MBNMS PERMITS

PERMIT #	PROJECT	ORGANIZATION	STATUS
MBNMS-03-93	Adventures By The Sea Fireworks Display '93	Adventures by the Sea	permit issued
MBNMS-05-93	Monterey Independence Day Fireworks Display	City of Monterey	permit issued
MBNMS-07-93	Pacific Grove Feast of Lanterns Fireworks	Pacific Grove Feast of Lanterns	permit issued
MBNMS-09-93	Pebble Beach Fireworks Display	Pebble Beach and Tennis Club	permit issued
MBNMS-12-93	Santa Cruz Third Annual Fireworks	City of Santa Cruz	permit issued
MBNMS-03c-93	Pebble Beach Fireworks Display	Pebble Beach Company	permit issued
MBNMS-05-94	Pebble Beach Fireworks Display	Pebble Beach Company	permit issued
MBNMS-10-94	Monterey Independence Day Fireworks Display	City of Monterey, Recreation	permit issued
MBNMS-11-94	Half Moon Bay Independence Day Fireworks	Coastside Fireworks Fundraising	permit issued
MBNMS-12-94	Pacific Grove Feast of Lanterns Fireworks	Feast of Lanterns	permit issued
MBNMS-28-94	Santa Cruz Third Annual Fireworks	City of Santa Cruz	permit issued
MBNMS-13-95	Pacific Grove Feast of Lanterns Fireworks	Pacific Grove Feast of Lanterns	permit issued
MBNMS-17-95	Monterey Independence Day Fireworks Display	City of Monterey,	permit issued
MBNMS-25-95	Santa Cruz Fourth Annual Fireworks	City of Santa Cruz, Parks and	permit issued
MBNMS-24-95	Aptos Fireworks Display	Rudolph F. Monte Foundation	permit issued
MBNMS-08-96	Monterey Independence Day Fireworks Display	City of Monterey	permit issued
MBNMS-13-96	Half Moon Bay Independence Day Fireworks	San mateo County Harbor District	permit issued
MBNMS-18-96	Pacific Grove Feast of Lanterns Fireworks	Pacific Grove Feast of Lanterns	permit issued

MBNMS PERMITS

PERMIT #	PROJECT	ORGANIZATION	STATUS
MBNMS-23-96	Aptos Fireworks Display	Rudolph F. Monte Foundation	permit issued
MBNMS-28-96	Santa Cruz Fifth Annual Fireworks	City of Santa Cruz, Parks and	No permit issuance ste
MBNMS-13-97	Monterey Independence Day Fireworks Display	City of Monterey	signed permit returned
MBNMS-14-97	Half Moon Bay Independence Day Fireworks	Pillar Point Harbor	signed permit returned
MBNMS-16-97	Pacific Grove Feast of Lanterns Fireworks	Pacific Grove Feast of Lanterns	signed permit returned
MBNMS-22-97	Aptos Fireworks Display	Rudolf Monte Foundation	signed permit returned
MBNMS-19-98	Monterey Independence Day Fireworks Display	City of Monterey	signed permit returned
MBNMS-22-98	Half Moon Bay Independence Day Fireworks	Pillar Point Harbor	signed permit returned
MBNMS-04-98	Private Fireworks Display	Foote, Cone & Belding (FCB)	signed permit returned
MBNMS-24-98	Pacific Grove Feast of Lanterns Fireworks	Pacific Grove Feast of Lanterns	signed permit returned
MBNMS-30-98	Rudolph F. Monte Foundation Fireworks	Rudolf F. Monte Foundation	signed permit returned
MBNMS-01-1999	California Fire Chief's Association Fireworks	City of Monterey	signed permit returned
MBNMS-03-1999	Monterey Independence Day Fireworks Display	City of Monterey	permit decision made
MBNMS-15-1999	City of Capitola 50 Year Anniversary	City of Capitola	signed permit returned
MBNMS-17-1999	Half Moon Bay Independence Day Fireworks	San Mateo County Harbor District	permit issued
MBNMS-18-1999	Pacific Grove Feast of Lanterns Fireworks	Pacific Grove Feast of Lanterns	signed permit returned
MBNMS-27-1999	Rudolph F. Monte Foundation Fireworks	Rudolph F. Monte Foundation	signed permit returned
MBNMS-32-1999	First Night Monterey Fireworks Display	First Night Monterey	signed permit returned

MBNMS PERMITS

PERMIT #	PROJECT	ORGANIZATION	STATUS
MBNMS-36-1999	Pebble Beach New Year's Fireworks Display	The Pebble Beach Company	no permit required
MBNMS-2000-003	Monterey Independence Day Fireworks Display	City of Monterey	signed permit returned
MBNMS-2000-017	Half Moon Bay Independence Day Fireworks	Pillar Point Harbor	late reporting notice se
MBNMS-2000-021	Cambria Independence Day Fireworks Display	American Legion	signed permit returned
MBNMS-2000-029	Fireworks Display for the Pacific Grove Feast	Pacific Grove Feast of Laterns	late reporting notice se
MBNMS-2000-030	Rudolph F. Monte Foundation Fireworks	Rudolph F. Monte Foundation	signed permit returned
MBNMS-2000-039	Private Fireworks Display	Adventures By The Sea	signed permit returned
MBNMS-2000-048	First Night Monterey, Fireworks Display	First Night Monterey	signed permit returned
MBNMS-2001-010	Private Fireworks Display	Adventures by the Sea	Decision suspended: E
MBNMS-2001-013	City of Monterey Fireworks Display	City of Monterey	

PYRO-SPECTACULARS

February 18, 1998

MAR [illegible]

Ms. Gwen Graham
FCB Events
733 Front Street
San Francisco, CA 94111

Dear Ms. Graham;

This letter is intended to serve as a brief explanation of environmental impact during our display for the Levis Straus fireworks display scheduled for Thursday March 26, 1998

Enclosed is a list of chemicals that are commonly used in the manufacture of pyrotechnic devices. Depending on the device, effect and color you will find a variety of these chemicals within each item. For proprietary reasons the exact amount of each chemical used within a specific device is not available.

Potassium Chlorate	Strontium nitrate	Iron
Potassium perchlorate	Strontium carbonate	Titanium
Potassium nitrate	Sulfur	Shellac
Sodium benzoate	Charcoal	Dextrine
Sodium oxalate	Copper oxide	Phenolic resin
Ammonium perchlorate	Aluminum	Polyvinyl chloride
Magnesium		

I would like to point out that these chemicals typically do not come into contact with the ground. After the device explodes in the air, the only thing left are bits of paper that drift with the prevailing wind and eventually fall back onto the ground.

I hope that this information will assist us in the granting of our permit. I have also enclosed a copy of our insurance certificate showing the Monterey Bay National Marine Sanctuary listed as an additional insured. Please feel free to contact my office with any further questions regarding this matter.

Sincerely,

PYRO SPECTACULARS, INC.

Jeff Thomas
Show Producer

APPENDIX B

Pyro Spectaculars • PO Box 6775 • Oakland • California 94603 • Tel 510-632-4516 • Fax 510-632-5061

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, California 93940

July 18, 1994

MEMORANDUM FOR: Terry Jackson, Manager

FROM: Mark Pickett, Assistant Manager
Aaron King, Program Specialist

SUBJECT: July 4, 1994, Fireworks Display off Del Monte Beach by the City of Monterey

Working under Monterey Bay National Marine Sanctuary Authorization Number MBNMS-10-94, the City of Monterey conducted a fireworks display, beginning at 2115 hrs on July 4, 1994, over Sanctuary waters. The launch site was approximately halfway between the end of Municipal Wharf #2 and Del Monte Beach. The City of Monterey had contracted the display out to a company named "Pyro Spectacular, Inc.", and had contracted the tug "Silver Prince" to tow the display out to the site. The display lasted about 20 minutes, and was choreographed with music played over a local radio station.

The barge from which the display was launched was tied to one end of the City's sewage barge at that site, while the Silver Prince was tethered to the other end of the sewer barge. Aaron King was placed aboard the Silver Prince to observe the display from that perspective. Mark Pickett observed the display from the Sanctuary boat, about 100 yards to the north of the launch site. Photos were taken from the Aaron's perspective near the barge. All personnel associated with the display were cooperative and freely answered questions about the display. Aaron was allowed access to the display barge before the display occurred, and was invited to come aboard it after the display was finished. Aaron declined this invitation since a required "cool down" time for the fireworks would have kept him from making other observations. At the "Breakwater" several bystanders were requested to note, and were later questioned, of their impression of the sea lions' response to the display.

Our observations are as follows:

1. While the impact of light and sound from the fireworks are hard to assess, bystanders on the Breakwater reported that the sea lions grew quite, and some would enter the water, whenever an explosion took place. No effects on wildlife were directly observed by us. We did observe marine mammals present in launch area before and after fireworks. They were not present during the fireworks. (Note: On July 4, 1993, a video was made by a Scott Kathey of the marine mammal

disturbance caused by the fireworks. We will locate that video and make it available if you care to view it.)

2. Contrary to a condition of Authorization Number MBNMS-10-94, no attempt was made to remove the outer fireworks shell plastics (labels, wrappings, etc.) before they were launched. This conclusion was reached by direct observations made by Aaron King, and through conversations he had with the Pyro Spectacular personnel present.

3. Significant amounts of debris covered a large area (at least 100 square yards) after the display. This debris consisted of the shell casings from the exploded fireworks. We made an attempt to qualitatively sample the debris from that which was floating at the surface, and filled two, 1-liter baggies. While most of the debris was made of paper and cardboard, some of the debris were plastics associated with the outer casings and the internal configuration of the shells. Contrary to a condition of Authorization Number MBNMS-10-94, no attempt was seen to clean the Sanctuary waters of the debris from the fireworks.

4. No observations were possible of the amount, or effect, of the chemicals that entered into Sanctuary waters.

cc: H. Golde, SRD
L. Moore, SRD
R. Jones, MBNMS

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, California 93940

July 10, 1995

MEMORANDUM FOR: The Record

FROM: Terry Jackson and Patrick Cotter
NOAA Divers

SUBJECT: Evaluation of Sanctuary off Del Monte Beach Before and After the Fireworks Display by the City of Monterey

Sanctuary divers (Terry Jackson and Patrick Cotter) conducted a bottom survey of the area northeast of the Monterey Fireworks Barge, anchored off Del Monte Beach on the afternoon of June 29 (pre-fireworks) and on the afternoon of July 5, 1995 (post- fireworks). This report summarizes the results of those dives, observations made by Mr. Cotter from the boat during the display, and observations made by Mr. Cotter on the beach the morning after the display.

Condition and characterization of the bottom during the pre-fireworks dive.

The first dive, conducted on June 29, before Monterey's fireworks display, consisted of laying 100 foot transect lines on the bottom at a depth of about 30 feet. The transect lines started below the fireworks barge (36°36.23'N 121°53.54'W) and were laid on courses of 60° magnetic and 120° magnetic. We surveyed the ocean floor within 3-4 meters of the transect line and found the bottom to be free of any noticeable debris, including cardboard. We also took several pictures of the ocean floor using a Nikonos V camera to document the habitats surveyed.

Condition and characterization of the bottom during the post-fireworks dive.

The second dive, conducted July 5, the afternoon after Monterey's fireworks display, occurred at the same depth and general location, but no transects were laid. We swam a search pattern on a course of 60° magnetic and its reciprocal (240° magnetic) in an area determined to be downwind of the fireworks barge as observed the night of July 4. We observed less than a dozen pieces of cardboard debris similar to the material we netted immediately after the July 4 fireworks celebration ended. Several pictures of debris were taken using a Nikonos V camera. We are not completely certain that we surveyed the densest depositional area for the fireworks debris but we thought the area searched had the highest probability of having debris given the wind and current conditions at the time of the display.

Amount of Monterey fireworks debris on the bottom compared to the amount of Monterey fireworks debris observed in the water after the fireworks display.

It is not possible to put a quantitative value on the material observed during the July 5 dive. However, the number of pieces observed on the July 5 dive was minor compared to the amount of debris observed in the water immediately after the fireworks display finished on July 4.

Amount of Monterey fireworks debris on the bottom compared to the amount of Monterey fireworks debris observed on the beach the morning after the fireworks display. Assessment of the distribution pattern for fireworks debris during the 24-hour period following the fireworks display.

Patrick walked the Del Monte Beach area at 8:00 A.M. on July 5, from the Monterey Kayak building north to the old discharge pipe west of the Naval Postgraduate School. He observed a large volume of fireworks debris from private citizens' celebrations of the Fourth of July. He also found pieces of Monterey's Fireworks Display debris that washed up on the beach beginning at a location west of the apartments that face the beach, and continuing up to and beyond the discharge pipe west of the Naval Postgraduate School. He estimates that the volume of debris on the beach was 3-4 times greater in number of pieces than the number of pieces observed in the water the night before. It appears that much of the debris washed ashore, rather than sinking to the bottom. He did not see any debris on the beach south of the condominiums.

Type and number of any wildlife harmed or in distress as a result of the fireworks display or resulting debris. Any potential harm to marine life from fireworks debris and the estimated degree of such impacts.

During the fireworks display, Patrick was on the Sanctuary boat and observed about 100 large marine worms in the surface waters near the fireworks barge. Generally, these invertebrates are sand dwellers, and he has never seen them swimming on the surface before. As the boat returned to the dock, Patrick noticed that the breakwater rocks were empty of California sea lions, brown pelicans and cormorants that normally haul out or roost there during the night.

During the dive on July 5, Terry and Patrick observed part of a fish carcass that appeared to have been discarded after being filleted. We did not observe any dead or disturbed wildlife during the dive that may have been affected by the fireworks or the debris.

Overall assessment of impacts of the fireworks to marine resources in the area.

The disappearance of the California sea lions, brown pelicans and cormorants on the breakwater was probably the most significant disturbance that Patrick

observed as a result of the fireworks display. This disturbance was temporary because the animals were back on the breakwater on the morning of July 5. In past years, MBNMS staff have observed sea lions returning to the breakwater in large numbers within 2 hours of the conclusion of the display. The more mature animals tend to return first and begin vocalizing. The younger animals then follow suit, and the normal jockeying and sparing for haul-out space resumes. We do not know of any other disturbances to marine life as a result of the fireworks display.

Recommended permit conditions to reduce hazards to marine life.

We recommend that Monterey be required to clean up all fireworks debris from the City's display and from spectator's fireworks displays along the observation beach (Del Monte Beach). We suggest that the City's maintenance personnel patrol the width of the beach from Wharf 2 toward Seaside to the point where no more debris is found. All fireworks debris should be picked up and disposed of properly. The beach should be inspected for a minimum of two days following the fireworks display, and cleanup efforts should continue as long as necessary until no further debris is found.

All efforts should be taken to ensure that fireworks and casings made of plastic parts, in whatever form, are not used in Monterey's fireworks display.

cc: MBNMS - S. Kathey
SRD - C. Wahle, D. Malek, L. Moore, H. Golde

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, California 93940

July 14, 1995

MEMORANDUM FOR: File

FROM: Scott Kathey
Program Specialist

SUBJECT: City of Monterey Fireworks Monitoring

MBNMS staff monitored preparations for the Independence Day fireworks display by the City of Monterey on July 3 and 4, 1995. Staff inspectd the launch barge during loading and after it was towed to the launch site from the US Coast Guard Pier. Staff reminded the launch supervisor on several occassions that all plastic wrapping must be removed from mortars prior to loading. The supervisor complied with the condition of the permit.

MBNMS staff observed the fireworks display and inspected surface waters of the fallout area immediately afterwards for fireworks debris. Staff surveyed the area for an hour. A debris field was detected east of the barge in the direction of the prevailing wind for a distance of approximately 800 yards and with a width of approximately 300 yards. A sample of the debris was collected immediately following the show by trolling through the heaviest concentrations of debris with a sampling net. Cardboard casings, cotton string, and a plastic fragment were recovered from surface waters. A total of 1077 grams of material was collected. Of that total, plastics comprised less than 10 grams.

Staff sighted three California Sea Lions swimming in the fallout area within 10 minutes of the conclusion of the fireworks show. Upon returning to the Harbor, staff noted that sea lions and seabirds were noticeably absent from the breakwater. Past observations have indicated, however, that sea lions begin to repopulate the breakwater within 30 minutes of the conclusion of the display. By next morning, the breakwater contained a typical assemblage of marine mammals and birds.

MBNMS staff inspected local beaches the morning following the fireworks display and found that much of the fallout (cardboard, paper and some plastic fragments) observed in surface waters after the show had washed ashore. The City of Monterey conducted an extensive beach cleanup effort on July 5.

A NOAA dive team inspected the seabed within the fallout area that same day and detected only a few pieces of debris in a 100 X 50 yard search area in the center of the fallout zone. No sign of distressed, damaged or dead marine life was detected. A separate report was prepared on the findings of the dive team.

Based upon the boat, shoreline and dive surveys, it appears that most of the debris entering the water washes ashore by morning where it can be recovered by a coastal cleanup effort. Some debris sinks to the bottom in the fallout area but has no harmful effect on wildlife or the environment. Though some plastic fragments are included in the debris, plastics comprise a small fraction (1/100th of the waterborne sample) of the total mass, which is primarily composed of biodegradable paper products and cotton string.

Conclusion: Aerial pyrotechnic displays performed within the Sanctuary produce debris from shell casings that fall into the water. However, there has been no evidence to date that indicates that the fallout from such displays damages or degrades the marine environment. The displays should be appropriately sited and timed to avoid disturbance of sensitive biological areas (e.g. marine mammal pupping areas, nesting colonies, estuaries) - current permit review and conditions assure that displays are confined to appropriate areas. Efforts should continue to minimize and reduce plastic debris. The standard condition that plastic packaging be removed from pyrotechnic mortars prior to launch has significantly reduced the potential discharge of plastic into the Sanctuary.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, California 93940

March 11, 1998

MEMORANDUM FOR: File

FROM: Scott Kathey
MBNMS Enforcement & Regulatory Coordinator

SUBJECT: Fireworks and Observed Effects on Marine Mammals at the Monterey Breakwater

Each year beginning in 1993, the Monterey Bay National Marine Sanctuary (MBNMS) has issued an authorization to the City of Monterey to conduct a pyrotechnic display for the annual city Independence Day celebration. The city is required to obtain authorization from the MBNMS for the display due to direct physical impacts to the marine environment and collateral impacts to marine resources. MBNMS staff have monitored past events and made empirical observations of impacts related to the event. The following are excerpts of staff reports that describe observations of impacts to marine mammals from the displays.

Excerpt from July 18, 1994 staff report
"While the impact of light and sound from the fireworks are hard to assess, bystanders on the Breakwater reported that the sea lions grew quiet, and some would enter the water whenever an explosion took place. No effects on wildlife were directly observed by us. We did observe marine mammals present in launch area before and after fireworks. (Note: On July 4, 1993, a video was made by a Scott Kathey of the marine mammal disturbance caused by the fireworks."

Excerpt from July 10, 1995 staff report
"As the boat returned to the dock, Patrick [Cotter] noticed that the breakwater rocks were empty of California sea lions, brown pelicans, and cormorants that normally haul out or roost there during the night.

During the dive on July 5, Terry [Jackson] and Patrick [Cotter] observed part of a fish carcass that appeared to have been discarded after being filleted. We did not observe any dead or disturbed wildlife during the dive that may have been affected by the fireworks or the debris."

Excerpt from July 14, 1995 staff report
"Staff sighted three California sea lions swimming in the fallout area within ten minutes of the conclusion of the fireworks show. Upon returning to the Harbor,

staff noted that sea lions and seabirds were noticeably absent from the breakwater. Past observations have indicated, however, that sea lions begin to repopulate the breakwater within 30 minutes of the conclusion of the display. By next morning, the breakwater contained a typical assemblage of marine mammals and birds."

Previously unrecorded observations by MBNMS staff indicate that California sea lions on the Monterey breakwater seem more disturbed by the audible effects of pyrotechnic displays, than by the visual effects. The breakwater is located approximately 700 yards (horizontal distance) from the primary impact zone for the aerial pyrotechnic display. Staff have observed the sea lion colony to become alert at the first appearance of overhead "color bursts", but general colony evacuation of the haulout is usually immediate following detonation of overhead "salute" rounds or their equivalent. Aerial shells called "salutes" are particularly effective in evoking a flight response by California sea lions at the Monterey breakwater. Salutes are special-effect aerial mortar shells that typically detonate between 500 and 1000 above ground level and produce a loud percussive explosion. The devices are specifically designed to produce a loud audible effect. The only light emitted is a brief flash from the exploding charge within the shell. Since salutes are usually launched in the first few seconds of a display to announce the beginning of the display for the audience, staff have been unable to determine whether sea lions would continue to tolerate an extended display of overhead color bursts without salute rounds.

In the first seconds of the display, the sea lion colony becomes very quiet, vocalizations cease, and younger sea lions and all marine birds evacuate the breakwater. The departing sea lions swim quickly toward the open sea. Most of the colony remains intact until the older bulls evacuate, usually after a salvo of overhead bursts in short succession. Once the bulls depart, the entire colony follows suit, swimming rapidly in large groups toward the open sea. A select few of the largest bulls may sometimes remain on the breakwater. Sea lions have been observed attempting to haul out onto the breakwater during the fireworks display, but most are frightened away by the continuing aerial bursts.

Sea lions begin returning to the breakwater within 30 minutes following the conclusion of the display but have been observed to remain quiet for some time. The colony usually reestablishes itself on the breakwater within 2-3 hours following the conclusion of the display, during which vocalization activity returns. Typically, the older bulls are the first to renew vocalization behavior (within the first hour), followed by the younger animals. By the next morning, the entire colony seems to be intact and functioning with no visible sign of abnormal behavior.

Sea lions at the Monterey breakwater are routinely subjected to urban noise levels. The Monterey breakwater lies directly under the approach/departure flight path for Monterey Regional Airport and is commonly impacted by low-flying aircraft of all kinds. Commercial and recreational vessels entering Monterey Harbor routinely pass within a few yards of the breakwater (day and night). Auto traffic is audible from Lighthouse Avenue, a main transportation artery along the nearby

shoreline. The Coast Guard Pier adjacent to the haulout area is visited by thousands of tourists per year and is the staging area for Coast Guard ship operations. Scuba divers operate in the waters adjacent to the breakwater throughout the year. A fog horn located at the seaward tip of the breakwater sounds during inclement weather. Despite these potential disturbances, sea lions have been observed on the breakwater in numbers as high as 300-500 in early July. (This is an empirical estimate only. The MBNMS has not conducted a scientific study of sea lion abundance at this site.) Habituation to these constant human activities by California sea lions may influence the rate at which they recolonize the breakwater following a fireworks display and return to normal behavioral activity.

MBNMS staff have not observed the behavior of resident harbor seals in response to the annual fireworks display. Up to 15 harbor seals may be typically present on rocks in the outer harbor in early July. The seal haulout area is approximately 700 yards (horizontal distance) from the primary impact zone for the aerial pyrotechnic display. Likewise, staff have made no observation of sea otter activity relative to the display. Up to 5 sea otters may typically frequent the immediate harbor area in early July. All the above abundance estimates are empirical values only. Marine birds (cormorants, pelicans, and gulls) are among the first wildlife to evacuate the area at the start of the display. Their return rates have not been noted, except that their numbers appear to be back to normal by the next morning.

This report summarizes the empirical observations made by MBNMS staff members over a four-year period. The observations herein were not collected using a prescribed scientific technique or sampling procedure, and any conclusions made from this report should be weighed accordingly.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, California 93940

March 31, 1998

MEMORANDUM FOR: File

FROM: Scott Kathey
Enforcement and Regulatory Coordinator, MBNMS

SUBJECT: Monitoring of March 26, 1998 Fireworks Display
Sponsored by FCB Events

On Thursday, March 26, 1998, Foote, Cone and Belding (FCB) Events of San Francisco sponsored a professional fireworks display conducted by Pyro-Spectaculars, Inc. from the Monterey City barge anchored off Del Monte Beach east of Municipal Wharf II in Monterey, California. FCB Events was contracted by Levi Strauss Company to stage the event. The MBNMS issued FCB Events a special use permit (SUP-MBNMS-04-98) to conduct the activity due to the likely deposition of debris directly into Sanctuary waters as a result of the fireworks demonstration.

Scott Kathey inspected the barge at approximately 7:00 PM on March 26. Pyro-Spectacular, Inc. personnel were setting up the pyrotechnic devices on the barge. There was no sign of debris in the water around the barge. The fireworks display began at approximately 8:15 PM and, pursuant to Special Use Permit MBNMS-04-98, the display was limited to low-level effects to minimize debris deposition into Sanctuary waters. Mr. Kathey observed a marine bird swim within 70 yards of the barge during the fireworks display. The bird remained on the water as the pyrotechnic effects were ignited aboard the barge.

Immediately following the conclusion of the approximate 10-minute display, Mr. Kathey surveyed the area around the launch barge and discovered a debris field in the water within 50 feet north of the barge. The debris field was concentrated and entrained in a narrow band approximately the length of the barge. A sample of the debris was collected using a dip net from the P/B Shark Cat. The mesh size precluded collection of most particles under one square inch in diameter, though some smaller particles were caught up in the sample. All particles consisted of cardboard and paper materials. No plastics were seen in the water or found in the sample. The collected sample weighed 2 ounces (dry weight) and represented approximately 10% of the total debris observed in the water (Note: observations were conducted at night using flood lights aboard the Shark Cat as well as a large hand-held flashlight). Total debris afloat at the end of the display is estimated to

have been 20 ounces (dry weight) or 1.25 pounds of paper and cardboard materials. Some cotton string was also included in the sample. Particles were typically round or cylindrical in shape and ranged in thickness from .5 mm - 6 mm and diameter from 2 cm - 10 cm. Some debris was observed sinking into the water column, but no volumetric measurements are available for sunken material. No dead, injured, or disturbed marine life was observed in the impact area.

The barge was inspected within 15 minutes of the conclusion of the display. It contained debris identical to that observed in the water, plus household grade aluminum foil. The foil is used to cover pyrotechnic devices to prevent sparks from prematurely igniting other devices scheduled for ignition later in the display. Once ignited, the pyrotechnic effects fire through the aluminum foil, shredding it and casting it aside. No aluminum foil was observed in the water, but pieces of foil were present aboard the barge. Mr. Jeff Thomas of Pyro-Spectaculars, Inc. was aboard the barge during the inspection and confirmed to Mr. Kathey that all loose debris remaining on the barge would be swept up and disposed of ashore. Empty launch devices, wiring, packaging, etc. were being readied for transport ashore by boat. The M/V Silver Prince home ported in Monterey Harbor was contracted to provide boat support for the activity.

Mr. Kathey observed the Monterey Breakwater during his return transit to the Coast Guard Pier at approximately 9:30 PM. The breakwater was filled with roosting marine birds and California sea lions. No visible signs of disturbance or reduction in pre-display numbers was evident. Mr. Kathey had noted the general population of marine life on the breakwater prior to the beginning of the display and observed no marked change.

Between 10:00 and 11:00 AM on Friday March 27, 1998, Mr. Kathey surveyed Del Monte Beach by foot between Municipal Wharf II and Park Avenue (approximately .5 miles) and observed no debris present from the previous evening's fireworks display. It is unknown whether the permit holder collected any debris prior to Mr. Kathey's survey.

Conclusions: Conditions placed on this activity restricting the type of pyrotechnic devices employed appear to have been very successful in minimizing impacts to both water quality and marine life. In contrast to the much larger public displays traditionally held on Independence Day, this activity produced only a small fraction of debris and had no significant observed impact on nearby marine species such as birds and marine mammals. The debris entering the water was limited to biodegradable paper and cotton products of relatively small volume. Some sparks from the pyrotechnic effects were discharged directly into the water and may have discharged small quantities of burned chemicals. No beached debris from the event was detected the following day. The permit holder should be required to sweep the barge immediately after the display to collect debris and prevent it from being blown overboard by winds. The permit holder should be required to dispose of all debris ashore.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, California 93940

Authorization **MBNMS-2000-030**
Monte Fireworks
Permit holder: Marcus Monte
Biological Monitoring report

Observer: Deirdre Hall, MBNMS

Primary operation area: Seacliff State Beach, Aptos, California. See attached map.

Timeline & Summary of Observations:

5 October 2000, 1445 – Scott Kathey and Deirdre Hall, MBNMS, surveyed the cement ship via the Sanctuary vessel, Shark cat. Birds and mammals are present at the site. Weather: overcast skies, sea surface mostly calm, tidal height ≈ 3.9 ft. See attached data.

11 October 2000, 1220 – Scott Kathey and Deirdre Hall, MBNMS, surveyed the cement ship via the Sanctuary vessel, Shark cat. Birds and mammals are present at the sited. During this survey 45 harbor seals were counted hauled out on the ship. Weather: overcast skies with hazy sun, five foot swells, tidal height ≈ 3.7 ft. See attached data.

12 October 2000, 1215 – Scott Kathey and Deirdre Hall, MBNMS, surveyed the cement ship via the Sanctuary vessel, Shark cat. Birds and mammals are present at the site Weather: partly sunny skies, wave height of 2 – 4 feet, tidal height ≈ 3.3 ft. See attached data.

14 October 2000, 1445 – I arrived at Seacliff State Beach, and met with a police officer who was stationed at the head of the steps leading onto the beach, which was enclosed with an orange plastic fence except for the area approximately 10 feet above the high tide line (pursuant to the California Coastal Commission permit). I identified myself and stated my intent to conduct a marine mammal & bird survey. The officer stated that access is being denied to the beach from the festival and directed me to the information booth. The information booth attendant then accompanied me back to the police officer. The police officer stated that I would need a police escort to conduct the survey. I made the police officer aware of the conditions of the authorization, and asked that he summon Mr. Monte to the scene. The information booth attendant hailed an Organizer on his hand held radio; I explained the situation, made her aware of the conditions of the Authorization, and she approved my access.

14 October 2000, 1500 – I walked down the steps, about 300 feet onto the beach, I stepped under the orange fencing material and was denied access by yet another police officer. I recommended that he contact the officer at the foot of the steps if he had questions regarding my presence and continued to walk towards the high tide line.

14 October 2000, 1505 -1535 – I began a survey of the beach area, approximately 0.5 miles north and south of the cement ship pier. The survey included species that were flying, on the beach and visible on the cement ship. Identifying birds to the species level on the cement ship from the beach proved to be difficult, as the sun was glaring onto the sea, so some were identified to genus. Weather: sunny skies, light breeze, tidal height ≈ 2.3 ft. The beach survey included:

Species	**Beach**-10/14/00 @1505
Black bellied plover, *Pluvialis squatarola*	1
Black turnstone, *Arenaria melanocephala*	0
CA brown pelican, *Pelicanus occidentalis*	43
Cormorandt sp., *Phalacrocorax*	45
Gull sp., *Larus sp.*	13
Harbor seal, *Phoca vitulina*	
Heermann's gull, *Larus heermanni*	4
Marbled godwit, *Limosa fedoa*	1
Pigeons	28
Tern sp., *Sterna sp.*	0
Western grebe, *Aechmophorus occidentalis*	0
Western gull, *Larus occidentalis*	13
Willet, *Catoptrophorus semipalmatus*	5

14 October 2000, 1702 –1718 – I began a survey from the water with the aid of the California Department of Fish and Game's rigid hull inflatable vessel, driven by Warden Jess Mitchell. We approached the cement ship slowly as to deter flight or flushing. I spent 16 minutes surveying the starboard and port sides of the sunken vessel. As we maneuvered to the port side of the cement ship many birds flushed and we backed the RHI away slowly. Tidal height ≈ 1.1 ft. See attached data.

14 October 2000, 1919 – I checked on the cement ship site again, the number of birds seems to be constant. I used the aid of a night vision monocular to survey the area, and I was able to see a few seals swimming in the mid-ship area. Sunset at 1813.

14 October 2000, 2110 – Deployment of fireworks. All the birds flushed the cement ship after the start of the fireworks display.

14 October 2000, 2115 – During the fireworks show some pelicans and cormorants could be seen circling the area. Within 10 minutes of the show being over, pelicans and cormorants began to return. I would estimate that approximately 25% of the birds returned by the end of the survey which was at 2155. Debris was visible floating on the surface of the water.

15 October 2000, 0727 – I conducted a sunrise survey aboard the CDFG rigid hull inflatable vessel, driven by Warden Jess Mitchell, the following day to determine presence/absence/numbers of individual birds and mammals. Weather: overcast skies, sea surface mostly calm, tidal height ≈ 2.7 ft.
See attached data.

Assessment:

One obstacle facing the Observer was the nighttime survey. It was obvious that all the birds flushed the cement ship after the start of the fireworks display, but even with the aid of a night vision monocular it was difficult to quantify exactly how many birds were returning. Harbor seals could not be seen during and immediately after the event. Its likely, based on the reaction of the birds and the noise of the display, that the seals evacuated the area on and around the cement ship. Harbor seals were sighted hauled out on the ship and in the water the following morning. Previous surveys were generally conducted mid-day and there may be some variability in the data, based on behavioral patterns of birds and mammals during afternoon hours as opposed to early morning and evening.

Species	**Boat**-10/05/00 @1445	**Boat**-10/11/00 @ 1220	**Boat**-10/12/00 @ 1215	**Boat**-10/14/00 @1702	**Boat**-10/15/00 @ 0727
Black turnstone, *Arenaria melanocephala*	0	2	0	1	2
Brandts cormorant, *Phalacrocorax penicillatus*	70	80	63	116	61
CA brown pelican, *Pelicanus occidentalis*	40	35	36	88	24
Double crested cormorant, *Phalacrocorax auritus*	20	20	15	5	4
Gull sp., *Larus sp.*	0	0	0	13	2
Harbor seal, *Phoca vitulina*	6	45	16	7	11
Heermann's gull, *Larus heermanni*			3	0	3
Pelagic cormorant, *Phalacrocorax pelagicus*	0	0	0	8	0
Tern sp., *Sterna sp.*	0	0	0	0	2
Western grebe, *Aechmophorus occidentalis*	0	0	0	3	2
Western gull, *Larus occidentalis*	20	30	14	44	26

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, California 93940

Special Use Permit **MBNMS-2000-039**
Adventures By The Sea Fireworks
Permit holder: Michelle Knight
Biological Monitoring Report

Observers:

Deirdre Hall & Scott Kathey, Monterey Bay National Marine Sanctuary

Primary operation area:

On the beach at 285 Figueroa, Monterey, California, approximately 400 feet from the edge of the building, and 350 feet from the waters edge. See attached map.

Timeline & Summary of Observations:

24 October 2000 @ 1746-1802 – Scott Kathey and Deirdre Hall, MBNMS, used the Sanctuary vessel Shark Cat, to survey the United States Coast Guard (USCG) pier/breakwater and floating barges in the harbor for birds and marine mammals before the fireworks event . The USCG pier/breakwater is a haul out site for the California sea lion as well as many species of marine birds. At the time of the survey there were 669 sea lions present and 234 birds, consisting of 7 species, roosting. See attached data. Tidal height ≈ 2.7 feet.

24 October 2000 @ 1805-1811 – Scott Kathey and Deirdre Hall, MBNMS, used the Sanctuary vessel Shark Cat, to survey the floating barges adjacent to Wharf 2. Six species of marine birds were present, accounting for 152 individuals roosting on the barges and flying in the vicinity. See attached data.

24 October 2000 @ 1811 – Sunset.

24 October 2000 @ 1956 – The number of animals on the breakwater seems constant.

24 October 2000 @ 2000-2008 – Fireworks begin. The Sanctuary vessel Shark Cat was just past the USCG pier/breakwater at the start of fireworks deployment (which happened 15 minutes earlier than planned). Scott, who had a different vantage point than Deirdre, estimates that 250-300 pelicans, cormorants, and gulls, flushed initially from all directions of the harbor for about 30 seconds. Scott turned the vessel around and immediately began transiting over to the breakwater, about 45 seconds away. Scott observed approximately fifty sea lions that were visible swimming in the water and leaving the area. The view from outside of the breakwater yielded Deirdre the opportunity to see approximately 150 birds flushing primarily pelicans and cormorants. There were many sea lions swimming and exiting the area of the breakwater. The splashing of sea lions into the water, from the breakwater, as well as many sea lion

exhalations could be heard from the Sanctuary vessel. The fireworks finale gave way to many more cormorants flushing, sea lions vocalizing, and some pelicans and gulls circling the breakwater area.

24 October 2000 @ 2008 – Fireworks end.

24 October 2000 @ 2029 -2040 – Inside the breakwater pelicans can be seen circling and landing. Visibility was a bit problematic due to the nighttime survey, but there are still pelicans, cormorants and sea lions on the rocks. Deirdre estimated the number of individuals to be that of about 60% of the pre-event survey.

24 October 2000 @ 2040 – A survey of the barge area revealed some pelicans on moorings. There were not any birds present on the barges. We began transiting back to the breakwater at which point we encountered 35 sea lions swimming towards shore.

24 October 2000 @ 2057 – Outside the breakwater there were three separate rafts of sea lions in the water. Small flights of pelicans continue to circle and land. Sea lion behavior seems to be returning to 'normal', meaning, vocalizations are happening at a less frequent rate and there appears to be a period of reduced activity.

24 October 2000 @ 2100 – While transiting back to the barge area we passed what appears to be the same group of ≈ 30 sea lions swimming near Wharf 2. There are no birds present on the barges with the exception of one seagull. Pelicans are still circling, there are a few cormorants in the water. We passed a small raft of 12 pelicans in the water, as well as 10 sea lions porpoising.

24 October 2000 @ 2105 – There are not any seal lions hauled out at the end point of the breakwater, yet there are many birds present. Survey completed.

24 October 2000 @ 2118 – Tidal height is 5.0 feet.

Assessment:

One obstacle facing the Observers was the nighttime survey. We were without the aid of night vision binoculars, therefore the numbers of animals recorded after sunset are estimates. The fireworks event was scheduled to begin at 8:15 p.m. but started fifteen minutes earlier. We were not in our ideal location, outside the breakwater, at that time, though not very far from it either. There appeared to be an obvious, sudden, flight & flushing of birds and mammals (though not all), both from within the harbor as well as from the breakwater, at the start and finale of the event. Behaviors appeared to be returning to normal at the completion of the survey. An additional Environmental Monitor was present, as required by the terms and conditions of Special Use Permit MBNMS-2000-039, who had a vantage point from land.

Species	USCG pier/breakwater @ 1746, 24 Oct 2000	Barge @ 1805, 24 Oct 2000
Black turnstone, *Arenaria melanocephala*	1	0
Brandts cormorant, *Phalacrocorax penicillatus*	154	61
CA brown pelican, *Pelicanus occidentalis*	21	78
CA sea lion, *Zalophuus californianus*	669	0
Double crested cormorant, *Phalacrocorax auritus*	6	2
Harbor seal, *Phoca vitulina*	0	0
Heermann's gull, *Larus heermanni*	12	7
Pelagic cormorant, *Phalacrocorax pelagicus*	0	0
Tern sp., *Sterna sp.*	0	23
Western grebe, *Aechmophorus occidentalis*	0	0
Western gull, *Larus occidentalis*	20	12

ENVIRONMENTAL EFFECTS OF FIREWORKS ON BODIES OF WATER

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ABSTRACT

The effects of fireworks decomposition products (FWDP) on the environment are unknown. The infrequence of fireworks displays at most locations, coupled with the wide dispersion of constituents, make detection of FWDP difficult. The present study was conducted to evaluate the impact of repeated fireworks displays (2,000 shows over a decade) on a small lake (WSL) located at EPCOT Center in Lake Buena Vista, Florida. Water chemistry data for WSL were collected from 1982 until the present, and sediments were characterized early in 1992. Heavy fireworks loading has not caused eutrophication or otherwise affected aesthetic characteristics of WSL, but it has added detectable amounts of barium, strontium and antimony to the water and sediments. The mass of antimony and barium in the surface sediments of WSL was found to be approximately 100X greater than that in the water column, demonstrating that these elements accumulate principally as insoluble compounds. Gradual increases in water column concentrations of antimony and barium over the past decade have paralleled the cumulative number of fireworks displays at the site. While current water column concentrations of these metals in WSL are higher than those of nearby lakes, these levels are not thought to be harmful to aquatic biota. Site-specific characteristics that will influence impacts of FW-borne constituents include size of the water body, hydraulic residence time, water and sediment physico-chemical characteristics, and cumulative fireworks loading over time. Data from this study suggest that environmental impacts from FWDP typically will be negligible in locations that conduct fireworks displays infrequently. Antimony may prove to be a good chemical "marker" for detecting fireworks activity at infrequently loaded sites, since for WSL, a close balance was found between the amount of antimony loaded from fireworks and the mass residing in the sediment and water column.

INTRODUCTION

Fireworks (FW) displays impose a variety of stresses upon local environments. These are manifested as the noise, explosive fiery, smoke and fallout debris that occur over communities during holidays and other festive occasions. Most of these effects are predictable, expected and short-lived.

The acute and chronic environmental impacts resulting from fireworks decomposition products (FWDP), however, are unknown. FWDP include a wide range of inorganic metals and organic polymer residues. The starting pyrotechnic composition consisting of oxidizers, fuels and binders, once reacted, produce a variety of metal oxides and particulate organics that fall to earth. Many of these metals (e.g., sodium, potassium, barium, strontium, magnesium and aluminum) comprise the cation in the various oxidizing agents, which typically are provided as nitrate and/or chlorate salts (1). Additionally, some metals (e.g., barium and strontium) are incorporated in FW to produce color effects. In most locations, the infrequence of FW displays and the wide spatial dispersion of constituents make it difficult to detect FWDP, or to evaluate their environmental impacts.

A small lake in central Florida has been the site of almost 2,000 fireworks displays in the past decade. This lake provides an ideal site for quantifying the long term accumulation of FWDPs, and of evaluating their environmental impacts. In the present study, we present findings on the accumulation of selected FWDP in the sediment and water column of this lotic system.

METHODS

Site Description

The study site is World Showcase Lagoon (WSL), a man-made lake located in EPCOT Center, Lake Buena Vista, FL, USA. The WSL is approximately 17.5 hectares in area, with an average depth of 3.5m. The lake volume is approximately 612,500 m^3. The hydraulic residence time for WSL is long: the only water inputs to this system are from rainfall and a small groundwater pump located at a nearby attraction. WSL receives no direct stormwater inputs, but considerable boat traffic and nearby maintenance activities (e.g., painting) may contribute contaminants to the system. Fireworks are thought to be a prominent contributor of particulate constituents to WSL. During FW displays, pyrotechnic devices are launched above WSL from the shoreline, as well as from barges anchored in the center of the lake. WSL is not utilized for recreation (no direct human contact occurs), nor is the lake used as a source of drinking water.

Field and Laboratory Techniques

Since 1982, quarterly water column measurements at two sites in WSL have been conducted for nutrients, metals and other general limnological parameters (e.g., alkalinity, conductivity, total organic carbon [TOC], pH and chloride). In January 1992, mid-depth water samples were collected from six sites in WSL. These samples were analyzed by ion chromatography for fluoride, chloride, nitrate, sulfate, alkalinity, sodium, potassium, magnesium and calcium.

Sediment samples also were collected from six sites in WSL during January 1992. These sediment cores (collected to a 20 cm depth) were partitioned into 4 depth increments: 0-2 cm; 2-5 cm; 5-10 cm; and 10-20 cm. Aliquots from each sediment layer were subjected to microwave digestion with acid, and the digestates were analyzed by ICP/MS (Inductively Coupled Plasma Mass Spectrometry). This instrument provided quantitative information for several metals, including chromium, manganese, iron, nickel, copper, zinc, antimony, barium and strontium.

The mass per unit area (in the top 20 cm of sediment) for selected metals in WSL was calculated as the product of sediment concentration and bulk density (dry mass per volume). This average value was then multiplied by the bottom area of the lake to provide an estimate of total mass of a particular metal in the WSL sediments.

An estimate of FWDP loading to WSL was calculated as follows. The mass (gross weight) of pyrotechnic devices exploded over WSL since 1982 was provided by entertainment personnel at EPCOT Center. A rough estimate of the composition of these FW was obtained from the pyrotechnic literature. Total mass loading to WSL by a particular constituent was estimated as the product of total FW mass and the average FW constituent concentration.

RESULTS AND DISCUSSION

Water Column and Sediment Characteristics

Water quality characteristics of WSL were summarized for three periods: during 1982 and 1983, prior to the extensive use of fireworks at the site; during 1987 and 1988, after the display of approximately 1,000 fireworks shows; and, January 1992, after display of nearly 2,000 shows (Tables 1 & 2). It should be noted that in 1989, WSL was connected to another lake system via a narrow canal. Hence, subsequent changes in water quality may have been due to mixing or dilution, rather than to activities occurring within or around the lake.

Of the non-metal constituents, total kjeldahl nitrogen (ammonium + organic forms) and alkalinity were the only water column parameters that changed substantially during the first five year period (Table 1). Alkalinity continued to increase during the subsequent five years, and slight increases in nitrate-N and chloride were also observed during this period. The major anion and cation analytes measured in 1992 in WSL all occur at concentrations typical of freshwater systems (Table 2). The nitrogen, phosphorus and total organic carbon concentrations show that WSL can be classified as an oligo-mesotrophic lake (2). The trophic status of WSL did not change during the 10 year study, and no marked changes in biota (aquatic macrophytes, fish or phytoplankton populations) were observed.

While most chemical and biological characteristics in WSL showed little temporal variation (Table 1), water column antimony (Sb) and barium (Ba) concentrations in WSL increased linearly from 1982 until 1989 (Fig. 1). The increase in concentrations of these elements in the water column undoubtedly was due to FW activity, since both of these elements are common constituents in pyrotechnic devices. Concentrations of other metals (copper, zinc, cadmium, manganese and

selenium) remained unchanged in WSL during the study. The decline in water column concentrations of Ba and Sb in 1989 (Fig. 1) probably was due to the dilution of WSL waters with that of the adjacent lake.

Metals concentrations in WSL sediments were highest in the top sediment layer (0-2 cm), and declined with depth (Fig. 2). For most metals, WSL surface sediment concentrations (Table 3) were typical of natural or "non-impacted" sediments (3). However, an unusual feature of WSL sediments is that Sb, Ba and strontium (Sr) were found in moderate to high concentrations. Little information on "typical" sediment concentrations for these metals could be found, but it is known that they usually occur at concentrations much lower than those of zinc, manganese and lead. Strontium, like Ba and Sb, is a common firework constituent (1) with few other commercial uses. Aluminum and magnesium also are used in pyrotechnic devices, but these were not analyzed for in the present study due to their high native concentrations in Florida soils and sediments.

While surface sediments displayed highest metals concentrations (e.g., Fig. 2), this sediment layer also was the least consolidated, with the lowest amount of dry mass per unit volume. The bulk density of 0-2 cm, 2-5 cm, 5-10 cm, and 10-20 cm sediment layers averaged 0.15, 0.68, 1.21, and 1.71 g/cm^3, respectively. Consequently, differences in total mass of metals among the sediment depth layers was not as pronounced as would be suggested by concentration differences. For example, the mean mass of Sb per unit area at 0-2 cm, 2-5 cm, 5-10 cm, and 10-20 cm sediment depths in WSL was 8.3, 13.0, 27.6, and 4.9 g/m^2, respectively.

The total mass of Sb, Ba and Sr in the WSL sediments (top 20 cm) was estimated to be 9,400, 84,000 and 18,500 kg, respectively. The spatial variability in concentrations of these metals in WSL sediments was high (due either to uneven depostion or to variations in native metals concentrations), so the above mass values should be considered rough approximations. Additionally, we have not yet quantified "natural" levels of these elements in nearby soils and lake sediments, so the percentage of these metals in WSL contributed by FW is unknown.

Antimony was selected for a mass balance calculation because it has a very low crustal abundance of 0.2 mg/kg (4). For purposes of this comparison, we therefore have assumed that all Sb in WSL was derived from fireworks. The total mass of Sb dissolved in the water column was estimated (using 1988 "maximum" concentration values) to be 200 kg. WSL therefore contains 9,600kg Sb, only 2.1% of which is in a dissolved form. The total mass loading of Sb to the WSL from pyrotechnic devices was estimated to be 11,800 kg, a value in fairly close agreement to the calculated mass of Sb in the water column and sediments. That most of the Sb is detectable in WSL is not surprising, since this element is not used as a nutrient by either plants or animals, and is not likely to be transported from the system.

A similar mass balance conducted for Ba was less precise: 84,500 kg of Ba was found in the WSL system (0.6% of which is in the water column), but only 19,000 kg of Ba was calculated to have been loaded from FW displays. The poor agreement between the calculated mass of Ba loaded from FW and the mass observed in WSL is likely due to an underestimate in the amount of Ba utilized in the pyrotechnic devices, or to high native Ba levels in the WSL sediments.

Environmental Impacts of Fireworks Decomposition Products

Fireworks activity does not appear to contribute substantially to the eutrophication of water bodies. FW contain almost no phosphorus (1), which frequently is the "growth-limiting" nutrient for aquatic plants. FW do contribute nitrogen, an element that can stimulate unwanted plant (micro- or macroscopic) growth. However, the biochemical N cycle in aquatic systems is dynamic, and there are several pathways through which N is lost to the atmosphere in gaseous forms (5). In WSL, a small lake with very heavy fireworks loading, no visible decline in the aesthetic quality (e.g., appearance of nuisance algae) of the system has occurred.

This study demonstrates that a principal environmental impact of FW activity is the deposition of selected metals. In WSL, a site that has received heavy FW loading for a decade, the FW-derived metals Ba, Sr and Sb were found both in the water column and sediments. These metals are deposited in largely insoluble forms, since in WSL, 97.9% of the Sb and 99.4% of the Ba occur in the sediments. Fireworks contain other metals (e.g., aluminum, magnesium and copper) that also are deposited in dryfall, but high "background" or native concentrations of these elements may render the small mass of metals contributed by FW difficult to detect. Antimony may prove to be a good chemical "marker" for detecting fireworks activity at infrequently loaded sites, since for WSL, a close balance was found between the amount of antimony loaded from fireworks and the mass residing in the sediment and water column.

The environmental consequences of FW metal deposition are difficult to discern. For any aquatic system over which FW are displayed, environmental impacts of FWDP will depend on the area and depth of the water body, hydraulic residence time, water and sediment physico-chemical characteristics, and total fireworks loading. For most sites that conduct FW displays infrequently, environmental impacts of FWDP probably are negligible. In contrast, a "worst-case" scenario would be where heavy, routine fireworks loading is conducted over a small, relatively stagnant body of water that is utilized as a drinking water source. It would be prudent to conduct periodic monitoring for metals at such locations, because both Sb and Ba at low levels are under consideration for various surface water and drinking water priority lists (6).

Data on FWDP presented herein suggest a number of topics that merit further study. These include: evaluating factors that influence speciation and mobility of fireworks metals in aquatic systems; evaluating techniques for reducing concentrations of selected analytes within FW shells; and, investigating the efficacy of binding FW-borne metals in lake sediments by chemical immobilization. In order to ensure that environmental impacts are understood and minimized, more detailed studies on the chemistry of FW-borne metals likely will be conducted in WSL during the coming decade.

ACKNOWLEDGEMENTS

Field and analytical assistance from the Reedy Creek Improvement District Environmental Laboratory is gratefully acknowledged. Preston Merrick and Eddie Snell provided the authors with historical water quality data for WSL. Sediment coring in WSL was conducted by Karen and Jim Peterson. Chris Coston performed ion chromatograph analyses on WSL water samples collected in 1992.

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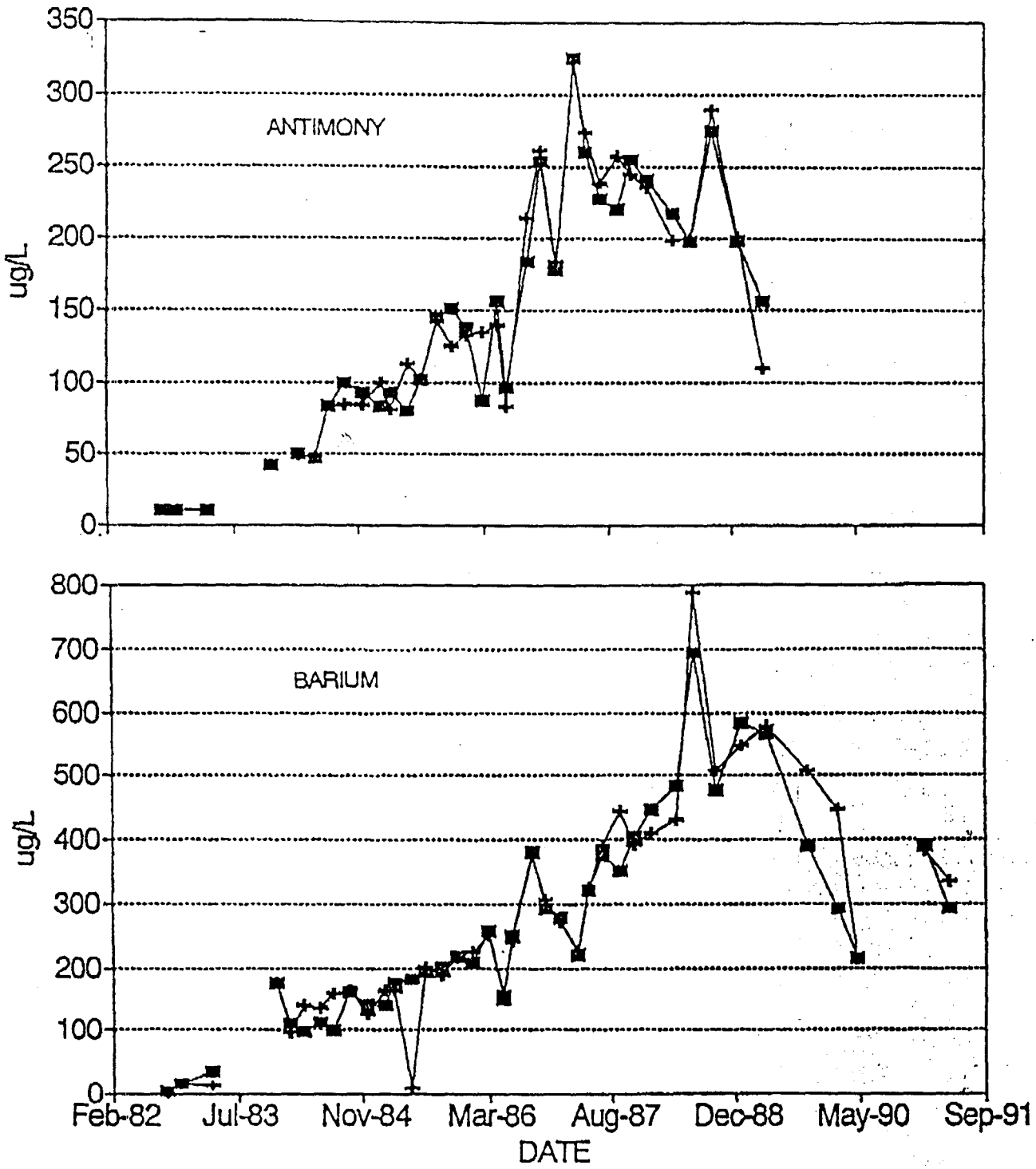

Figure 1. World Showcase Lagoon (WSL) water column antimony and barium concentrations from 1982 through 1991. The two symbols on each graph depict values from separate surface water sampling stations.

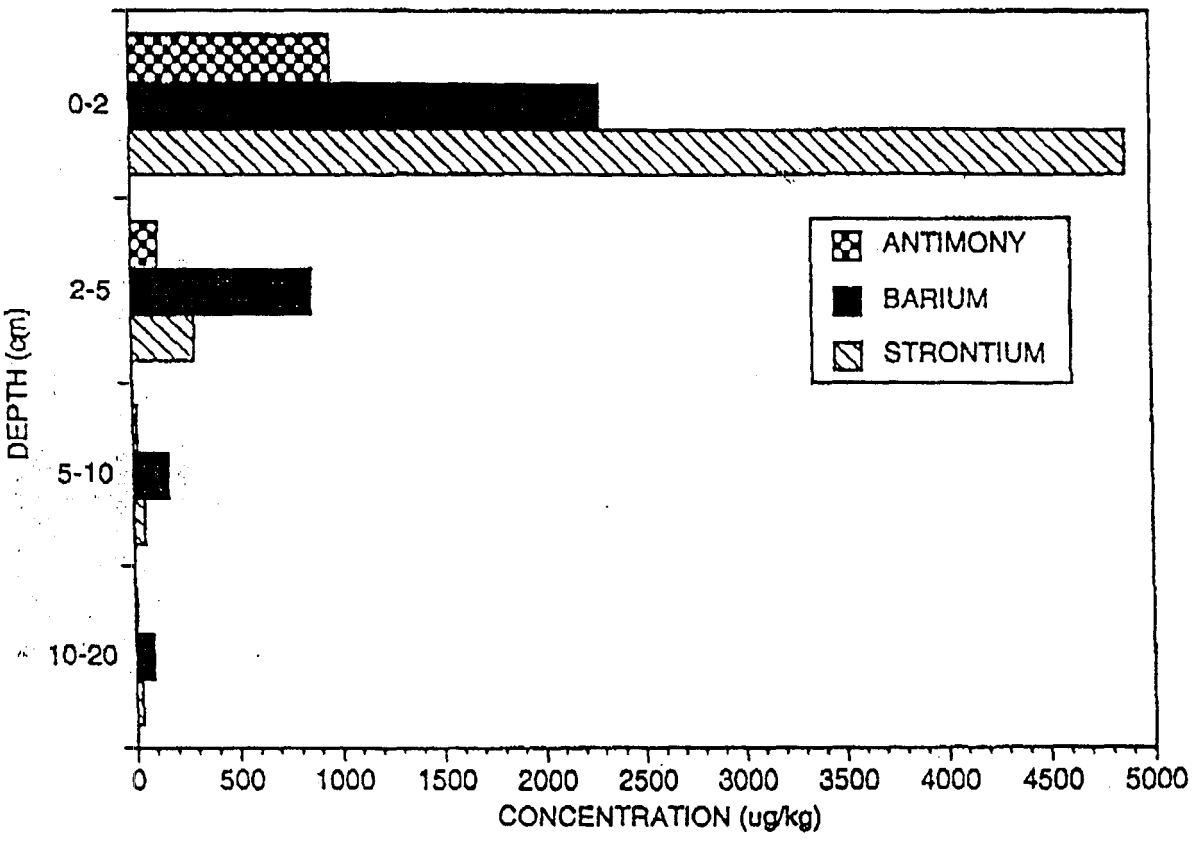

Figure 2. Concentrations of strontium, barium and antimony with sediment depth in WSL. These values are from one core sample collected on the east side of WSL.

Table 1. Mean water quality characteristics for WSL at a mid-lake sampling station before (1982-1983) and after (1987-1988) five years of heavy fireworks loading.

analyte	1982-1983	1987-1988
Total Kjeldahl N (mg/L)	0.22	0.40
Ammonium-N (mg/L)	0.05	0.04
Nitrate-N (mg/L)	0.06	0.05
Total phosphorus (mg/L)	0.03	0.02
Total organic C (mg/L)	3.3	3.8
Chloride (mg/L)	6.0	6.2
Conductivity (umhos/cm)	174	162
Alkalinity (mg/L)	29.4	57.0

Table 2. Mean anion and cation concentrations (mg/L) for WSL at mid-lake sampling stations in January 1992. Median reference values (with ranges) are from a study of 165 Florida lakes (7). Other data references are cited below.

analyte	WSL	Reference Values
Fluoride	0.14	0.26[1]
Chloride	8.7	14 (2 - 2300)
Ammonium-N	0.02	NA
Nitrate-N	0.10	NA
Sulfate-S	11.1	11 (3.4 - 186)
Alkalinity	72.0	10 (0 - 204)
Sodium	4.2	7.6 (1 - 1200)
Potassium	2.6	1.3 (0 - 51)
Magnesium	5.0	4.1[2]
Calcium	24.4	1.5[2]

1 Reference #2
2 Reference #4

NA - not available

Table 3. Mean metal concentrations for surface (0-2 cm) sediments from WSL, January 1992. Values reflect the mean of six sampling sites.

Metal	WSL Sediment (mg/kg)	Natural or Non-Impacted Sediments[1] (mg/kg)
Iron	189	< 17,000
Barium	23.2	NA
Copper	8.9	< 25
Antimony	7.6	NA
Strontium	4.8	NA
Zinc	1.97	< 90
Manganese	0.77	< 300
Lead	0.70	< 90
Chromium	1.47	< 25
Nickel	0.67	< 20

1 Reference #3

NA - not available