Box jellyfish (*Carybdea alata*) in Waikiki:

Their influx cycle plus the analgesic effect of hot and cold packs on their stings to swimmers at the beach: A randomized, placebo-controlled, clinical trial.

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Abstract

The study measured the analgesic effect of hot and cold packs on box jellyfish (Carybdea alata) stings to Waikiki swimmers at the beach. Analysis of data showed a minimal trend toward pain relief 10 minutes after the application of hot packs, particularly when the initial pain was mild to moderate. Cold packs showed no clinically significant relief of pain, compared to the control. Date tracking shows that most box jellyfish appear in Waikiki waters on the 9th or 10th day after the full moon.

Introduction

Box jellyfish (*Carybdea* species) annually inflict hundreds of painful stings to Hawaii ocean-goers.[1] On July 29, 1997, over 800 people were stung at Waikiki Beach alone.[2] Worldwide, thousands more people are stung annually by these and other box jellyfish species. Box jellyfish belong to the jellyfish class Cubomedusae, found only in tropical and subtropical waters. Cubomedusae have transparent, almost perfectly square bells. Their bottom edges are straight rather than scalloped, and tentacles hang from each of the bell's four corners.

In the middle of each of the four, flat sides of a box jellyfish bell lay the animal's sensory organs including elaborate, well-developed eyes. In darkness, a box jellyfish can detect light from a match 4 or 5 feet away and will swim toward it. These creatures appear to be sensitive to bright sunlight and most apparently retreat to deep water at midday. Because of this, most stings occur to swimmers in the morning.

Box jellyfish are strong, fast swimmers, some cruising up to about 2 miles per hour. These creatures feed mainly on shrimp and fish, stinging them with cells called nematocysts, abundant on the trailing tentacles. When a human comes in contact with these nematocysts, they sting exposed skin.

Two kinds of stinging, but non-lethal, box jellyfish appear periodically in Hawaii's bays and shorelines. These are *Carybdea alata*, about 3 to 4 inches high and about 2 inches wide, and *Carybdea rastoni*, about 1 inch square. Both have pinkish tentacles trailing from the four corners of the square. The tentacles of the larger species can be up to 2.5 feet long.

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The box jellyfish called sea wasps (*Chironex fleckeri*) are infamous in Australia and surrounding areas for their sometimes-fatal stings. This species does not inhabit Hawaiian waters.

No confirmed deaths have occurred in Hawaii from box jellyfish stings but the pain they inflict can be severe. The pain and marks from box jellyfish stings is nearly always self-limited, usually disappearing with no treatment from 20 minutes to one day. Some victims suffer persistent pain and/or recurring rash.

Therapies to minimize box jellyfish pain have not been studied in controlled, clinical trials. Some remedies, such as application of ice packs or heat in the form of hot showers or hot water soaks are common at home and in Hawaii's emergency rooms but are unproven. Additionally, chemical hot packs and chemical cold packs are a significant expense to the City and County of Honolulu since lifeguards sometimes use these to treat the pain of jellyfish stings at the beach.

This study was undertaken to determine whether applying hot or cold packs at the beach significantly relieves pain from box jellyfish (*Carybdea alata*) stings.

Box jellyfish have been in Hawaii at least since 1906 and a swarm of *Carybdea alata* was reported appearing on Waikiki Beach in June, 1951.[3] According to Honolulu City and County lifeguards, however, box jellyfish began occurring in Waikiki waters and on Waikiki beaches on a regular basis and in large numbers in the late 1980s. The first of these influxes was noted in December of 1988, followed by influxes in April, May, June and July of 1989.[4] In May of 1989, daily Waikiki swimmer Minoru Yoneshige noticed that box jellyfish seemed to be appearing in Waikiki waters on a regular basis. He recorded influx dates for 4 years and discovered that box jellyfish usually appeared there two days after the last quarter moon. He notified one of the authors (S.S.) and lifeguards of his findings.

Lifeguards also began recording influx dates and counting individual jellyfish found in the area of Waikiki Beach near tower 2C, a place where box jellyfish were often highly concentrated. From their unpublished data, it was confirmed that the highest influxes occurred on the 9th and 10th days after the full moon (another way of saying two days after the last quarter moon). The authors believe that compiling and publishing the dates of box jellyfish influxes in Waikiki over the last three years is of value to lifeguards, heath care workers and the public in general since box jellyfish sometimes cause painful and fearful experiences for people recreating in Waikiki waters.

Methods

This study is one part of an ongoing, larger study examining the efficacy of different temperatures and solutions in treating the pain of box jellyfish and Portuguese man-of-war stings in Hawaii. The University of Hawaii's human subjects committee has approved all portions of this on-going study.

The main study sites for applying hot and cold packs to box jellyfish stings were at Waikiki Beach at the lifeguard towers marked 2C and 2D. These sites were chosen for their high number of box jellyfish sting incidents compared to other leeward beaches. This increased incidence is likely due to the trapping of box jellyfish inside nearby concrete breakwaters.

The study was conducted from January 1997 through December 1999. During this time, any adult or child who came to the lifeguard tower complaining of a sting was assessed immediately for the possible need of ambulance assistance. Criteria for such assistance were respiratory distress, altered consciousness, uncontrollable pain, widespread rash, stings to eyes or victim request. Five victims needed ambulance transport. Two had a hot pack applied to their stings, two had a cold pack applied and one had a control pack applied, all before ambulance arrival.

Those victims not requiring ambulance assistance, and who likely had box jellyfish stings as indicated by the lunar cycle and wind direction, had their sting areas immediately doused with vinegar. Vinegar is currently the recommended method of neutralizing undischarged nematocysts in box jellyfish stings.[5] This treatment is not purported to relieve pain, but prevents additional stings. Following this dousing, a worker applied one of three temperature variants to the sting: a chemical hot pack, a chemical cold pack or an air temperature pack (control). The worker selected the type of pack applied in a random manner by reaching into a box containing an approximately equal number of the three types of packs and choosing the first one at hand. This method of providing randomized treatment is not flawless but proved a practical method of randomization at the beach. Also, blinding the researcher as to whether he or she was using hot, cold or air-temperature packs was difficult since as soon as the pack was activated, its temperature change, or lack thereof, was noticeable instantly by touch.

The chemical hot packs (Kwik-Heat) reached a maximum temperature of 110 degrees F. soon after being activated by squeezing the bag. The cold packs (Kwik-Kold) soon reached a minimum temperature of 42 degrees after being activated in the same manner. Control packs were depleted hot or cold packs. At 0 (immediately after the vinegar dousing), 5, 10 and 15 minutes, victims 7 years of age and older made a single mark, or told the field researcher where to make a mark, through a standard 100-mm visual analog scale (VAS), with 0 being no pain and 100 being severe pain.

Results

Sample and Data Analysis

The dataset contained information on 133 individuals. However, two (both in the cold group) dropped out before the vinegar dousing, and three more (one in the hot group, two in the cold group) dropped out before the 5-minute pain score was recorded. Another participant had a final pain score of 0 after the vinegar dousing. The sample size for the analysis of pain score at 5 minutes after the vinegar dousing is therefore 127. More serious sample attrition begins after the 5-minute mark. Only 100 participants gave complete data at 10 minutes, and only 43 at 15 minutes. Thus, the most reliable results are those from the pain score at 5 minutes. After that, two different analytic methods were used, one which considered only the data actually collected (method 1), and another method in which missing pain scores were imputed with the last pain score recorded (method 2). Both methods give results that are limited in comparison to the results from the pain score at 5 minutes. The former method does not take into account any treatment effect on dropping out and the latter relies heavily on imputed pain scores.

The pain scores were analyzed as both continuous and binary outcomes. Graphical analyses indicated the pain scores were somewhat skewed, so a square root transformation was used for the analysis of covariance. The results were similar to those with the untransformed data, however, so the latter are presented here for ease of interpretation. Nonparametric statistical tests also corroborated the results obtained with the untransformed data. The analysis of covariance described the inter-treatment differences in the mean pain scores at 0, 5, 10 and 15 minutes, with statistical control for the pain score at 0 minutes for the last 3 outcomes. A binary outcome was also constructed, depending on whether the participant experienced complete cessation of pain or not over the 15 minute testing period. However, only 7 of the 127 participants reported a final pain score of "0", 5 in the hot group and 2 in the cold group. (Three other participants reported 0 after 5 minutes, but re-elevated pain scores after 10 and 15 minutes.) Since there were no participants in the neutral group (the reference group) who reported a final score of 0, the definition of cessation of pain was widened to include a final pain score of 10. A logistical regression model was used to analyze the odds of the cessation of pain across the treatment groups, while controlling for initial (after vinegar dousing) levels of pain.

Records of the dates of appearance and box jellyfish counts at Waikiki Beach near lifeguard tower 2C since 1998 were collected and recorded in tables and graphs.

Estimation of pain scores at 5, 10 and 15 minutes by treatment group.

Results are summarized in the following table, including both of the above-described analytic techniques for pain scores at 10 and 15 minutes after vinegar dousing. The basic model was: pain score at 5-, 10- and 15-minute intervals (after vinegar dousing) = intercept + baseline pain score (after vinegar dousing) + treatment effect.

At 5 minutes, both the cold and hot treatment groups had significantly lower average pain scores than the neutral group. The estimated difference was approximately 5 points for the cold group and 6 points for the hot group. This is shown graphically in the figure below (Graph 1). There is some suggestion of an interaction with the effect of the hot group in that the difference between the hot and neutral group was greater among those participants with lower initial pain scores, compared to those with higher initial pain scores. This interaction was not statistically significant, however. The decrement associated with the cold group was fairly constant across the range of initial pain scores (no interaction).

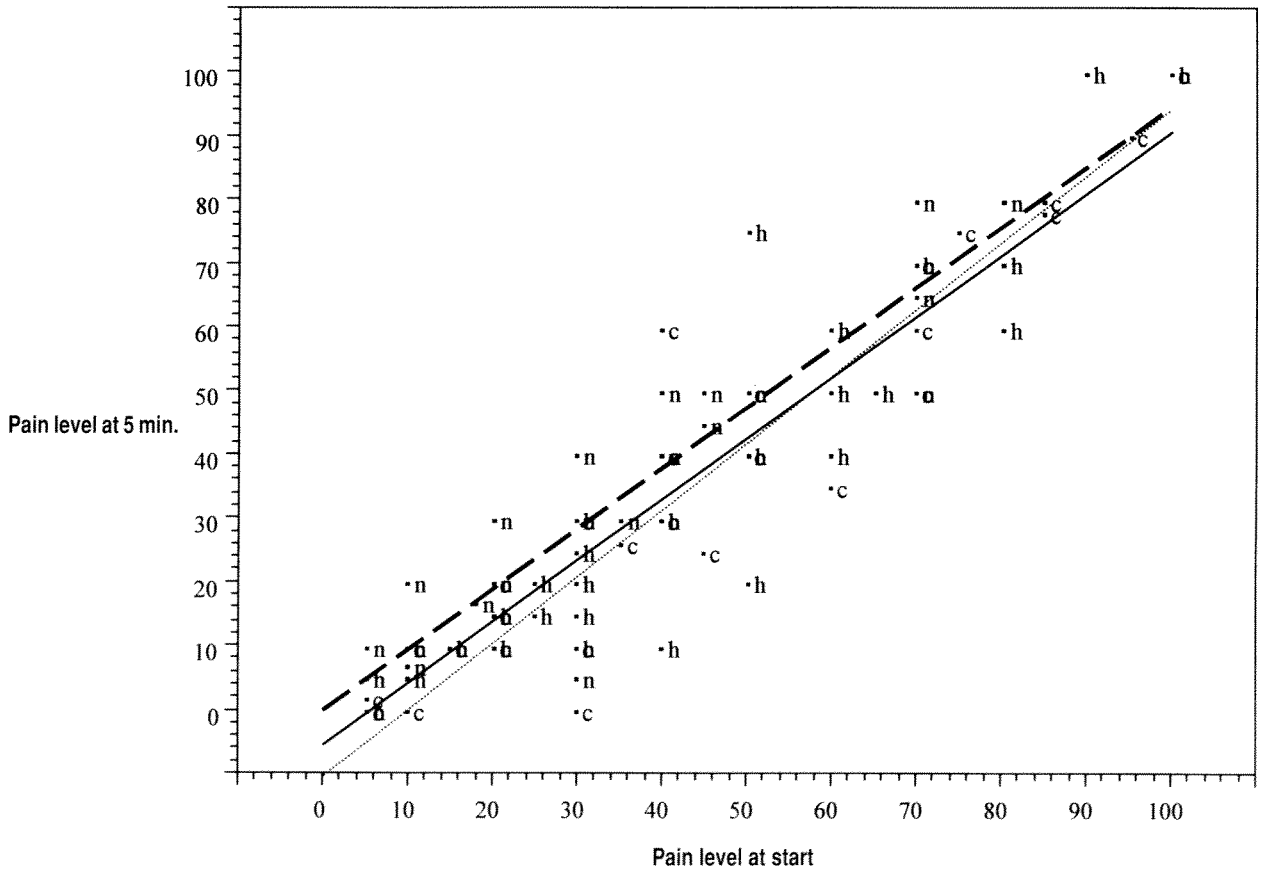
At 10 minutes, participants in the hot treatment group had significantly lower pain scores compared to the cold and neutral groups, between which there were no longer differences (Table 1). This was true for both methods 1 and 2.

Table 1. — Estimated* average pain scores, by 5-minute intervals and treatment group.

		Method 1[1]					Method 2[2]	
Group	time:	0 min.	5 min.	10 min.	15 min.		10 min.	15 min.
Cold	n	42	42	31	17		42	42
	pain score	38.3[a]	32.8[a]	36.2[a]	45.0[a]		33.2[a]	33.9[a]
	standard error of pain score	3.9	1.4		2.4	4.3	2.0	2.2
Hot	n	44	44	35	12		44	44
	pain score	42.3[a]	31.3[a]	27.5[b]	34.1[a]		26.0[b]	23.8[b]
	standard error of pain score	3.8	1.4		2.3	5.2	2.0	2.2
Neutral	n	41	41	34	14		41	41
	pain score	38.6[a]	37.7[b]	38.2[a]	37.3[a]		35.0[a]	33.4[a]
	standard error of pain score	3.9	1.4	2.3	4.8		2.0	2.3

*Estimates at 5, 10 and 15 minutes are adjusted for pain level after vinegar dousing (0 minutes).
[1]Method 1 utilized only non-missing data in estimation of average pain scores.
[2]Method 2 imputed missing values after 5 minutes, using the last recorded pain level for all subsequent missing values. (Note that the sample sizes for each treatment group remain constant in Method 2.)
Significance tests between treatment groups (within 5 minute intervals): groups with same letter are not significantly different ($p \geq 0.05$).

Graph 1. — Prediction of pain at 5 minutes by treatment group.



(Fitted lines: Neutral group indicated by dashed line, hot group by dotted line, and cold group by solid line.)
(Data points: Neutral group indicated by "n", hot group by "h", and cold group by "c".)

Prediction of the cessation of pain by treatment group. The proportion of participants who experienced the cessation of pain within the study period was highest in the hot treatment group (41%) and lowest in the neutral group (29%). After adjustment for initial pain scores, participants in the hot group were estimated to be 5 times more likely to experience cessation of pain, compared to those in the neutral group. While this estimate was statistically significant (p=0.02), note the wide confidence interval, ranging from roughly 1 to 23. In fact, exploratory data analysis indicated the odds estimate was substantially decreased by artificially changing the status of 1 or 2 participants in the hot group. There was no statistical difference in the odds of pain cessation between those in the cold group and the neutral group (p=0.4).

Table 2.—Odds of cessation of pain*, by treatment group.

Treatment group	Cessation of pain? yes (%)	no	Odds ratio (95% confidence interval)
cold	14 (33%)	28	0.5 (0.1 - 2.1)
hot	18 (41%)	26	5.2 (1.3 - 22.8)
neutral (reference)	12 (29%)	29	1.0

*Cessation of pain is defined as a final pain score of 10 or less. All estimates are adjusted for initial pain scores.

Box jellyfish appeared on Waikiki Beach at tower 2C nearly always between the 8th day and 12th day after the full moon. In the 1998 graph, a 13th day column was added because of the unusually high influx of jellyfish on the 12th day in March. The counts near tower 2C on all other dates were zero or near zero. Analysis of the dates of box jellyfish influxes in Waikiki for the past three years confirms that these jellyfish most often appear on and near the beach in the highest numbers on the 9th and 10th days after a full moon.

Recent research suggests that the synchronous arrivals of box jellyfish in Waikiki are monthly spawning aggregations. Box jellyfish start to arrive on the beaches of Waikiki approximately one hour before the high tide on the ninth and tenth days after the full moon. The first individuals to arrive are usually mature spawning males. Approximately one hour later, mature spawning females arrive.[6] It is unknown why this occurs only on the leeward shore of Oahu.

Discussion

Our data analysis shows that after 5 minutes of holding packs on a box jellyfish sting, both the cold and hot treatment groups had lower pain scores (less pain) on average than the control group: cold was approximately 5 points lower than neutral; hot approximately 6 points lower. It is doubtful, however, that such small differences are clinically significant. One study examining the significance of this visual analog scale (VAS) model reports that in acute traumatic pain in an emergency department, less than a 13-mm change in pain severity, although statistically significant, may have no clinical importance.[7] Another emergency department study on VAS pain scores found the minimum clinically significant difference in VAS pain scores to be 9 mm.[8] From these studies the authors conclude that the 5 or 6 point VAS difference in hot and cold pack treatment at 5 minutes is not clinically significant.

At 10 minutes, there is neither a statistically nor clinically significant difference between the cold packs and neutral packs (in both methods 1 and 2), thus in this study, cold packs were ineffective in relieving jellyfish sting pain 10 minutes after application.

At 10 minutes, hot pack victims are lower (less pain) than the control in both statistical methods. In Method 1, the decrease was approximately 11 points; Method 2, approximately 9 points. This difference is clinically significant according to one VAS study and not clinically significant according to the other. In Method 1, the average pain score estimates in the cold and hot groups increase at the 15-minute mark, compared to the 5-minute mark. (Actually at 10 minutes in the case of the cold group.) There are at least three possible explanations for this. One is that there is less potential for late pain relief among those in the hot and cold groups, since they experienced a greater decrease of pain earlier. Another possibility is that people in the hot and cold treatment groups are dropping out earlier than those in the control group because of lessened pain. A third option is that both the hot and cold packs used tended to lose their maximum temperatures after 10 to 15 minutes, therefore, their efficacy diminished with time.

One uncontrolled and possibly significant variable in this study was the time elapsed between the time the victim was stung and the time he or she sought help. Often, victims continued surfing or swimming for a while, took freshwater showers at the beach or treated the stings with their own remedies before coming to the lifeguard. Considering this is a self-limited affliction, it's possible that this unmeasured variable skewed study results.

Some clinicians in Hawaii's emergency rooms instruct their box jellyfish victims to take hot showers. Anecdotal reports indicate that victims who do this say they feel an immediate relief of pain. The pain of jellyfish stings, however, is self-limited, often disappearing on its own from 20 minutes to a day, thus any intervention often appears to work. The analgesic effect of hot showers should be studied with a control, examining the effects of fresh water, water pressure from the showerhead, water temperature and elapsed time. Similarly, ice packs used at home or in the emergency room need a controlled clinical trial to examine their effectiveness as do cool fresh water showers at the beach. Such studies, however, are extremely difficult to conduct. Studying late interventions is problematic in self-limited injuries plus few victims (fortunately) are seen in emergency rooms for jellyfish stings in Hawaii.

Based on the findings of this study, and the results of other studies regarding clinical significance in VAS scores, the authors conclude that there is a trend toward relief of box jellyfish pain with hot packs 10 minutes after application particularly if the initial pain was mild to moderate. The clinical significance of this trend, however, is borderline and thus makes it unlikely that noticeable relief of pain from Hawaii's box jellyfish stings is achieved with the application of hot packs at the beach. Applying cold packs at the beach does not appear to be effective in relieving the pain of these box jellyfish stings. Because of these results, the authors recommend that all box jellyfish stings be sprayed liberally with vinegar, but that neither hot nor cold packs be applied routinely.

Because box jellyfish influxes occur with relative regularity, lifeguards should continue to monitor Waikiki beaches in the early mornings on the 8th through 13th, and particularly on the 9th and 10th, days after the full moon and post jellyfish warnings to swimmers as warranted.

Graph 2

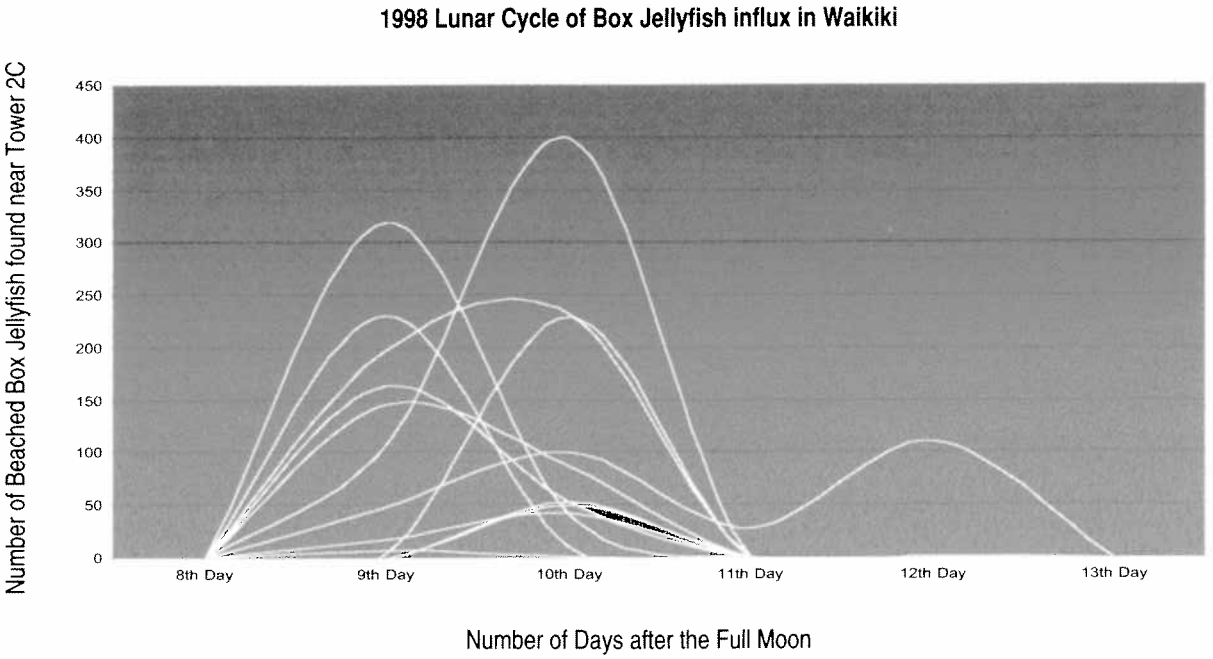


Table 3

Month	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13
January	0	18	43	0	0	0
February	0	147	88	0	2	0
March	0	49	100	28	111	0
April	0	108	400	1	1	0
May	0	165	53	0	1	0
June	0	4	230	0	0	0
July	0	0	50	1	0	0
August	0	0	54	0	0	0
September	0	231	10	0	0	0
October	0	320	42	0	0	0
November	0	198	232	1	0	0
December	0	7	1	0	0	0

Graph 3

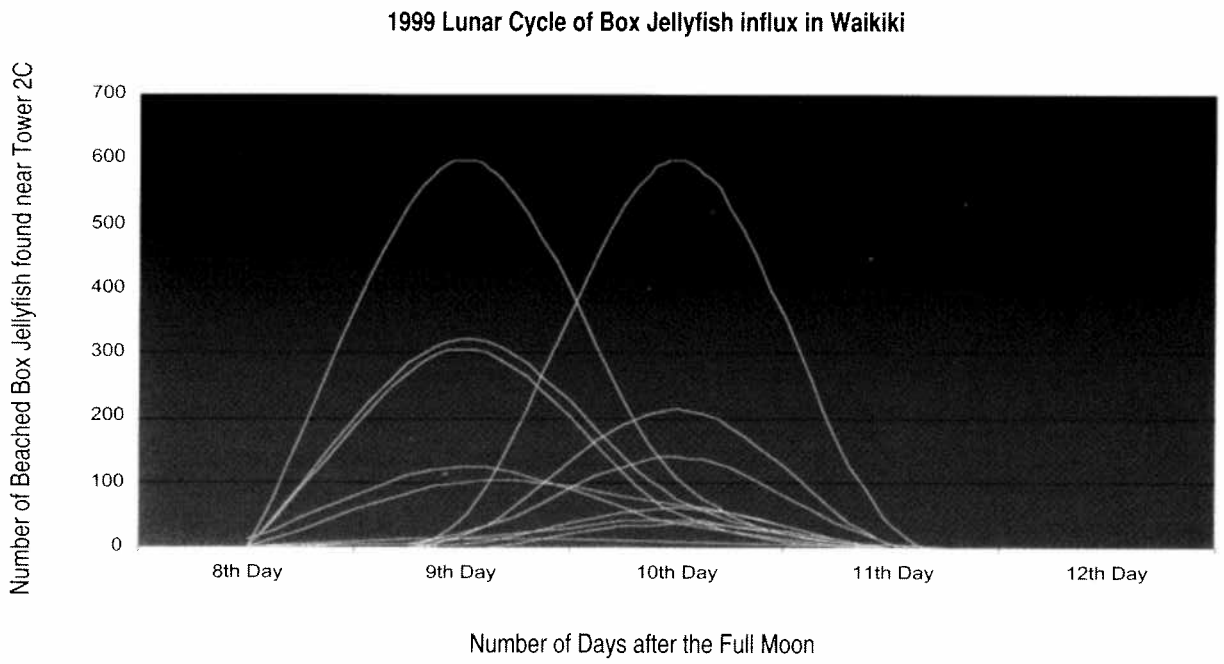


Table 4

Month	Day 8	Day 9	Day 10	Day 11	Day 12
January	0	20	141	7	1
February	2	324	76	0	0
March	0	45	600	36	0
April	0	14	43	0	0
May	0	100	70	1	0
June	0	1	39	4	0
July	1	18	216	4	0
August	0	16	11	0	0
September	0	5	61	3	0
October	13	127	38	0	0
November	0	307	54	0	0
December	1	600	108	0	0

Graph 4

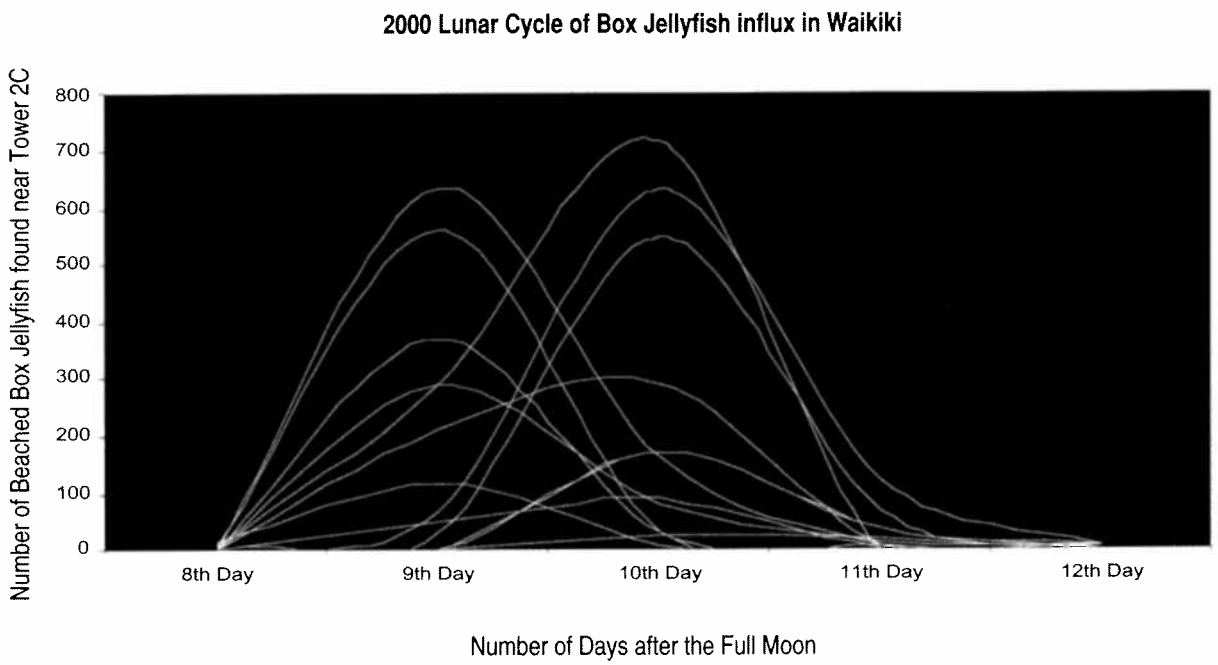


Table 5

Month	8th Day	9th Day	10th Day	11th Day	12th Day
Dec/Jan	15	117	8	1	5
January	7	288	79	14	5
February	7	560	31	5	0
March	0	210	292	8	0
April	0	372	28	0	0
May	0	3	171	36	7
June	0	0	22	18	0
July	3	29	550	67	1
August	0	1	168	35	2
September	0	47	87	3	1
October	0	67	630	122	5
November	0	634	162	9	3
December	0	0	22	18	0

The authors stress that their recommendations do not pertain to Portuguese man-of wars (*Physalia physalis* and *Physalia utriculus*), two other stinging marine species that also sometimes plague Hawaii's ocean goers. Portuguese man-of–wars' nematocysts (stinging cells) are different from one another and from those of box jellyfish, and therefore, need to be studied separately.[9]

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