A study of the Virgin Islands Spiny Lobster Fishery: Growth, Population Size and Mortality

SEDAR57-RD-10

June 2018

A study of the Virgin Islands Spiny Lobster Fishery: Growth, Population Size and Mortality.

Un estudio de las pesquerías de langosta espinosa Islas Vírgenes:

Crecimiento, tamaño de la población y la mortalidad

Une étude sur les pêcheries de homard épineux des Iles Vierges: Croissance, taille de la population et mortalité

David[1] A. Olsen, St. Thomas Fishermen's Association
Josh Nowlis[2], Bridge Environment
Daryl Bryan[3], St. Thomas Fishermen's Association

[1] 865 NE Jeffries Ct., Newport, OR 97365
[2] 9721 20th Ave NE, Seattle, WA 98115
[3] 3AC Estate Lerkenlund, St. Thomas, VI 00802

ABSTRACT

Expansion of the tourism industry in the Virgin Islands led to development of a fishery for spiny lobster (*Panulirus argus*). Spiny lobster was not a traditional element of the Virgin Islands diet, but it has become one of the Virgin Islands most important fisheries and supplies an important product to local restaurants and hotels. Members of the St. Thomas Fishermen's Association have undertaken a tag and recapture study of the fishery in St. Thomas/St. John and St. Croix. Preliminary results were presented at the 66th Gulf and Caribbean Fisheries Institute meeting in 2013, but tag recaptures have continued through November of 2016. The additional data have permitted calculation of refined growth, movement, mortality and population size estimates and provided additional information about movement of the resource in St. Thomas and St. John. Analysis of historical data collected by the Territorial Government has provided information about long-term trends in average carapace length and mortality. Management recommendations are provided which point out problems with the current quota system required by the Magnusan-Stevens Act. The project is a clear indication of the value of collaboration between fishermen and fishery managers.

INTRODUCTION

Lobster was not a traditional element of the Virgin Islands diet and before the development of the islands' tourism industry lobsters were frequently broken up in the traps and used as bait. However, as hotels developed and a substantial tourism industry expanded, fishermen found an increasing market for their product. Currently (2014) lobster is selling on St. Thomas for $9-10 per pound and on St. Croix for $8 per pound whole weight.

Virgin Islands spiny lobster landings have risen from less than 5,000 kg in the early 1970s to the point where current combined landings for St. Thomas/St. John (i.e., St. Thomas[4]) and St. Croix have approached nearly 136,000 kg (Figure 1).

There is a pronounced difference between the St. Thomas and St. Croix island groups in the manner in which the fishery is carried out (Figure 1). In St. Thomas 98% of the landings come from the trap fishery while in St. Croix 92% of the landings are taken by diving methods. Some of this difference came about following Hurricane Hugo in 1989, which did considerable damage to the trap fishery in St. Croix and resulted in a fishery-wide shift from traps to diving methods.

A more detailed description of the fisheries off the two islands and history of management can be found in Olsen et al. (2014) where study methodologies and preliminary results were presented.

Data on lobster landings (and other species) has been available since the early 1970s when the Virgin Islands Bureau (now Division) of Fish and Wildlife (DFW) instituted a voluntary catch reporting system. Fishermen in the Virgin Islands market their catch directly to the consumer and there is no processing/marketing sector present. Currently, fishermen are required to supply daily records of their catch. The "voluntary" nature of this program requires a high degree of trust between the fishermen and fishery managers. Port sampling began in 1979 and was continuous in St. Croix since that time. In St. Thomas, there were substantial gaps in sampling, particularly during the 1990s.

Like many places in the tropics, Virgin Islands fisheries data are not generally sufficient for standard stock assessment evaluation. Attempts to apply conventional stock assessment methods to Virgin Islands fisheries carried out by the National Marine Fisheries Service SEDAR program (http://sedarweb.org/sedar-8), have been largely unsuccessful in undertaking analyses leading to quantitative management advice. In the Virgin Islands, inconsistent port sampling data collection has further hindered analysis efforts. Thus, it remains highly unlikely that tropical fisheries data can meet rigid criteria for conventional stock analysis and there is a need for development of techniques and management modalities that reflect the realities of these fisheries. Collaborative management efforts offer the most likely way forward in this regard.

Studies such as the current effort, undertaken in cooperation with local fishermen, can significantly improve the knowledge base for resource management while also increasing understanding by fishermen of the value of accurate data in management of the resources under exploitation. The St. Thomas Fishermen's Association (STFA) was established in 2004 in order to provide a voice for its fishermen on management issues. Its members have carried out federally funded projects relating to bycatch, trap loss, yellowtail snapper (*Ocyurus chrysurus*), and the current project on spiny lobster in order to improve the information basis for management decisions.

METHODS

Members of the STFA have undertaken a tag and recapture study of the spiny lobster fishery in St. Thomas/St. John and St. Croix. Preliminary results were presented at the 66th Gulf and

Caribbean Fisheries Institute meeting (Olsen et al. 2014), but tag recaptures have continued through November of 2016. During the study, landings by the individual fishermen involved in the project constituted as high as 55% of the total monthly landings for St. Thomas. In general, STFA fishermen land between 85 and 97% of the total annual lobster landings for the island so that most of the recaptured lobsters would have been seen and reported by STFA members. This constitutes a fairly high participation in sampling of the population which, coupled with the relatively high contribution for recaptures from non-project fishermen and sport divers, provides some confidence that the entire population of the northern U.S. Virgin Islands was being adequately sampled.

Sampling Activities

The current study consists of six activities which were described in detail in the prior report:

A **tag and recapture study** where fishermen on both island groups were paid to tag short and berried (with eggs) lobster that would normally be discarded. Fishermen were compensated financially for each lobster tagged and recaptured and for “observer” trips.

“Observer” trips were completed in which project staff accompanied fishermen and measured the entire catch in order to obtain a complete size-frequency distribution of all of the lobsters being caught. On St. Croix eight “observer” trips were made and 385 lobsters measured, whereas on St. Thomas 21 trips were made and 1,515 lobsters measured.

Recapture data. Posters in English and Spanish were distributed on both islands and Puerto Rico at dive shops and other public gathering sites. Recaptures ranged from eight to 1,244 days (3.4 years) days at large.

Lobster movement. For all of the St. Thomas tagged lobsters subsequently recaptured, the fisherman provided either GPS data or location information sufficient to indicate location caught. These data were analyzed by Geographic Information System software to provide information on distances moved. The majority of St. Croix movements were only approximate because the mark and/or recovery location of nearly all tagged lobsters was recorded by fishermen who did not have GPS.

Tag loss was estimated by placing 46 tagged lobsters in the Coral World (www.coralworldvi.com) aquarium facility, as described in Olsen et al. (2014).

Analysis

Growth from Recapture Data

Lobster growth was characterized using the widely used von Bertalanffy growth equation that relates current length L_t to three growth parameters, L_∞ (asymptotic growth limit, on average), k (growth rate), and t_0 (age at 0 length), as follows:

$$L_t = L_\infty\left(1 - e^{-k(t-t_0)}\right) \tag{1}$$

In order to estimate parameters, we utilize the fact that each lobster is measured when tagged (t_0 = T) and recaptured (t = T+τ, where τ is the time at liberty). The growth is represented by $L_{T+\tau} - L_T$, or:

$$L_{\mathrm{T}+\tau} - L_T = L_\infty\left(1 - e^{-k(T+\tau-t_0)}\right) - L_\infty\left(1 - e^{-k(t-t_0)}\right) \tag{2}$$

By collecting terms, simplifying, and substituting, this relationship can be expressed as:

$$L_{\mathrm{T}+\tau} - L_T = (L_\infty - L_T)(1 - e^{-k\tau}) \tag{3}$$

Equation 3 thus relates the growth, $L_{T+\tau} - L_T$, to the time at liberty, τ. Since both are observed, this equation can be used to estimate L_∞ and k by finding the parameter values that minimize the log-transformed errors between observed and modeled growth measures. Observations were excluded when lobster were at liberty for less than 30 days. Only observations from St. Thomas were used in the analysis. There were only a small number of observations from St Croix, preventing us from conducting a similar analytical exercise for St. Croix with any acceptable level of confidence. However, given the deep trench separating the islands it is unlikely that there was any interchange between the two populations.

Population Size Estimation

The population size (P) and fishing mortality rate (F) were estimated using monthly data on commercial catches (in pounds), number of newly tagged lobsters, and number of recaptures (R), as well as estimates of total mortality rate (Z) obtained from an analysis of the size distribution of lobster (Olsen et al., 2014) and of the rate of tag loss obtained by observing tagged lobsters in captivity. Note that only lobsters large enough to be caught were included in this study, so the population estimate is a measure of spiny lobster of sufficient size (3.5" carapace length or metric equivalent) to be recruited to the fishery. Landings were converted to numbers caught (C) using an average lobster size of 1.07 kg, as observed in samples of commercial catches. The number of tagged lobster at liberty (T) was estimated using the number tagged after correcting for mortality, tag loss, and recaptured lobsters retained by the fishermen. The population size estimate was then obtained based on the assumption that the fraction of tagged lobster in catches (R/C) was equal to fraction of lobster tagged in the population as a whole (T/P). Rearranging terms, we have:

$$P = \frac{TC}{R} \quad (4)$$

Finally, fishing mortality (F) estimates were obtained using the fraction of the estimated population (P) caught (C).

$$F=C/P \quad (5)$$

The ultimate estimates of population size and fishing mortality were obtained by averaging monthly estimates over the course of the study. However, we also produced averages that only included months after tagging was completed because there was some evidence that it took some time for released lobster to mix with the population as a whole.

RESULTS

Tagging

A total of 5,718 short or berried lobsters weighing 3,898 kg was tagged by fishermen. An additional 1,245 market sized lobsters weighing 1,253 kg were tagged, bringing the total tagged lobster population to 6,963 lobsters weighing 5,151 kg. Tagging locations are shown in Figure 2 for St. Thomas/St. John and Figure 3 for St. Croix and tagging results are in Table 2.

Recapture Reporting

There were 58 recaptures from St. Croix (49 from project fishermen and nine from sport divers and non-project fishermen) and 358 recaptures from St. Thomas (339 from project fishermen and 18 from sport divers and non-project fishermen). St. Thomas Fishermen's Association members generally account for between 85-97% of the lobster landings so they were most likely to see the recaptured lobsters. Location and movement between tagging and recapture for the St. Thomas recaptures are shown in Figure 4.

Recaptures were collected between 9/21/2012 and 11/28/2016 with time at large ranging from eight days to 1,244 days (3.4 years). Average time between tagging and recapture for St. Thomas lobsters was 81.9 days (SD=98.0). Movements between tag and recapture ranged from zero (caught in the same trap string 24 days later) to 60 km 217 days later. Average distance traveled was 4,113 m (SD=7,582m). Three lobsters were tagged on one side of St. Thomas and recaptured on the other and 15 lobsters moved nearly 30 km between tagging and recapture. The longest period between tagging and recapture was 1,244 days although that lobster was recaptured less than one km from where it was tagged.

Tag Loss by Captive Lobster

There were four tags which came loose from the forty-five tagged lobsters that were held at Coral World. The lobsters were held for a total of 3,877 days (equivalent to 10.6 years) with a tag loss rate of 3.1% /month or 96.9% monthly retention rate.

Observer Trips

The results of the “Observers” trips from St. Thomas and St. Croix indicated that St. Croix fishermen are harvesting smaller lobsters from fewer size classes than St. Thomas (Olsen et. al., 2013). The average size lobster from St. Croix “observer” trips was 92.9 mm Carapace Length, (CL) while it was 102.4 mm CL on St. Thomas. The average size “legal” (>89mm CL) was 108.1 mm on St. Thomas and 102.5 mm on St. Croix. On St. Thomas 81% of the lobsters sampled were legal size while only 50% were legal on St. Croix.

There was a concern that this difference in mean size was due to the difference in fishing methods employed in the two island groups (traps vs. diving). We analyzed the carapace length of 3,441 St. Croix lobsters which were port sampled by the Division of Fish and Wildlife. The average CL of dive-caught lobsters (N=2,451, CL=106.97 mm) was compared by single factor ANOVA to trap-caught lobsters (N=990, CL=106.30 mm) and the difference was not significant (F=1.320, p=0.251, n.s.).

Analysis

Growth from Recapture Data

We estimated von Bertalanffy parameters for a variety of populations (Table 3). Estimates for the asymptotic growth limit, L_{∞}, were fairly consistent across wild and captive populations. The L_{∞} ranged from 190.2 mm to 216.8 mm CL. For the most part, growth rates (k) were consistent as well, with values of approximately 0.2. Wild males, however, appeared to grow more quickly. The estimates in Table 1 provide parameter values.

Population Size Estimation

Monthly estimates of population size jumped substantially after tagging was completed (Table 4). The likely explanation for this pattern is that tagged lobster remained in the area of their release, which typically were fishing locations. Under this scenario, newly released tagged lobsters would have had a higher chance than lobster in the general population of being caught. This phenomenon would have made the ratio of recaptures to number of lobster caught (R/C) an overestimate of the proportion of tagged lobsters in the population (T/P), and therefore produce underestimates of P.

Fortunately, this phenomenon appears to have been short-lived. Judging by the rise in monthly population size estimates following the end of tagging, it took 2-3 months for tagged and released lobster to mix sufficiently into the population such that they were no longer preferentially caught. Consequently, our best estimate of the population size of spiny lobster of sufficient size to be recruited to the fishery ranges from 296,679 (while tagging was taking place) to 1,007,115, Average of all months. The estimate from September 2014 until August 2014, when recapture rates tapered off and tagging was ended was 2,191,175.

Based on those same population size estimates, an estimate of instantaneous monthly fishing mortality rate (F) of 0.0083 (average of all months) was obtained. The annual fishing mortality rate was 0.0996. There is also fishing mortality from recreational and subsistence fishing which was not measured in this project. Natural mortality (M) was determined as the difference between total mortality (Z) (estimated at 0.828 for 2012, Olsen et. al. 2014) and fishing mortality (F). Natural morality (M) was estimated to be 0.728

DISCUSSION AND CONCLUSIONS

Virgin Islands fishermen market their catch directly to consumers and there is no processing/marketing sector to record transactional landings information. Direct port sampling is limited and, in St. Thomas/St. John, inconsistently gathered. Currently, fishermen are required to be port sampled quarterly in order to renew their fishing licenses. As a result, fishery management must rely upon cooperation from the fishermen themselves for data on landings.

In the case of St. Croix, fishermen have developed a suspicious approach to management and when “Observer Trips” indicated that they were harvesting smaller lobster (than in St. Thomas) they withdrew from our sampling efforts. Project results from St. Croix then, were more or less limited to analysis of historical data from St. Croix which was complete over the time period

(1975 to present for landings data and 1980 to present for port sampling data). Analysis of historical data also documented that the St. Croix lobster resource is harvested by more than twice as many fishermen as in St. Thomas and that the diving fishery there leads to many more trips with smaller landings. Thus, one would expect that the economic impact from lobster harvest is greater in St. Croix than in St. Thomas.

The CFMC response to management of the lobster resources has been to set allowable catch limits 10% below a three year average of reported landings levels and has led to a short accountability measure closure in St. Croix in December of 2013 during the peak season for lobster fishing.

Following that closure both St. Croix and St. Thomas/St. John reported landings fell significantly. The recent "declines" in reported landings on both islands (75% in St. Croix and 30% in St. Thomas) may well indicate under reporting by fishermen on both islands in a preemptive attempt to prevent further closures. It is interesting that the landings reported for St. Thomas in 2013 are exactly the amount that brings the three year average below the ACL limit. Since three year average reported landings (Figure 1) have been used as the basis for quotas for the fishery, one must question whether or not these declines reflect events within the fishery or simply the unwillingness of fishermen to accurately report their landings. It is imperative that the relationship between the two parties does not lead to inaccurate reporting. Resolution of this concern and efforts for fishermen and managers to co-manage Virgin Islands fishery resources should be a high priority for the CFMC.

The present project has provided information on growth, mortality and population size of the Virgin Islands spiny lobster resource which might form a basis for reexamination of existing management actions and has involved fishermen with an activity which might create both benefit and understanding of the modalities employed in resource management.

During 2013 when our population estimate was completed, St. Thomas/St. John Fishermen landed 38,827 kg of lobster (data provided by the National Marine Fisheries Service Southeast Fisheries Science Center) or approximately 35,850 lobsters (St. Thomas lobsters average 1.068 kg) which are 3.9% of the average estimated population of 924,265 lobsters or slightly below the average fishing mortality (F) calculated in the current study for 2013 (Table 3).

The results of the growth analysis are consistent with prior growth studies from the region (de León et.al, 2005) although the maximum carapace lengths are somewhat higher than those in that study. The population and mortality analysis should prove useful to fishery managers.

The recapture data also indicate a high degree of mixing within the population with several lobsters traveling over 50 km between tagging and recapture. The average time at large was 82 days (SD=82.17) and the daily movement was 127 m/day (SD=399).

The limited recapture data from St. Croix were insufficient to evaluate population size and the fact the St. Croix fishermen generally do not use GPS restricted discussion of movements.

In contrast, in St. Thomas, the STFA's history of successful studies proved to be a real asset for the current project as well as the somewhat unexpected response from non-project fishermen and sport divers. Hopefully, study results can be used to refine management actions.

REFERENCES

Dammann, A.E. 1969. Study of the fishery potential of the Virgin Islands. Virgin Islands Ecological Research Station, Contribution No. 1. 204 p.

de León, Maria Estela J. López M., D. L. Cota, S. Hernández Vázquez and R. Puga1. 2005. Decadal variability in growth of the Caribbean spiny lobster *Panulirus argus* (Decapoda: Paniluridae) in Cuban waters. Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 53 (3-4): 475-486, September-December 2005

Erhardt, N.M. 2008. Estimating growth of the Florida spiny lobster, Panulirus argus, from molt frequency and size increment data derived from tag and recapture experiments. Fisheries Research 93 (332–337).

Idyll, C.P. and J.E. Randall. 1959. Sport and commercial fisheries potential of St. John, Virgin Islands. Report presented at the 4th International Game Fish Conference, Nassau, Bahamas. November 10, 1959.

Olsen, D.A., W.F. Herrnkind, and R.A. Cooper, 1975, Population Dynamics, Ecology, and Behavior of Spiny Lobsters, *Panulirus argus* of St. John, USVI, (1): Introduction and General Population Characteristics, *Bull. Nat. Hist. Mus., Los Angeles Co*., 20:11-16.

Olsen, D.A., and I.G. Koblick. 1975, The Ecology and Behavior of *Panulirus argus* in St. John, USVI: (2) Population Dynamics and Growth, *Bull. So. Calif. Acad. Sci*, 20:17-29.

Olsen, D.A., J. Nowlis, and D. Bryan. 2013. A Collaborative Assessment of the Virgin Islands Spiny Lobster Fishery. Proc. 66th Ann. Gulf and Carib. Fish. Inst.—Corpus Christi, Texas, 66:440-451.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. J. Fish. Res. Bd of Canada. Bull. 191: 382 pp.

ACKNOWLEDGEMENTS

As always, any research project carried out by the St. Thomas Fishermen's Association owes its success to the fishermen involved. Project fishermen included, Tony Blanchard, Danny Berry, Robert Berry, Michael Berry, Daryl Bryan, Ricky LaPlace, Julian Magras, Gregory Ledee, Thierry Ledee and Winston Ledee. Daryl Bryan carried out important coordination among the fishermen.

The project was funded by the Caribbean Fishery Management Council. Miguel Rolon CFMC Executive Director. The tag loss study was carried out at Coral World (www.coralworldvi.com/) and supported by staff (Lee Keller, Coral World Manager, Matt Tartaglia and Jacob Rosner).

The Southeast Fishery Science Center provided historic data on landings and port sampling. We especially appreciate the efforts of Josh Bennet and David Glockner in assisting the project.

Bill Arnold of the NMFS Regional Office provided data and manuscript review. Jessica Petersen provided much of the data input effort.

TABLES

Table 1. Overfishing Limits (OFL) and Allowable Catch Limits (ACL) in kg for Virgin Islands spiny lobster resources set by the Caribbean Fishery Management Council in 2011.

Island	Overfishing Limit(kg)	Allowable Catch Limit (kg)
St. Thomas/St. John	52,515	47,263
St. Croix	54,081	48,673

Table 2. Summary of Tagging Results

	# Trips	# Tagged	# Project Recaptures	# Non Project Recaptures	# Kept by Fishermen
St. Croix	105	1,391	50	9	7
St. Thomas	220	4,832	350	39	61

Table 3—Estimates of Von Bertalanffy growth parameters for St. Thomas spiny lobster. Analyses examined growth of lobster at liberty in the wild (primarily adults) or held captive in an aquarium (primarily juveniles). Wild males were analyzed with and without the largest individual included, which may have been an outlier. N is sample size, residual is the lack of fit of the ln-transformed model.

Population	Sex	N	L_∞	k	Residual
All	All	271	193.2	0.216	3151
Wild	All	242	199.0	0.204	2705
Wild	Females	147	190.2	0.196	1189
Wild	Males	94	216.8	0.323	1009
Captive	All	30	208.6	0.199	427.4
de Leon et al. (2005)		10-20,000/yr	177-190	.20-.27	

Table 4—Estimation of population size and fishing mortality rates. Estimates were based on a total mortality rate (Z) of 0.93, estimated from size distribution analysis, and a monthly tag loss rate estimate of 0.0391, derived from observation of captive lobster (Olsen et al., 2014).

Date	Landings (kg)	# Lobsters	Cum # Tagged	Adjusted for Mortality*	Adjusted for Tag Loss**	Adjusted for non-return	# Recapture ***	Population	F
Sep-12	2,450	2,290	494	494	494	494	7	161,576	0.012
Oct-12	2,653	2,479	1,270	1,237	1,219	1,217	17	177,450	0.012
Nov-12	3,449	3,223	1,592	1,477	1,432	1,431	18	256,249	0.011
Dec-12	3,803	3,553	1,902	1,688	1,636	1,632	31	187,071	0.018
Jan-13	4,076	3,808	2,178	1,852	1,792	1,780	29	233,767	0.015
Feb-13	3,604	3,368	2,477	2,027	1,962	1,953	20	328,853	0.010
Mar-13	3,288	3,072	2,736	2,151	2,080	2,072	24	265,217	0.012
Apr-13	2,980	2,784	3,333	2,605	2,529	2,525	36	195,274	0.013
May-13	2,918	2,727	3,695	2,793	2,701	2,694	39	188,351	0.013
Jun-13	2,563	2,395	3,887	2,799	2,701	2,692	30	214,864	0.010
Jul-13	3,547	3,314	4,085	2,810	2,712	2,701	34	263,293	0.007
Aug-13	2,615	2,444	4,199	2,737	2,638	2,623	25	256,414	0.009
Sep-13	2,755	2,575	4,387	2,742	2,646	2,631	12	564,552	0.003
Oct-13	2,906	2,715	4,649	2,821	2,725	2,719	12	615,282	0.004
Nov-13	3,419	3,195	4,832	2,816	2,717	2,714	16	541,976	0.006
Dec-13	3,614	3,377	4,832	2,629	2,530	2,518	12	708,508	0.004
Jan-14	3,532	3,300	4,832	2,453	2,361	2,357	7	1,111,301	0.003
Feb-14	3,070	2,869	4,832	2,290	2,204	2,203	3	2,106,610	0.001
Mar-14	4,074	3,806	4,832	2,151	2,071	2,070	2	3,939,326	0.001
Apr-14	3,676	3,435	4,832	2,008	1,932	1,931	4	1,658,360	0.002
May-14	3,408	3,184	4,832	1,874	1,804	1,802	3	1,912,047	0.002
Jun-14	3,193	2,983	4,832	1,749	1,683	1,683	3	1,673,710	0.002
Jul-14	3,527	3,296	4,832	1,632	1,571	1,568	2	2,583,944	0.001
Aug-14	2,941	2,748	4,832	1,523	1,466	1,465	**1**	4,026,759	0.001
							372		

Average weight= 1.07 kg	**While Tagging=**	**322,418**	**0.0042**
*** Annual 2012 (Z)=0.828, Monthly (Z)=0.069**	**All Months=**	**1,007,115**	**0.0080**
**** Tag loss 3.63%/Month**			
***** Additional recaptures in 2014 (1), 2015 (2) and 2016 (1)**			

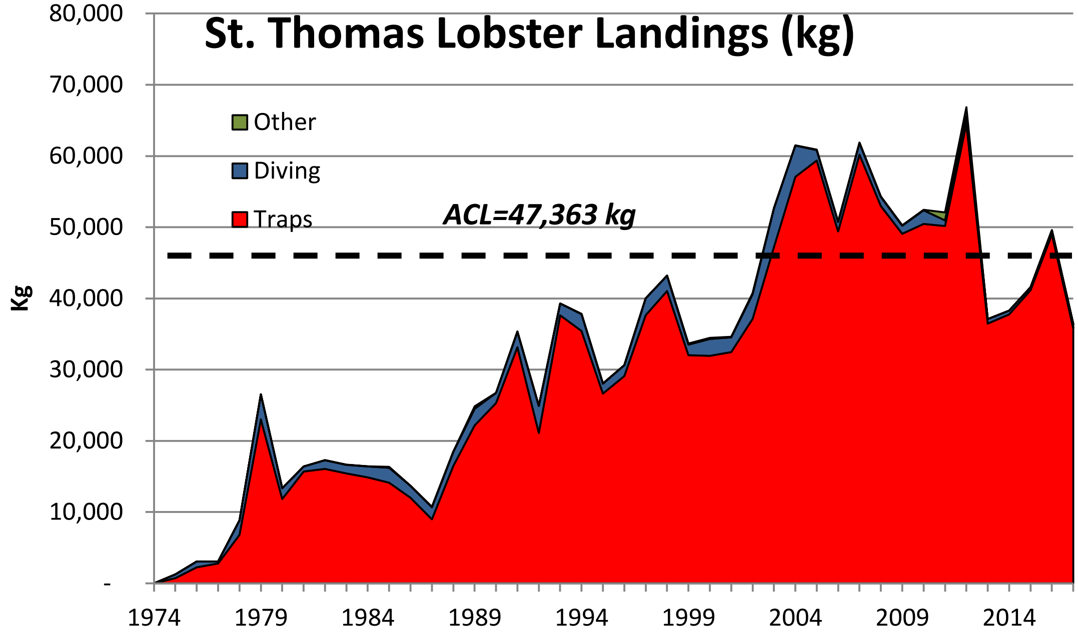
FIGURES

Figure 1. Lobster landings by fishing method for St. Thomas/St. John and St. Croix from 1974 through 2017. Landings for 2017 are incomplete.

Figure 2. St. Thomas/St. John tagging sites.

Figure 3. St. Croix tagging sites.

Figure 4. St. Thomas recaptures.


St. Thomas Lobster Landings (kg)
Other
Diving
Traps
ACL=47,363 kg
Kg
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
1974
1979
1984
1989
1994
1999
2004
2009
2014

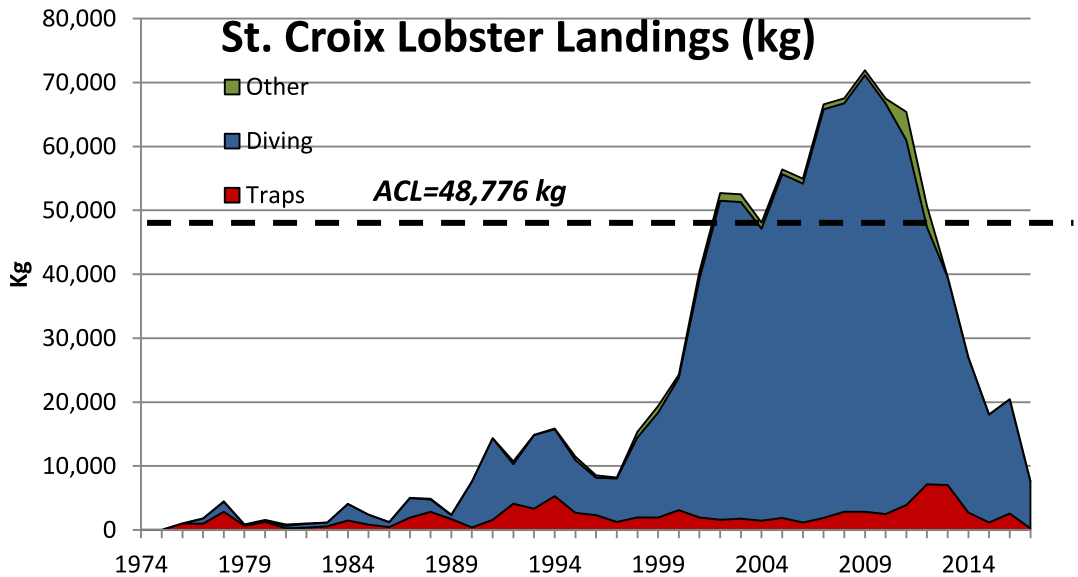

St. Croix Lobster Landings (kg)
Other
Diving
Traps
ACL=48,776 kg
Kg
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1974
1979
1984
1989
1994
1999
2004
2009
2014

Figure 1

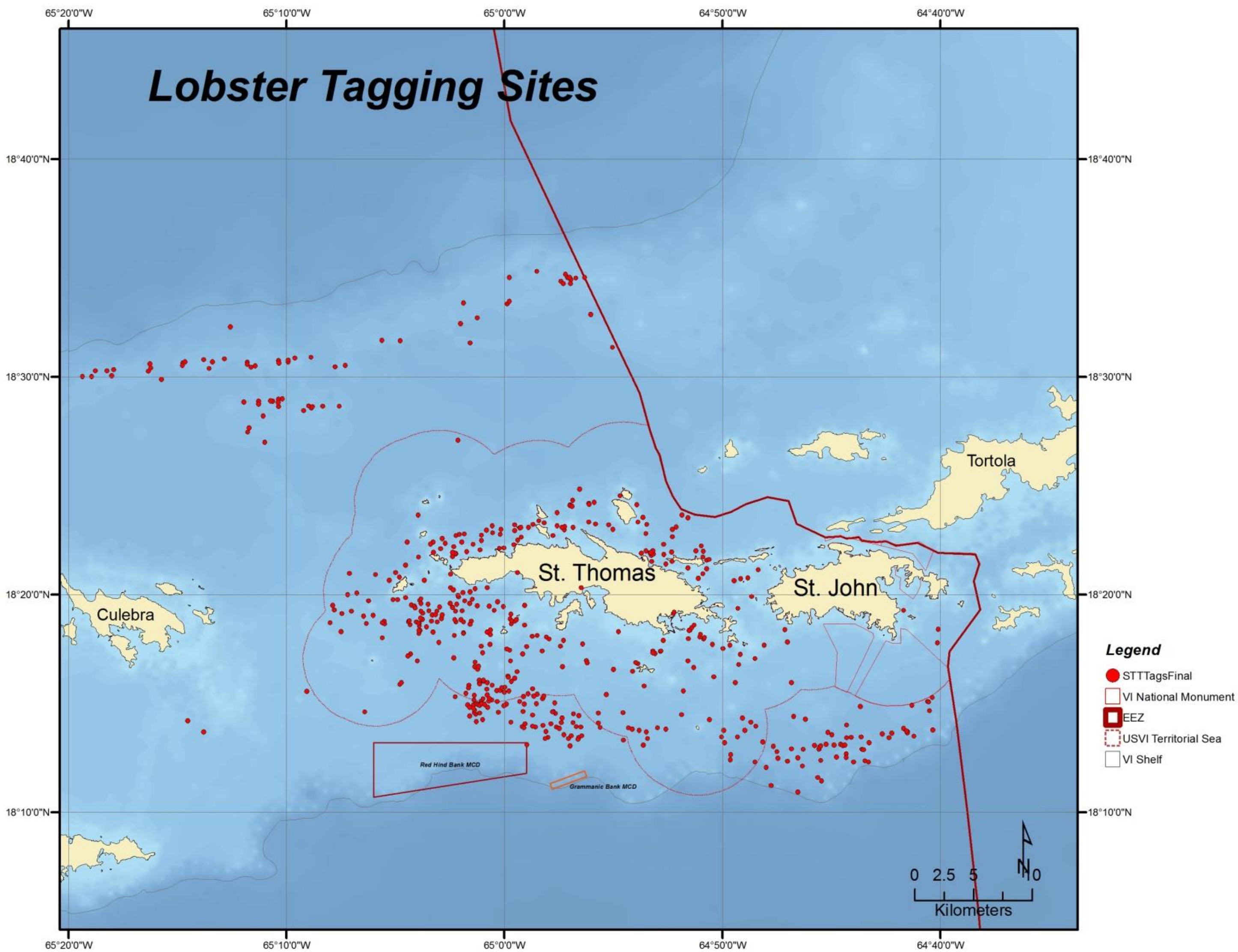

Lobster Tagging Sites
65°20'0"W
65°10'0"W
65°0'0"W
64°50'0"W
64°40'0"W
18°40'0"N
18°30'0"N
18°20'0"N
18°10'0"N
Tortola
St. Thomas
St. John
Culebra
Red Hind Bank MCD
Grammanic Bank MCD
Legend
STTTagsFinal
VI National Monument
EEZ
USVI Territorial Sea
VI Shelf
0 2.5 5 10
Kilometers
N

Figure 2.

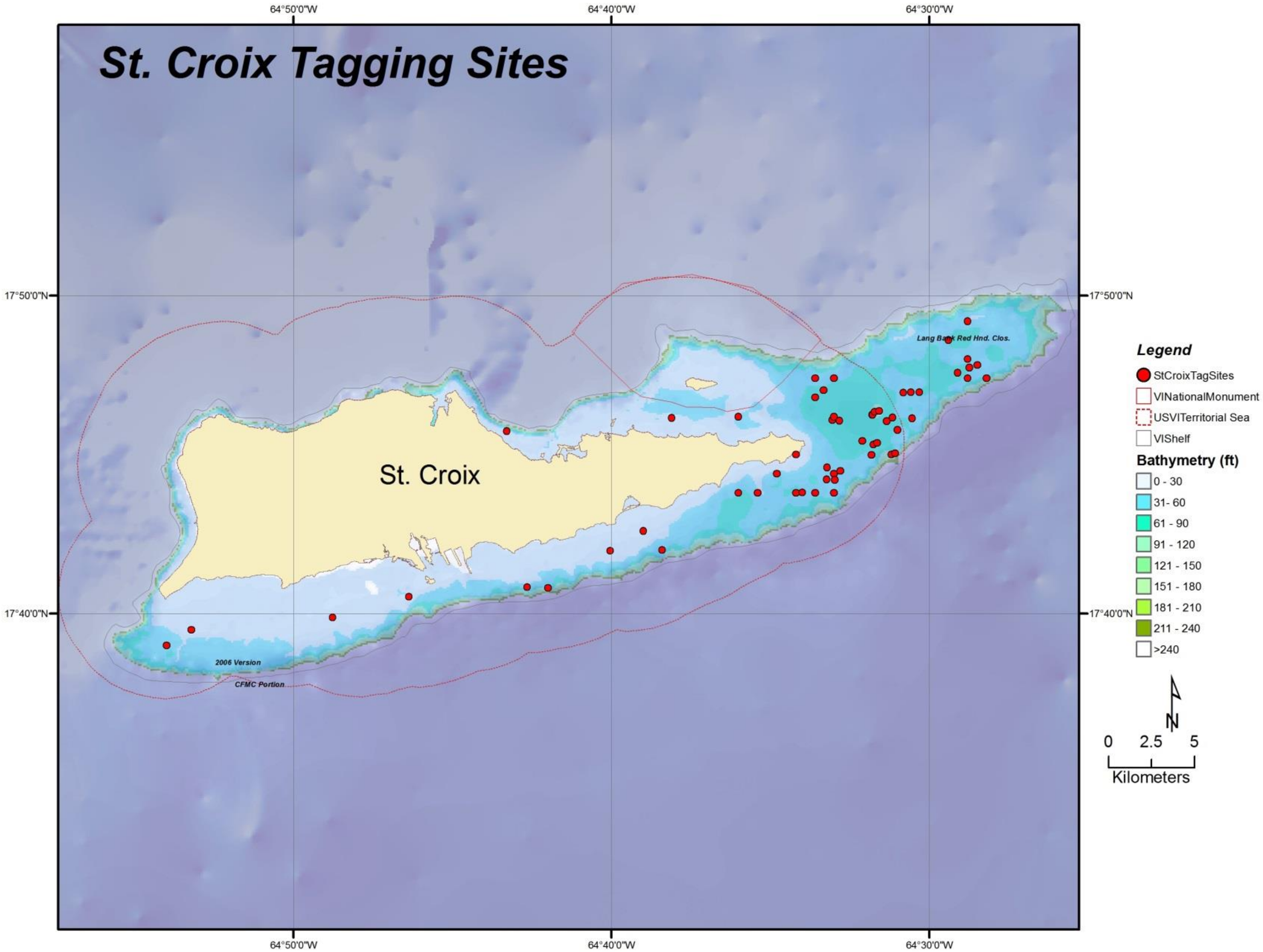

St. Croix Tagging Sites
St. Croix
Lang Bank Red Hnd. Clos.
2006 Version
CFMC Portion
64°50'0"W
64°40'0"W
64°30'0"W
17°50'0"N
17°40'0"N
Legend
StCroixTagSites
VINationalMonument
USVITerritorial Sea
VIShelf
Bathymetry (ft)
0 - 30
31- 60
61 - 90
91 - 120
121 - 150
151 - 180
181 - 210
211 - 240
>240
N
0 2.5 5
Kilometers

Figure 3.

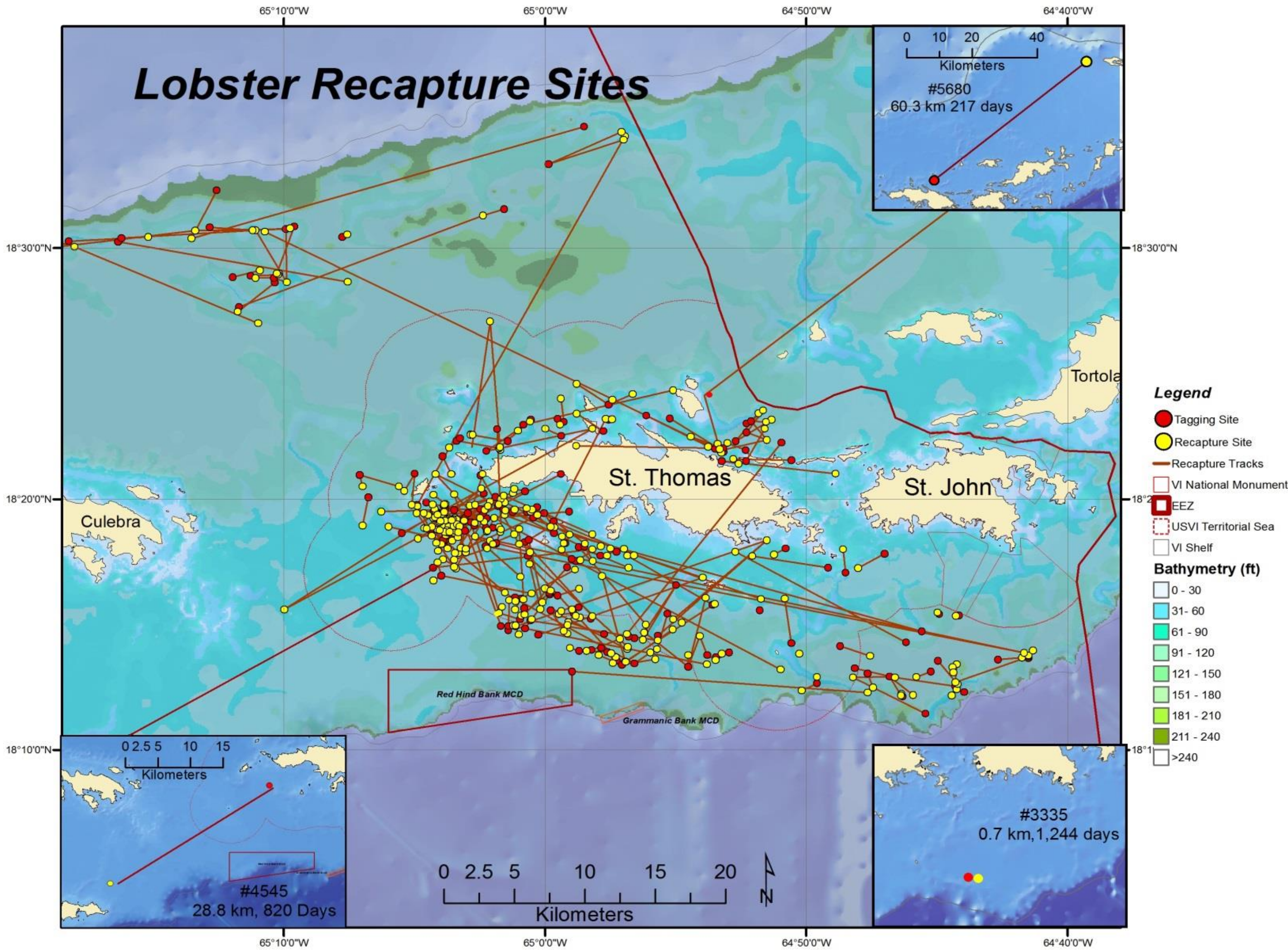

Lobster Recapture Sites
65°10'0"W
65°0'0"W
64°50'0"W
64°40'0"W
18°30'0"N
18°20'0"N
18°10'0"N
0 10 20 40
Kilometers
#5680
60.3 km 217 days
Tortola
St. Thomas
St. John
Culebra
Red Hind Bank MCD
Grammanic Bank MCD
0 2.5 5 10 15
Kilometers
#4545
28.8 km, 820 Days
0 2.5 5 10 15 20
Kilometers
#3335
0.7 km,1,244 days
Legend
Tagging Site
Recapture Site
Recapture Tracks
VI National Monument
EEZ
USVI Territorial Sea
VI Shelf
Bathymetry (ft)
0 - 30
31- 60
61 - 90
91 - 120
121 - 150
151 - 180
181 - 210
211 - 240
>240

Figure 4