	<	<
B7	6/17/98	0:41	<	<	<	<
B8	6/17/98	1:01	<	<	<	<
B9	6/17/98	1:23	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
B1	6/17/98	9:15	<	<	<	<
B2	6/17/98	9:33	<	<	<	<
B3	6/17/98	9:47	<	<	<	<
B4	6/17/98	10:37	<	<	<	<
B5	6/17/98	10:21	<	<	<	<
B5 dup	6/17/98	10:21	<	<	<	<
B6	6/17/98	10:01	<	<	<	<
B7	6/17/98	10:47	<	<	<	<
B8	6/17/98	10:59	<	<	<	<
B9	6/17/98	11:13	<	<	<	<
22-24 HOUR PERMANONE 10-11 HOUR DIBROM						
B1	6/17/98	17:08	<	<	<	<
B2	6/17/98	17:19	<	<	<	<
B3	6/17/98	17:28	<	<	<	<
B4	6/17/98	18:07	<	<	<	<
B5	6/17/98	17:57	<	<	<	<
B5 dup	6/17/98	17:57	<	<	<	<
B6	6/17/98	17:39	<	<	<	<
B7	6/17/98	18:15	<	<	<	<
B8	6/17/98	18:25	<	<	<	<
B9	6/17/98	18:36	<	<	<	<
37-39 HOUR PERMANONE 23-24 HOUR DIBROM						
B1	6/18/98	8:30	<	<	<	<
B2	6/18/98	8:42	<	<	<	<
B3	6/18/98	8:51	<	<	<	<
B4	6/18/98	9:30	<	<	<	<
B5	6/18/98	9:25	<	<	<	<
B5 dup	6/18/98	9:25	<	<	<	<
B6	6/18/98	9:05	<	<	<	<
B7	6/18/98	9:40	<	<	<	<
B8	6/18/98	9:50	<	<	<	<
B9	6/18/98	10:01	<	<	<	<

Table 2C. Spiked Surface Water Recoveries (%REC).

Spiked Glass Fiber Filter Recoveries (%REC)						
			DDVP	Naled	Cis Perm	Trans Per
A5 sp	6/16/98	17:15	58.5	54.1	82.0	64.0
A5 sp	6/16/98	23:32	31.0	19.4	99.9	83.0
A5 sp	6/17/98	10:26	45.7	41.1	83.7	69.9
A5 sp	6/17/98	17:47	53.7	46.3	81.3	63.3
A5 sp	6/18/98	9:09	83.8	35.6	95.0	95.7
B5 sp	6/16/98	17:57	32.6	37.4	91.9	85.9
B5 sp	6/16/98	23:59	77.7	35.0	91.5	91.3
B5 sp	6/17/98	17:57	1.2	22.8	79.7	57.5
B5 sp	6/18/98	9:25	53.0	34.8	106.0	110.9
		av	48.6	36.3	90.1	80.2
		stdev	25.1	10.7	9.1	17.7

Table 3A. Keys Sub-Water Data: June 16-18, Atlantic.

Station	Date	Time	DDVP µg/l	Naled µg/l	Cis Perm µg/l	Trans Per µg/l
PRE APPLICATION						
A1	6/16/98	16:47	<	<	<	<
A5	6/16/98	17:15	<	<	<	<
A9	6/16/98	18:35	<	<	<	<
3-6 HOUR PERMANONE						
A1	6/16/98	22:19	<	<	<	<
A2	6/16/98	22:40	<	<	<	<
A3	6/16/98	22:53	<	<	<	<
A4	6/17/98	0:03	<	<	<	<
A5	6/16/98	23:32	<	<	<	<
A5 dup	6/16/98	23:32	<	<	<	<
A6	6/16/98	23:09	<	<	<	<
A7	6/17/98	0:22	<	<	<	<
A8	6/17/98	0:50	<	<	<	<
A9	6/17/98	1:08	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
A1	6/17/98	9:15	<	<	<	<
A2	6/17/98	9:28	0.56	<	<	<
A3	6/17/98	9:48	0.08	0.19	<	<
A4	6/17/98	10:46	0.31	<	<	<
A5	6/17/98	10:26	<	<	<	<
A5 dup	6/17/98	10:26	0.15	<	<	<
A6	6/17/98	10:05	0.44	<	<	<
A7	6/17/98	11:00	<	<	<	<
A8	6/17/98	11:17	<	<	<	<
A9	6/17/98	11:28	<	<	<	<
22-24 HOUR PERMANONE 10-11 HOUR DIBROM						
A1	6/17/98	17:09	0.24	<	<	<
A2	6/17/98	17:18	0.33	<	<	<
A3	6/17/98	17:28	0.05	<	<	<
A4	6/17/98	17:59	<	<	<	<
A5	6/17/98	17:47	<	<	<	<
A5 dup	6/17/98	17:47	<	<	<	<
A6	6/17/98	17:37	<	<	<	<
A7	6/17/98	18:08	<	<	<	<
A8	6/17/98	18:18	<	<	<	<
A9	6/17/98	18:29	<	<	<	<
37-39 HOUR PERMANONE 23-24 HOUR DIBROM						
A1	6/18/98	8:22	<	<	<	<
A2	6/18/98	8:32	<	<	<	<
A3	6/18/98	8:48	<	<	<	<
A4	6/18/98	9:18	<	<	<	<
A5	6/18/98	9:09	<	<	<	<
A5 dup	6/18/98	9:09	<	<	<	<
A6	6/18/98	8:57	<	<	<	<
A7	6/18/98	9:27	<	<	<	<
A8	6/18/98	9:35	<	<	<	<
A9	6/18/98	9:44	<	<	<	<

Table 3B. Keys Sub-Water Data: June 16-18, Bayside.

Station	Date	Time	DDVP µg/l	Naled µg/l	Cis Perm µg/l	Trans Per µg/l
PRE APPLICATION						
B1	6/16/98	17:09	<	<	<	<
B5	6/16/98	17:57	<	<	<	<
B9	6/16/98	18:40	<	<	<	<
3-6 HOUR PERMANONE						
B1	6/16/98	22:20	<	<	<	<
B2	6/16/98	22:40	<	<	<	<
B3	6/16/98	23:01	<	<	<	<
B4	6/17/98	0:18	<	<	<	<
B5	6/16/98	23:59	<	<	<	<
B5 dup	6/16/98	23:59	<	<	<	<
B6	6/16/98	23:28	<	<	<	<
B7	6/17/98	0:41	<	<	<	<
B8	6/17/98	1:01	<	<	<	<
B9	6/17/98	1:23	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
B1	6/17/98	9:15	<	<	<	<
B2	6/17/98	9:33	<	<	<	<
B3	6/17/98	9:47	<	<	<	<
B4	6/17/98	10:37	<	<	<	<
B5	6/17/98	10:21	<	<	<	<
B5 dup	6/17/98	10:21	<	<	<	<
B6	6/17/98	10:01	<	<	<	<
B7	6/17/98	10:47	<	<	<	<
B8	6/17/98	10:59	<	<	<	<
B9	6/17/98	11:13	<	<	<	<
22-24 HOUR PERMANONE 10-11 HOUR DIBROM						
B1	6/17/98	17:08	<	<	<	<
B2	6/17/98	17:19	<	<	<	<
B3	6/17/98	17:28	<	<	<	<
B4	6/17/98	18:07	<	<	<	<
B5	6/17/98	17:57	<	<	<	<
B5 dup	6/17/98	17:57	<	<	<	<
B6	6/17/98	17:39	<	<	<	<
B7	6/17/98	18:15	<	<	<	<
B8	6/17/98	18:25	<	<	<	<
B9	6/17/98	18:36	0.08	<	<	<
37-39 HOUR PERMANONE 23-24 HOUR DIBROM						
B1	6/18/98	8:30	<	<	<	<
B2	6/18/98	8:42	<	<	<	<
B3	6/18/98	8:51	<	<	<	<
B4	6/18/98	9:30	<	<	<	<
B5	6/18/98	9:25	<	<	<	<
B5 dup	6/18/98	9:25	<	<	<	<
B6	6/18/98	9:05	<	<	<	<
B7	6/18/98	9:40	<	<	<	<
B8	6/18/98	9:50	<	<	<	<
B9	6/18/98	10:01	<	<	<	<

Table 3C. Spiked Sub-Water Recoveries (%REC).

Spiked Subsurface Water Recoveries (%REC)

			DDVP	Naled	Cis Perm	Trans Per
A5 sp	6/16/98	17:15	147.4	74.8	141.9	141.7
A5 sp	6/16/98	23:32	68.3	70.5	99.8	85.6
A5 sp	6/17/98	10:26	70.2	38.0	24.6	57.0
A5 sp	6/17/98	17:47	60.9	69.2	98.9	92.6
A5 sp	6/18/98	9:09	85.3	58.4	107.1	112.8
B5 sp	6/16/98	17:57	32.5	73.9	93.7	97.2
B5 sp	6/16/98	23:59	80.0	97.8	110.5	69.6
B5 sp	6/17/98	10:21	96.3	27.9	115.9	100.0
B5 sp	6/17/98	17:57	54.2	67.3	104.3	124.5
B5 sp	6/18/98	9:25	64.8	94.4	96.4	96.7
		average	76.0	67.2	99.3	97.8
		stdev	30.6	21.8	29.7	24.7

Table 4A. Keys Field Data: June 16-18, Atlantic.

Station	Date	Time	Sal ppt	Temp øC	DO mg/l	pH Units	SpCond mS/cm	Depth Dec feet
PRE APPLICATION								
A1	6/16/98	18:35	37.28	33.05	7.19	8.01	56.12	4.25
A5	6/16/98	17:15	37.55	32.62	8.15	8.02	56.4	5.5
A9	6/16/98	16:47	37.44	32.77	7.1	8.04	56.23	6
3-6 HOUR PERMANONE								
A1	6/16/98	22:19	37.5	32.48	6.17	7.94	56.34	4.5
A2	6/16/98	22:40	37.26	32.01	5.82	7.86	56.07	4.83
A3	6/16/98	22:53	37.32	33.16	7.23	7.94	56.15	1.67
A4	6/17/98	0:03	37.34	31.91	5.78	8	56.6	8.33
A5	6/16/98	23:32	37.49	31.83	5.71	7.99	56.36	6.17
A6	6/16/98	23:09	37.55	32.99	7.47	8.06	56.39	4.75
A7	6/17/98	0:22	37.41	31.91	5.96	8.03	56.25	8.92
A8	6/17/98	0:50	37.67	31.73	5.55	8.02	56.66	6.42
A9	6/17/98	1:08	37.51	32.01	6.34	8.04	56.34	6.33
14-16 HOUR PERMANONE 2-4 HOUR DIBROM								
A1	6/17/98	9:15	37.55	31.68	4.53	7.88	56.45	3.92
A2	6/17/98	9:28	37.08	31.36	3.79	7.75	55.91	3.83
A3	6/17/98	9:48	37.33	30.78	3.65	7.66	56.21	2.08
A4	6/17/98	10:46	37.55	31.84	5.03	7.92	56.46	7.17
A5	6/17/98	10:23	37.51	31.86	4.8	7.86	56.37	5.08
A6	6/17/98	10:05	37.68	31.03	2.98	7.79	56.63	4.17
A7	6/17/98	11:00	37.79	31.7	5.18	7.96	56.75	7.83
A8	6/17/98	11:17	37.37	31.92	5.22	7.93	56.23	5.01
A9	6/17/98	11:28	37.16	31.73	5.03	7.8	55.98	5.42
22-24 HOUR PERMANONE 10-11 HOUR DIBROM								
A1	6/17/98	17:09	37.79	33.02	7.06	7.94	56.69	6
A2	6/17/98	17:18	37.57	32.99	7.46	7.96	56.4	5.42
A3	6/17/98	17:28	36.7	33.07	6.89	7.91	55.25	5.5
A4	6/17/98	17:59	37.67	33.12	7.15	8.01	56.56	8.08
A5	6/17/98	17:47	37.71	32.61	6.52	8.02	56.58	6.33
A6	6/17/98	17:37	37.55	33.38	7.76	8.01	56.34	5.58
A7	6/17/98	18:08	37.41	32.73	6.55	8.01	56.28	8.67
A8	6/17/98	18:18	37.67	32.58	6.17	8.03	56.56	6
A9	6/17/98	18:29	37.33	33.39	7.07	8.01	56.07	5.92
37-39 HOUR PERMANONE 23-24 HOUR DIBROM								
A1	6/18/98	8:22	37.34	30.86	3.37	7.65	56.23	4.5
A2	6/18/98	8:32	37.21	31.38	3.8	7.8	56.02	4.25
A3	6/18/98	8:48	37.99	30.86	2.42	7.8	57.05	3.75
A4	6/18/98	9:18	37	31.46	4.2	7.83	55.71	6.75
A5	6/18/98	9:09	37.67	31.57	4.27	7.92	56.61	5.17
A6	6/18/98	8:57	36.55	29.88	2.51	7.63	55.16	4.25
A7	6/18/98	9:27	37.57	31.22	4.37	7.92	56.48	7.5
A8	6/18/98	9:35	37.7	31.35	4.63	7.92	56.65	4.75
A9	6/18/98	9:44	36.85	30.12	2.79	7.64	55.57	4.75

Table 4B. Keys Field Data: June 16-18, Bayside.

Station	Date	Time	Sal ppt	Temp øC	DO mg/l	pH Units	SpCond mS/cm	Depth Dec feet
PRE APPLICATION								
B1	6/16/98	17:09	28.83	32.97	7.61	8.25	44.59	5.83
B5	6/16/98	17:57	28.81	32.93	6.64	8.21	44.57	6.33
B9	6/16/98	18:40	28.69	32.8	6.1	8.16	44.41	6.25
3-6 HOUR PERMANONE								
B1	6/16/98	22:20	28.88	32.64	8.41	8.27	44.66	6.17
B2	6/16/98	22:40	28.77	32.61	7.67	8.27	44.51	5.67
B3	6/16/98	23:01	28.83	32.84	5.56	8.04	44.6	4.42
B4	6/17/98	0:18	29.1	32.18	6	8.17	44.98	6.42
B5	6/16/98	23:59	28.99	32.34	7.14	8.26	44.82	6.5
B6	6/16/98	23:28	28.72	32.56	5.67	8.08	44.45	2.67
B7	6/17/98	0:41	29.27	31.92	7.03	8.24	45.23	6.58
B8	6/17/98	1:01	29.13	32.15	6.53	8.22	45.04	6.08
B9	6/17/98	1:23	28.92	32.27	7.57	8.3	44.27	6.17
14-16 HOUR PERMANONE 2-4 HOUR DIBROM								
B1	6/17/98	9:15	28.9	31.81	6.34	8.23	44.73	5.67
B2	6/17/98	9:33	28.81	31.82	5.14	8.15	44.6	4.5
B3	6/17/98	9:47	28.77	32.04	4.62	8.04	44.57	4.25
B4	6/17/98	10:37	29.05	31.92	5.75	8.18	44.92	6.33
B5	6/17/98	10:21	29.08	31.9	5.93	8.2	44.97	6.42
B6	6/17/98	10:01	28.87	32.02	5.78	8.13	44.7	2.83
B7	6/17/98	10:47	29.25	31.89	5.66	8.17	45.29	6.67
B8	6/17/98	10:59	29.24	31.94	5.58	8.17	45.18	6.67
B9	6/17/98	11:13	28.96	32.26	6.51	8.23	44.81	6
22-24 HOUR PERMANONE 10-11 HOUR DIBROM								
B1	6/17/98	17:08	29.25	33.2	8.47	8.24	45.15	6
B2	6/17/98	17:19	29.08	33.22	8.74	8.28	44.92	6
B3	6/17/98	17:28	28.9	33.79	7.26	8.2	44.67	4.67
B4	6/17/98	18:07	29.27	32.95	7.12	8.25	45.19	6.17
B5	6/17/98	17:57	29.04	33.03	7.01	8.25	44.89	6.58
B6	6/17/98	17:39	28.83	33.69	5.4	8.08	44.55	2.67
B7	6/17/98	18:15	29.43	32.76	7.06	8.25	45.42	6.67
B8	6/17/98	18:25	29.14	32.96	7.12	8.27	45.02	6.5
B9	6/17/98	18:36	29.11	33.04	6.91	8.24	44.98	6.08
37-39 HOUR PERMANONE 23-24 HOUR DIBROM								
B1	6/18/98	8:30	29.15	31.46	4.08	8.07	45.08	5.25
B2	6/18/98	8:42	29.09	31.62	5.11	8.15	45	5.5
B3	6/18/98	8:51	28.93	31.64	4.75	8.14	44.77	4.83
B4	6/18/98	9:30	29.31	31.57	5.73	8.2	45.34	6.58
B5	6/18/98	9:25	29.32	31.51	5.61	8.2	45.33	6.33
B6	6/18/98	9:05	28.5	31.53	4.35	8.06	44.17	2.58
B7	6/18/98	9:40	29.5	31.38	5.86	8.2	45.59	6.5
B8	6/18/98	9:50	29.09	31.64	5.41	8.21	45.01	6.25
B9	6/18/98	10:01	29.12	31.49	4.8	8.13	45.03	6

Table 5A. Keys Filter Data: July 28-29, Atlantic.

Station	Date	Time	DDVP µg/M^2	Naled µg/M^2	Cis Perm µg/M^2	rans Per µg/M^2
PRE APPLICATION						
A1	7/28/98	16:24	<	<	<	<
A5	7/28/98	16:44	<	<	<	<
A9	7/28/98	17:09	<	<	<	<
3-6 HOUR PERMANONE						
A1	7/28/98	21:55	<	<	<	<
A2	7/28/98	22:11	<	<	<	<
A3	7/28/98	22:23	<	<	<	<
A4	7/28/98	23:14	<	<	<	<
A5	7/28/98	22:54	<	<	<	<
A5dup	7/28/98	22:54	<	<	<	<
A6	7/28/98	22:37	<	<	<	<
A7	7/28/98	23:28	<	<	<	<
A8	7/28/98	23:45	<	<	<	<
A9	7/29/98	0:01	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
A1	7/29/98	12:38	<	<	<	<
A2	7/29/98	12:50	<	<	<	<
A3	7/29/98	13:04	<	<	<	<
A4	7/29/98	13:41	<	<	<	<
A5	7/29/98	13:28	<	<	<	<
A5dup	7/29/98	13:28	<	<	<	<
A6	7/29/98	13:14	<	<	<	<
A7	7/29/98	13:51	<	<	<	<
A8	7/29/98	14:03	<	<	<	<
A9	7/29/98	14:13	<	<	<	<

Table 5B. Keys Filter Data: July 28-29, Bayside.

Station	Date	Time	DDVP µg/M²	Naled µg/M²	Cis Perm µg/M²	Trans Per µg/M²
PRE APPLICATION						
B1	7/28/98	15:06	<	<	<	<
B5	7/28/98	15:51	<	<	<	<
B9	7/28/98	16:28	<	<	<	<
3-6 HOUR PERMANONE						
B1	7/28/98	22:00	<	<	3.38	6.38
B2	7/28/98	22:16	<	<	2.16	5.69
B3	7/28/98	22:35	<	<	1.29	3.55
B4	7/28/98	23:36	<	<	1.32	1.28
B5	7/28/98	23:17	<	<	2.37	5.38
B5dup	7/28/98	0:17	<	<	1.59	4.36
B6	7/28/98	22:50	<	<	4.49	12.61
B7	7/28/98	23:52	<	<	<	1.10
B8	7/29/98	0:20	<	<	0.53	1.76
B9	7/29/98	0:45	<	<	0.62	1.58
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
B1	7/29/98	9:45	<	<	<	<
B2	7/29/98	9:55	<	<	<	<
B3	7/29/98	10:08	<	<	<	<
B4	7/29/98	10:55	0.40	<	<	<
B5	7/29/98	10:44	<	<	<	<
B5dup	7/29/98	10:44	<	<	<	<
B6	7/29/98	10:24	<	<	<	<
B7	7/29/98	11:02	<	<	<	<
B8	7/29/98	11:14	<	<	<	<
B9	7/29/98	11:23	<	<	<	<

Figure 2.

Deposition of (cis + trans) permethrin to the FL Keys National Marine Sanctuary following ground (truck) application of Permonone at Key Largo, FL. Filter pads recovered 2 to 4 hrs after application: 7/28/98.

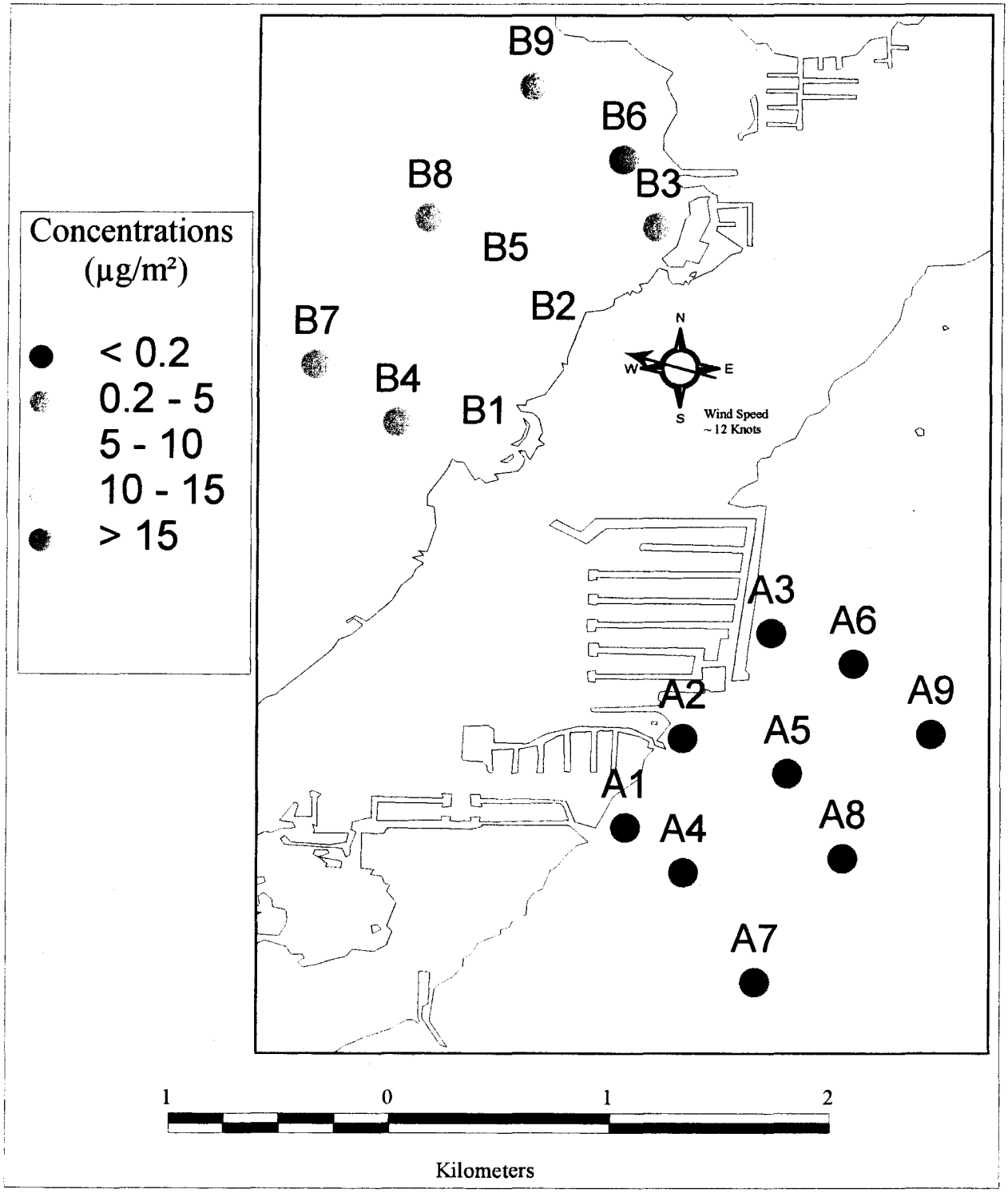

Table 5C. Spiked Glass Fiber Filter Recoveries (%REC).

Spiked Glass Fiber Filter Recoveries (%REC)

			DDVP	Naled	Cis Perm	Trans Per
A5sp	7/28/98	16:44	4.7	16.8	96.7	129.8
A5sp	7/28/98	22:54	37.2	27.2	75.9	104.4
B5sp	7/28/98	15:51	2.0	2.0	122.1	86.7
B5sp	7/28/98	1:17	91.9	95.1	101.1	66.7
B5sp	7/29/98	10:44	35.0	29.1	103.5	120.6
		average	34.2	34.0	99.8	101.6
		stdev	36.2	35.8	16.5	25.5

Table 6A. Keys Surface Water Data: July 28-29, Atlantic.

Station	Date	Time	DDVP µg/l	Naled µg/l	Cis Perm µg/l	rans Per µg/l
PRE APPLICATION						
A1	7/28/98	16:24	<	<	<	<
A5	7/28/98	16:44	<	<	<	<
A9	7/28/98	17:09	<	<	<	<
3-6 HOUR PERMANONE						
A1	7/28/98	21:55	<	<	<	<
A2	7/28/98	22:11	<	<	<	<
A3	7/28/98	22:23	<	<	<	<
A4	7/28/98	23:14	<	<	<	<
A5	7/28/98	22:54	<	<	<	<
A5dup	7/28/98	22:54	<	<	<	<
A6	7/28/98	22:37	<	<	<	<
A7	7/28/98	23:28	<	<	<	<
A8	7/28/98	23:45	<	<	<	<
A9	7/29/98	0:01	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
A1	7/29/98	12:38	<	<	<	<
A2	7/29/98	12:50	<	<	<	<
A3	7/29/98	13:04	<	<	<	<
A4	7/29/98	13:41	<	<	<	<
A5	7/29/98	13:28	<	<	<	<
A5dup	7/29/98	13:28	<	<	<	<
A6	7/29/98	13:14	<	<	<	<
A7	7/29/98	13:51	<	<	<	<
A8	7/29/98	14:03	<	<	<	<
A9	7/29/98	14:13	<	<	<	<

Table 6B. Keys Surface Water Data: July 28-29, Bayside.

Station	Date	Time	DDVP µg/l	Naled µg/l	Cis Perm µg/l	rans Per µg/l
PRE APPLICATION						
B1	7/28/98	15:06	<	<	<	<
B5	7/28/98	15:51	<	<	<	<
B9	7/28/98	16:28	<	<	<	<
3-6 HOUR PERMANONE						
B1	7/28/98	22:00	<	<	<	<
B2	7/28/98	22:16	<	<	<	<
B3	7/28/98	22:35	<	<	<	<
B4	7/28/98	23:36	<	<	<	<
B5	7/28/98	23:17	<	<	<	<
B5dup	7/29/98	0:17	<	<	<	<
B6	7/28/98	22:50	<	<	<	<
B7	7/28/98	23:52	<	<	<	<
B8	7/29/98	0:20	<	<	<	<
B9	7/29/98	0:45	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
B1	7/29/98	9:45	<	<	<	<
B2	7/29/98	9:55	<	<	<	<
B3	7/29/98	10:08	<	<	<	<
B4	7/29/98	10:55	<	<	<	<
B5	7/29/98	10:44	<	<	<	<
B5dup	7/29/98	10:44	<	<	<	<
B6	7/29/98	10:24	<	<	<	<
B7	7/29/98	11:02	<	<	<	<
B8	7/29/98	11:14	<	<	<	<
B9	7/29/98	11:23	<	<	<	<
22-24 HOUR PERMANONE 10-11 HOUR DIBROM						
B1	7/29/98	16:01	<	<	<	<
B2	7/29/98	16:11	<	<	<	<
B3	7/29/98	16:20	<	<	<	<
B4	7/29/98	17:00	<	<	<	<
B5	7/29/98	16:46	<	<	<	<
B5dup	7/29/98	16:46	<	<	<	<
B6	7/29/98	16:31	<	<	<	<
B7	7/29/98	17:09	<	<	<	<
B8	7/29/98	17:20	<	<	<	<
B9	7/29/98	17:30	<	<	<	<

Table 6C. Spiked Surface Water Recoveries (%REC).

Station	Date	Time	DDVP	Naled	Cis Perm	rans Per
A5sp	7/28/98	16:44	28.60	21.02	99.13	83.98
A5sp	7/28/98	22:54	55.00	12.00	84.97	69.76
A5sp	7/29/98	13:28	25.90	25.30	76.89	63.40
B5sp	7/28/98	15:51	32.00	52.20	92.59	93.44
B5sp	7/30/98	1:17	10.00	35.50	98.08	84.98
B5sp	7/29/98	10:44	24.80	22.20	84.49	71.22
B5sp	7/29/98	16:46	59.19	45.60	110.53	91.60
		average	33.64	30.55	92.38	79.77
		stdev	17.48	14.44	11.29	11.64

Table 7A. Keys Sub-Water Data: July 28-29, Atlantic.

Station	Date	Time	DDVP µg/l	Naled µg/l	Cis Perm µg/l	rans Per µg/l
PRE APPLICATION						
A1	7/28/98	16:24	<	<	<	<
A5	7/28/98	16:44	<	<	<	<
A9	7/28/98	17:09	<	<	<	<
3-6 HOUR PERMANONE						
A1	7/28/98	21:55	<	<	<	<
A2	7/28/98	22:11	<	<	<	<
A3	7/28/98	22:23	<	<	<	<
A4	7/28/98	23:14	<	<	<	<
A5	7/28/98	22:54	<	<	<	<
A5dup	7/28/98	22:54	<	<	<	<
A6	7/28/98	22:37	<	<	<	<
A7	7/28/98	23:28	<	<	<	<
A8	7/28/98	23:45	<	<	<	<
A9	7/29/98	0:01	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
A1	7/29/98	12:38	<	<	<	<
A2	7/29/98	12:50	0.09	<	<	<
A3	7/29/98	13:04	<	<	<	<
A4	7/29/98	13:41	<	<	<	<
A5	7/29/98	13:28	<	<	<	<
A5dup	7/29/98	13:28	<	<	<	<
A6	7/29/98	13:14	<	<	<	<
A7	7/29/98	13:51	<	<	<	<
A8	7/29/98	14:03	<	<	0.07	<
A9	7/29/98	14:13	<	<	<	<

Table 7B. Keys Sub-Water Data: July 28-29.

Station	Date	Time	DDVP µg/l	Naled µg/l	Cis Perm µg/l	rans Per µg/l
PRE APPLICATION						
B1	7/28/98	15:06	<	<	<	<
B5	7/28/98	15:51	<	<	<	<
B9	7/28/98	16:28	<	<	<	<
3-6 HOUR PERMANONE						
B1	7/28/98	22:00	<	<	<	<
B2	7/28/98	22:16	<	<	<	<
B3	7/28/98	22:35	<	<	<	<
B4	7/28/98	23:36	<	<	<	<
B5	7/28/98	23:17	<	<	<	<
B5dup	7/29/98	0:17	<	<	<	<
B6	7/28/98	22:50	<	<	0.07	<
B7	7/28/98	23:52	<	<	<	<
B8	7/29/98	0:20	<	<	<	<
B9	7/29/98	0:45	<	<	<	<
14-16 HOUR PERMANONE 2-4 HOUR DIBROM						
B1	7/29/98	9:45	0.07	<	<	<
B2	7/29/98	9:55	<	<	<	<
B3	7/29/98	10:08	<	<	<	<
B4	7/29/98	10:55	<	<	<	<
B5	7/29/98	10:44	<	<	<	<
B5dup	7/29/98	10:44	<	<	<	<
B6	7/29/98	10:24	0.09	<	<	<
B7	7/29/98	11:02	<	<	<	<
B8	7/29/98	11:14	<	<	<	<
B9	7/29/98	11:23	<	<	<	<
22-24 HOUR PERMANONE 10-11 HOUR DIBROM						
B1	7/29/98	16:01	<	<	<	<
B2	7/29/98	16:11	<	<	<	<
B3	7/29/98	16:20	<	<	<	<
B4	7/29/98	17:00	<	<	<	<
B5	7/29/98	16:46	<	<	<	<
B5dup	7/29/98	16:46	<	<	<	<
B6	7/29/98	16:31	<	<	<	<
B7	7/29/98	17:09	<	<	<	<
B8	7/29/98	17:20	<	<	<	<
B9	7/29/98	17:30	<	<	<	<

Table 7C. Spiked Sub-Water Recoveries (%REC).

Spiked Station	Subsurface Water Recoveries (%REC) Date	Time	DDVP	Naled	Cis Perm	rans Per
A5sp	7/28/98	16:44	23.56	0.00	89.35	86.60
A5sp	7/28/98	22:54	46.88	83.20	71.41	68.33
A5sp	7/29/98	13:28	4.82	60.24	99.47	118.53
B5sp	7/28/98	15:51	26.20	0.00	49.41	48.00
B5sp	7/30/98	1:17	43.40	51.42	88.47	87.80
B5sp	7/29/98	10:44	24.58	28.46	86.26	93.27
B5sp	7/29/98	16:46	63.04	57.94	90.06	88.33
		average	33.2	40.2	82.1	84.4
		stdev	19.2	31.8	16.6	21.8

Table 8A. Keys Field Data: July 28-29, Atlantic.

Station	Date	Time	Sal ppt	Temp øC	DO mg/l	pH Units	SpCond mS/cm	Depth Dec feet
PRE APPLICATION								
A1	7/28/98	16:24	34.86	32.28	6.73	8.13	52.85	6.17
A5	7/28/98	16:44	34.31	32.15	7.32	8.2	52.1	6.25
A9	7/28/98	17:09	35.01	32.72	8.38	8.2	53.01	5.83
3-6 HOUR PERMANONE								
A1	7/28/98	21:55	35.47	31.69	5.95	8.04	53.6	6
A2	7/28/98	22:11	35.62	31.59	5.8	8.02	53.86	7
A3	7/28/98	22:23	35.43	32.09	7.46	8.19	53.6	6
A4	7/28/98	23:14	35.02	31.59	6.66	8.21	53.05	7
A5	7/28/98	22:54	35.07	31.37	6.3	8.18	53.12	7
A6	7/28/98	22:37	35.24	32.23	7.78	8.26	53.34	8.67
A7	7/28/98	23:28	34.78	31.34	6.27	8.17	52.77	9.83
A8	7/28/98	23:45	34.64	31.3	5.63	8.14	52.56	6.83
A9	7/29/98	0:01	34.8	31.49	5.63	8.13	52.77	6.67
14-16 HOUR PERMANONE 2-4 HOUR DIBROM								
A1	7/29/98	12:38	34.57	31.64	6.69	8.13	52.5	6.5
A2	7/29/98	12:50	35.38	31.51	5.87	8.04	53.54	7.17
A3	7/29/98	13:04	35.31	31.42	5.27	8.08	53.46	6.92
A4	7/29/98	13:41	34.93	31.4	5.87	8.14	7.52	9.5
A5	7/29/98	13:28	34.93	31.55	6.44	8.17	52.93	7.83
A6	7/29/98	13:14	34.74	31.23	5.41	8.11	52.7	7.58
A7	7/29/98	13:51	34.74	31.37	5.96	8.15	52.71	9.25
A8	7/29/98	14:03	34.68	31.47	5.69	8.1	52.58	6.58
A9	7/29/98	14:13	34.62	31.42	5.76	8.13	52.53	7.42

Table 8B. Keys Field Data: July 28-29, Bayside.

Station	Date	Time	Sal ppt	Temp øC	DO mg/l	pH Units	SpCond mS/cm	Depth Dec feet
PRE APPLICATION								
B1	7/28/98	15:06	36.3	33.74	6.65	8.07	54.67	4
B5	7/28/98	15:51	35.69	32.77	6.04	8.04	53.93	6.5
B9	7/28/98	16:28	35.77	33	5.62	8	54.02	6.33
3-6 HOUR PERMANONE								
B1	7/28/98	22:00	35.91	33.26	8.41	8.14	54.21	4.75
B2	7/28/98	22:16	36.24	32.72	6.68	8.1	54.64	6
B3	7/28/98	22:35	35.88	32.67	5.56	8.02	54.21	4.42
B4	7/28/98	23:36	36.92	32.11	6.22	8.11	55.59	7.42
B5	7/28/98	23:17	36.03	32.21	6.09	8.07	54.38	6.5
B6	7/28/98	22:50	35.82	32.62	3.68	7.83	54.09	3.67
B7	7/28/98	23:52	37.27	31.76	5.97	8.1	56.06	6.92
B8	7/29/98	0:20	36.14	31.92	6.2	8.09	54.56	7
B9	7/29/98	0:45	36.5	31.78	5.23	8.06	55.09	5.75
14-16 HOUR PERMANONE 2-4 HOUR DIBROM								
B1	7/29/98	9:45	35.83	31.59	4.12	7.97	54.28	4.75
B2	7/29/98	9:55	36.27	31.72	4.95	8.05	54.74	6
B3	7/29/98	10:08	35.99	31.66	4.66	7.99	54.34	3.75
B4	7/29/98	10:55	36.94	31.46	5.67	8.09	55.63	6.67
B5	7/29/98	10:44	35.94	31.51	5.54	8.07	54.3	6.33
B6	7/29/98	10:24	35.74	31.63	3.93	7.88	54.03	3.75
B7	7/29/98	11:02	36.72	31.35	5.56	8.09	55.34	7.08
B8	7/29/98	11:14	36.24	31.6	5.51	8.06	54.7	6.58
B9	7/29/98	11:23	36.74	31.53	5.59	8.09	55.37	6.5
22-24 HOUR PERMANONE 10-11 HOUR DIBROM								
B1	7/29/98	16:01	35.85	33.7	8.74	8.2	54.08	5.75
B2	7/29/98	16:11	36.1	33.26	6.92	8.1	54.48	6.33
B3	7/29/98	16:20	35.71	33.53	6.79	8.07	53.92	4
B4	7/29/98	17:00	36.79	32.83	5.91	8.07	55.38	6.67
B5	7/29/98	16:46	35.95	32.78	6.46	8.07	54.29	6.33
B6	7/29/98	16:31	35.71	34.03	8.18	8.13	53.9	3.67
B7	7/29/98	17:09	36.73	32.64	6.48	8.11	55.28	6.75
B8	7/29/98	17:20	36.26	32.94	6.82	8.09	54.66	6.33
B9	7/29/98	17:30	36.17	36.11	5.74	8.01	54.54	5.75

Table 9A. Keys Filter Data: September 22-23, Atlantic.

Station	Date	Time	Cis Perm µg/m^2	rans Per µg/m^2
PRE APPLICATION				
A1	9/22/98	16:55	<	<
A5	9/22/98	16:30	<	<
A9C	9/22/98	17:30	<	<
A9Cdup	9/22/98	17:30	<	<
3-6 HOUR PERMANONE				
A1	9/22/98	22:03	2.62	5.14
A2	9/22/98	22:13	2.01	5.24
A3	9/22/98	22:23	3.51	9.18
A4	9/22/98	22:51	2.41	4.87
A5	9/22/98	22:42	<	<
A6	9/22/98	22:33	1.82	6.00
A7C	9/22/98	23:49	15.11	35.91
A9C	9/22/98	23:07	5.20	13.44
A9Cdup	9/22/98	23:07	4.22	9.42

Table 9B. Keys Filter Data: September 22-23, Bayside.

Station	Date	Time	Cis Perm µg/m^2	rans Per µg/m^2
PRE APPLICATION				
A1	9/22/98	16:55	<	<
A5	9/22/98	16:30	<	<
A9C	9/22/98	17:30	<	<
A9Cdup	9/22/98	17:30	<	<
3-6 HOUR PERMANONE				
A1	9/22/98	22:03	2.62	5.14
A2	9/22/98	22:13	2.01	5.24
A3	9/22/98	22:23	3.51	9.18
A4	9/22/98	22:51	2.41	4.87
A5	9/22/98	22:42	<	<
A6	9/22/98	22:33	1.82	6.00
A7C	9/22/98	23:49	15.11	35.91
A9C	9/22/98	23:07	5.20	13.44
A9Cdup	9/22/98	23:07	4.22	9.42

Figure 2.

Deposition of (cis + trans) permethrin to the FL Keys National Marine Sanctuary following ground (truck) application of Permonone at Key Largo, FL. Filter pads recovered 2 to 4 hrs after application: 9/22/98.

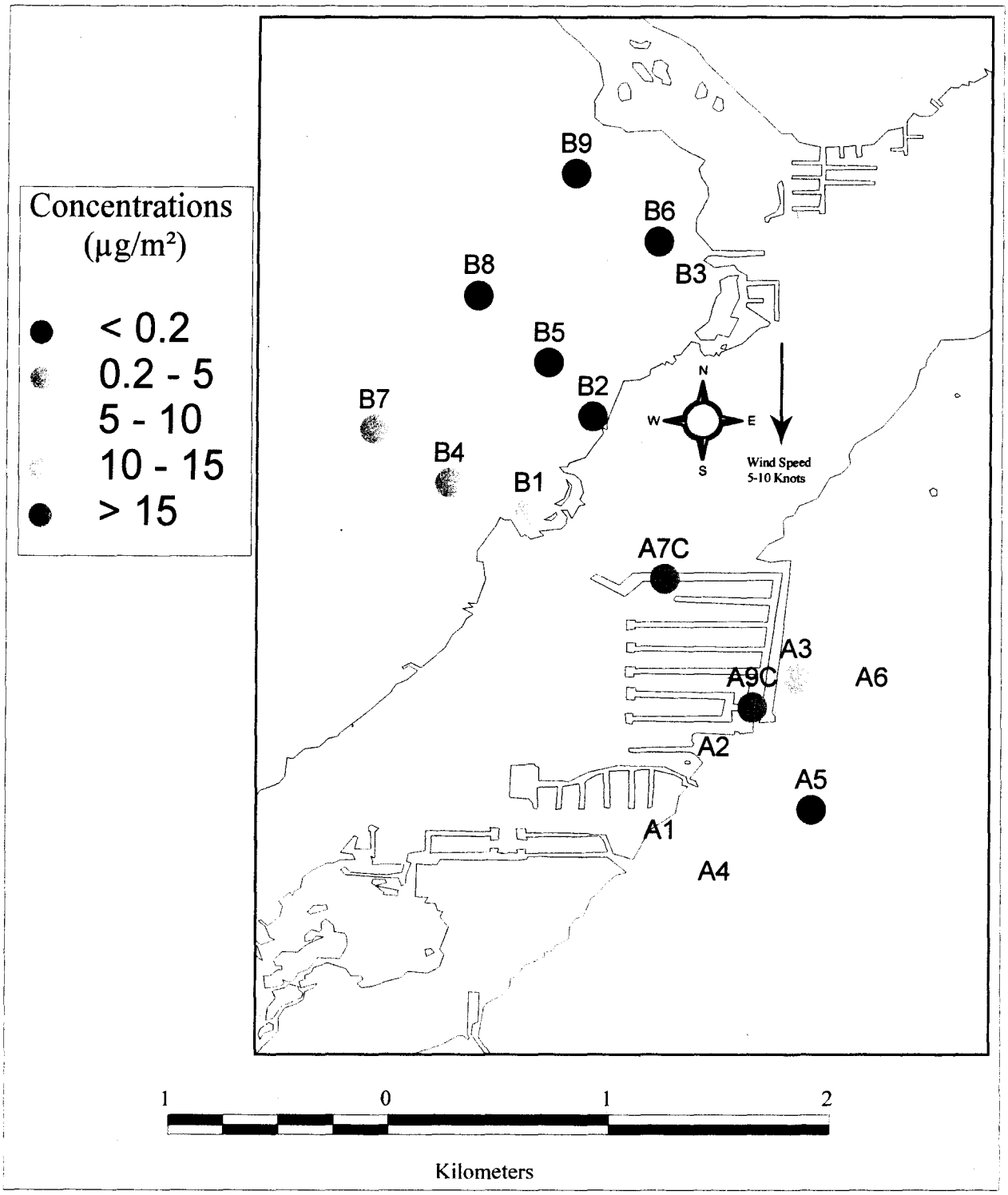

Table 10A. Keys Surface Water Data: September 22-23, Canal System.

Station	Date	Time	Cis Permeth µg/l	s Permet µg/l
PRE APPLICATION				
A9C	9/22/98	17:30	<	<
A9Cdup	9/22/98	17:30	<	<
3-6 HOUR PERMANONE				
A7C	9/22/98	23:49	3.41	3.42
A8C	9/22/98	23:20	2.08	3.05
A9C	9/22/98	23:07	3.94	5.47
A9Cdup	9/22/98	23:07	1.85	4.34
A9Csp	9/22/98	17:30	62.97	82.67
A9Csp	9/22/98	23:07	82.62	92.33
		average	72.80	87.50
		stdev	13.90	6.84

Table 11A. Keys Sub-Water Data: September 22-23, Atlantic & Canal System.

Station	Date	Time	Permeth µg/l	s Permet µg/l
PRE APPLICATION				
A1	9/22/98	16:55	<	<
A5	9/22/98	16:30	<	<
A9C	9/22/98	17:30	<	<
A9Cdup	9/22/98	17:30	<	<
3-6 HOUR PERMANONE				
A1	9/22/98	22:03	<	<
A2	9/22/98	22:13	<	<
A3	9/22/98	22:23	<	<
A4	9/22/98	22:51	<	<
A5	9/22/98	22:42	<	<
A6	9/22/98	22:33	<	<
A7C	9/22/98	23:49	<	<
A8C	9/22/98	23:20	<	<
A9C	9/22/98	23:07	<	<
A9Cdup	9/22/98	23:07	<	<
14-16 HOUR PERMANONE				
A1	9/23/98	9:30	<	<
A2	9/23/98	9:40	<	<
A3	9/23/98	9:45	<	<
A4	9/23/98	10:10	<	<
A5	9/23/98	9:55	<	<
A6	9/23/98	9:50	<	<
A7C	9/23/98	8:40	<	<
A8C	9/23/98	9:10	<	<
A9C	9/23/98	9:20	<	<
A9Cdup	9/23/98	9:20	<	<

Table 11B. Keys Sub-Water Data: September 22-23, Bayside.

Station	Date	Time	Permeth µg/l	s Permet µg/l
PRE APPLICATION				
B1	9/22/98	16:20	<	<
B5	9/22/98	16:48	<	<
B5dup	9/22/98	16:48	<	<
B9	9/22/98	17:16	<	<
3-6 HOUR PERMANONE				
B1	9/22/98	21:55	<	<
B2	9/22/98	22:04	<	<
B3	9/22/98	22:12	<	<
B4	9/22/98	22:45	<	<
B5	9/22/98	22:31	<	<
B5dup	9/22/98	22:31	<	<
B6	9/22/98	22:20	<	<
B7	9/22/98	22:50	<	<
B8	9/22/98	22:58	<	<
B9	9/22/98	23:02	<	<
14-16 HOUR PERMANONE				
B1	9/23/98	9:00	<	<
B2	9/23/98	9:06	<	<
B3	9/23/98	9:15	<	<
B4	9/23/98	9:43	<	<
B5	9/23/98	9:32	<	<
B5dup	9/23/98	9:32	<	<
B6	9/23/98	9:22	<	<
B7	9/23/98	9:51	<	<
B8	9/23/98	9:59	<	<
B9	9/23/98	10:06	<	<

Spikes Subsurface Water Recoveries (%REC)

			Cis Perm	Trans Per
A9Csp	9/22/98	17:30	119.75	123.83
A9Csp	9/22/98	23:07	130.39	136.97
A9Csp	9/23/98	9:20	132.77	139.10
B5sp	9/22/98	16:48	84.65	90.27
B5sp	9/22/98	22:31	99.93	109.30
B5sp	9/23/98	9:32	102.33	115.50
		average	111.64	119.16
		stdev	19.06	18.34

Table 12A. Keys Field Data: September 22-23, Atlantic.

Station	Date	Time	Sal ppt	Temp øC	DO mg/l	pH Units	SpCond mS/cm	Depth Dec feet
PRE APPLICATION								
A1	9/22/98	16:55	33.79	32.21	6.78	7.91	51.29	5.83
A5	9/22/98	16:30	33.89	31.58	6.77	7.89	51.41	6
A7C	9/22/98	15:15	33.1	30.55	6.06	7.65	50.37	-99
3-6 HOUR PERMANONE								
A1	9/22/98	22:03	33.83	31.35	6.76	7.93	51.37	8.42
A2	9/22/98	22:13	33.68	31.43	6.3	7.92	51.17	7.33
A3	9/22/98	22:23	33.67	31.32	6.09	7.9	51.13	7.5
A4	9/22/98	22:51	33.71	31.12	6.65	7.99	50.97	9.5
A5	9/22/98	22:42	33.75	30.94	6.22	7.96	51.31	8.92
A6	9/22/98	22:33	33.71	31.19	5.96	7.91	51.15	7.67
A7C	9/22/98	23:49	32.86	30.2	5.78	7.77	50.05	-99
A9C	9/22/98	23:07	33.61	31.02	5.53	7.89	51.02	-99
14-16 HOUR PERMANONE 2-4 HOUR DIBROM								
A1	9/23/98	9:30	33.96	30.93	5.18	7.87	51.55	8
A2	9/23/98	9:40	33.81	30.88	4.57	7.8	51.34	6.42
A3	9/23/98	9:45	33.74	30.91	4.33	7.8	51.26	7.17
A4	9/23/98	10:10	33.98	30.9	5.16	7.92	51.6	9.33
A5	9/23/98	9:55	33.9	30.69	5.25	7.92	51.48	8.67
A6	9/23/98	9:50	33.82	30.63	4.86	7.87	51.33	7.33
A7C	9/23/98	8:40	32.89	29.94	4.43	7.34	50.49	-99
A9C	9/23/98	9:20	33.77	30.67	4.58	7.76	51.26	-99

Table 12B. Keys Field Data: September 22-23, Bayside.

Station	Date	Time	Sal ppt	Temp øC	DO mg/l	pH Units	SpCond mS/cm	Depth Dec feet
PRE APPLICATION								
B1	9/22/98	16:20	37.54	31.67	8.62	8.08	56.38	5.08
B5	9/22/98	16:48	37.8	31.67	6.54	7.98	56.72	7
B9	9/22/98	17:16	37.25	31.81	7.24	8.02	55.97	6.83
3-6 HOUR PERMANONE								
B1	9/22/98	21:55	37.82	31.32	8.32	8.09	56.76	5.08
B2	9/22/98	22:04	37.85	31.09	7.99	8.08	56.78	6.67
B3	9/22/98	22:12	37.43	31.63	6.7	7.99	56.23	6.17
B4	9/22/98	22:45	37.89	30.92	6.27	8.01	56.84	7.17
B5	9/22/98	22:31	37.9	31.17	6.41	8.02	56.86	7.17
B6	9/22/98	22:20	37.24	31.44	6.63	8.02	55.95	4.25
B7	9/22/98	22:50	37.69	30.8	6.6	8.06	56.58	7.33
B8	9/22/98	22:58	37.87	31.18	6.52	8.03	56.82	7.17
B9	9/22/98	23:02	37.33	31.23	6.72	8.07	56.11	6.5
14-16 HOUR PERMANONE								
B1	9/23/98	9:00	37.85	30.39	5.19	7.98	56.8	5
B2	9/23/98	9:06	37.9	30.22	4.66	7.97	56.89	6.75
B3	9/23/98	9:15	37.58	30.72	5.29	7.96	56.43	6.17
B4	9/23/98	9:43	38.01	30.5	5.59	8	57	6.33
B5	9/23/98	9:32	37.98	30.58	5.81	8.01	56.96	7
B6	9/23/98	9:22	37.31	30.59	5.22	8	56.05	5.17
B7	9/23/98	9:51	37.85	30.56	5.41	8	56.81	7.17
B8	9/23/98	9:59	37.72	30.42	6.13	8.05	56.61	7.08
B9	9/23/98	10:06	37.65	30.89	6.47	8.06	56.52	6

Table 13. Acute Toxicity Threshold (NOEL) of Permethrin, Dibrom and DDVP to marine invertebrates, *Mysidopsis bahia*, and *Penaeus duoarum*.

Pesticide	Acute NOEL µg/L		Aqueous Half Life
	M. bahia	*P. duoarum*	
Permethrin	0.01	0.07	< 2.5 days
Dibrom	4.7	1.8	< 1 day*
DDVP	<1.0**	< 1 day	

* *half life reduced by photo degradation.*
** *Palaemonetes pugio*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
WATER MANAGEMENT DIVISION
SOUTH FLORIDA OFFICE
400 NORTH CONGRESS AVE., SUITE 120
WEST PALM BEACH, FLORIDA 33401

June 7, 2000

Dr. Richard Pierce
Mote Marine Laboratory
1600 Ken Thompson Parkway
Sarasota, FL 34236

Dear Dr. Pierce:

Thank you for the opportunity to review your research proposal entitled "Ecotoxicity and risk management of mosquito control pesticides in the Florida Keys National Marine Sanctuary". It is my understanding that you are submitting that proposal to the CESI Ecotoxicity Program of the U.S. Geological Survey.

The Florida Keys National Marine Sanctuary Water Quality Protection Program (WQPP) identified mosquito spraying as a potential concern to Sanctuary biological resources and discussed the need for research and monitoring of pesticides in the WQPP Document. In 1997, the WQPP Technical Advisory Committee included the need for research on the effects of mosquito spraying as a priority research topic and selected your proposal entitled "Effects of mosquito control measures on non-targeted organsisms in the Florida Keys National Marine Sanctuary" for funding. As you know, because of funding difficulties we were only able to fund field monitoring of pesticides at two locations following pesticide application and could not fund research on threshold effects.

The work that you have completed for the WQPP remains the only site-specific information on the distribution of pesticides following spraying events in the Florida Key National Marine Sanctuary (FKMNS). Your proposed research is an excellent extension of the completed work and is consistent with the goals and objectives of the WQPP. I enthusiastically support funding of your proposed research and anxiously await the results.

The development of biomarkers for two keystone species in the Sanctuary is particularly important. There is evidence that reproduction and larval development of the queen conch may be impacted by poor water quality. Your proposed research on correlation of hatching success and development with contaminants will provide valuable information concerning the future of that important species.

Thank you again for your interest in restoring and improving the biological resources of the FKNMS. Please let me know if I can help in any way to direct funding to your important research on the biological effects of pesticides in the FKNMS.

Sincerely,

William L. Kruczynski, Ph.D.
Program Scientist
Water Quality Protection Program