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Engineering Bycatch Reduction in West Indian Fish Traps:

**Preliminary Results from
STFA CRP Trap Vent Study**

Phase 1: Diving Studies

CRP Project No. NMF4540101

Prior Escape Vent Studies

Source	Vent Height (inches)	Vent Width (inches)	Trap Mesh Size	Catch/ Trap Haul (Control Traps)
Munro (1999)	2.76	1.10	1 inch	10.0
	3.15	1.18		
	3.54	1.30		
	3.54	0.98		
Johnson (2010)	7.87	0.98	1 inch	11.8
	15.75	0.98		
STFA Pilot (2008)	6	1	2 Inch	4.8
	4	1		
	4	2		
STFA CRP (2010)	5.75	1.75	2 Inch	8.2
	5.75	1.5		
	5.75	1		
	17.50	1		
	5.75	1.375		
	9.75	1.375		

Calculation of Vent Sizes

Table 2. Morphometric characteristics of the 21 species of reef fish that yield 78% of the trap catch in the Discovery Bay area in Jamaica. All dimensions are in mm. L = length (either TL = total length or FL = fork length), BD = body depth, BW = body width, L_c = length at first capture in traps with 43x32 mm mesh, L_m = length at maturity, L_∞ = asymptotic length, a and b = values of the length-weight equation ($W = aL^b$), W_∞ = asymptotic weight in g, K = growth coefficient, Z = total mortality rate (calculated from the mean weight of individuals in the catch and the growth parameters). Growth parameters from Munro (1983) and Munro (1999b).

Family	Species		BD:L	BW:L	L_c	L_m	L_∞	a	b	W_∞	K	Z
Acanthuridae	<i>Acanthurus bahianus</i>	FL	0.477	0.113	95	155	280	0.0191	3.08	547	0.36	1.1
	<i>A. chirurgus</i>	FL	0.428	0.107	101	210	313	0.0221	3.01	701	0.58	1.3
	<i>A. coeruleus</i>	FL	0.518	0.144	81	130	333	0.0278	3.02	1101	0.24	0.8
Balistidae	<i>Balistes vetula</i>	FL	0.468	0.144	92	175	496	0.0518	2.88	3941	0.28	0.4
Carangidae	<i>Carang ruber</i>	FL	0.289	0.113	149	240	540	0.0180	2.99	2724	0.19	0.9
Holocentridae	<i>Holocentrus ascensionis</i>	FL	0.30	0.124	145	145	261	0.0198	3.00	352	0.23	0.5
	<i>H. rufus</i>	FL	0.265	0.121	168	135	188	0.0131	3.06	104	0.48	1.0
Haemulidae	<i>Haemulon flavolineatum</i>	FL	0.305	0.132	144	155	287	0.0111	3.23	588	0.25	3.1
	<i>H. plumieri</i>	FL	0.328	0.147	130	220	400	0.0238	2.93	1177	0.26	0.8
	<i>H. sciurus</i>	FL	0.313	0.137	137	180	370	0.0200	3.01	1050	0.26	0.4
Lutjanidae	<i>Lutjanus apodus</i>	FL	0.305	0.130	138	250	349	0.0089	3.20	770	0.35	0.3
	<i>Ocyurus chrysurus</i>	FL	0.268	0.120	148	300	525	0.0145	3.03	2363	0.18	0.6
Mullidae	<i>Mulloidichthys martinicus</i>	FL	0.223	0.132	201	180	250	0.0207	3.00	323	1.07	>10
	<i>Pseudopeneus maculatus</i>	FL	0.222	0.127	199	185	244	0.0229	2.96	293	1.14	>10
Scaridae	<i>Scarus iserti/taeniopterus</i>	TL	0.23	0.122	182	155	223	0.0166	3.02	196	0.48	>10
	<i>Sparisoma aurofrenatum</i>	TL	0.287	0.138	155	150	280	0.0129	3.11	324	1.10	6.4
	<i>S. chrysopteron</i>	TL	0.291	0.141	161	240	418	0.0199	3.00	1453	0.78	4.5
	<i>S. rupripinne</i>	TL	0.291	0.146	158	160	465	0.0194	3.00	1951	0.58	1.6
	<i>S. viride</i>	TL	0.325	0.140	140	180	549	0.0370	3.12	9901	0.27	7.8
Serranidae	<i>Cephalopholis fulva</i>	TL	0.26	0.142	165	160	325	0.0174	3.00	597	0.30	1.2
	<i>C. cruentata</i>	TL	0.266	0.136	161	160	365	0.0121	3.08	785	0.26	1.2

Length (mm) at Escapement for Various Vent Combinations

Species	Lm	Vent Width (inches)					Vent Height (inches)		
		1 inch Vent	1.25 inch Vent	1.375 inch Vent	1.5 inch Vent	1.75 inch Vent	2	4	6
<i>A. bahaianus</i>	155	225	281	309	337	393	106	213	319
<i>A. chirurgus</i>	210	237	297	326	356	415	119	237	356
<i>A. coeruleas</i>	130	176	220	243	265	309	98	196	294
<i>Balistes vetula</i>	130	176	220	243	265	309	109	218	327
<i>Caranx ruber</i>	240	225	281	309	337	393	176	352	527
<i>Holocentrus ascensionis</i>	145	205	256	282	307	358	169	339	508
<i>H. rufus</i>	135	210	262	289	315	367	192	383	575
<i>Haemulon flavolineatum</i>	155	192	241	265	289	337	167	333	500
<i>H. plumieri</i>	220	173	216	238	259	302	155	310	465
<i>H. sciurus</i>	180	185	232	255	278	324	162	325	487
<i>Lutjanus apodus</i>	250	195	244	269	293	342	167	333	500
<i>Ocyurus chrysurus</i>	300	212	265	291	318	370	190	379	569
<i>Mulloidichthys martinicus</i>	180	192	241	265	289	337	228	456	683
<i>Pseudopeneus madulatus</i>	185	200	250	275	300	350	229	458	686
<i>Scarus taeniopterus</i>	155	208	260	286	312	364	221	442	663
<i>Scarus autofrenatus</i>	150	184	230	253	276	322	177	354	531
<i>S. chrysopterus</i>	240	180	225	248	270	315	175	349	524
<i>S. rubripinne</i>	160	174	217	239	261	304	175	349	524
<i>S. viridae</i>	180	181	227	249	272	318	156	313	469
<i>Cephalopholis fulva</i>	160	179	224	246	268	313	195	391	586
<i>C. cruentata</i>	160	187	233	257	280	327	191	382	573

Release length less than age at first maturity

Scientists Don't Know Everything

5 lb tang = 2270 gms (2 times W_{∞})

<http://filaman.uni-kiel.de/photos/PicturesSummary.php?StartRow=5&ID=944&what=species&TotRec=8>



Value of Listening:

(lessons from the data management workshop)

1. “Stock Assessment” has no value when it’s based on crap data. Examples are consistent under and over estimates of maximum sizes in Ault, et al., 2008.
2. Fishermen’s knowledge about maximum sizes, age at maturity, lunar affects on fishing, seasonality is frequently more precise and thorough than scientific studies which are limited by funding at personnel.
3. Scientific studies frequently fail to incorporate significant variables.
4. Fishermen are aware of flaws in data collection approaches that SEFSC has clearly failed to appreciate.
5. Australians have clearly recognized the value of collaborative management that recognizes the expertise of all involved parties as opposed to “top down” US approach.
6. We think Magnusan has failed the fishermen, the resources and the Councils by cornering them into quotas based primarily on landings data.
7. STFA has always supported collaboration and we hope that the workshop will lead towards a new initiative in that direction.

Experimental Design

- **Standard St. Thomas Fish Traps**
 - Rectangular and Arrowhead Design.
 - Set in Strings of 10
 - Fishermen told to “fish them like they normally do” during field testing.
- **Vents (2 per trap)**
 - Control (no vent)
 - 1 by 5.75 inch vent
 - 1 inch vent along entire (18 inch) edge of trap
 - 1.5 by 5.75 inch Vent
 - 1.75 by 5.75 inch Vent
 - Vents in Random order on trap string

Escape Vents Tested



1 by 16 inch Edge



1 by 5.75 inch Vent



1.5 by 5.75 inch Vent



1.75 by 5.75 inch Vent



1 3/8 by 10 inch Edge



1 3/8 by 5.75 inch Vent

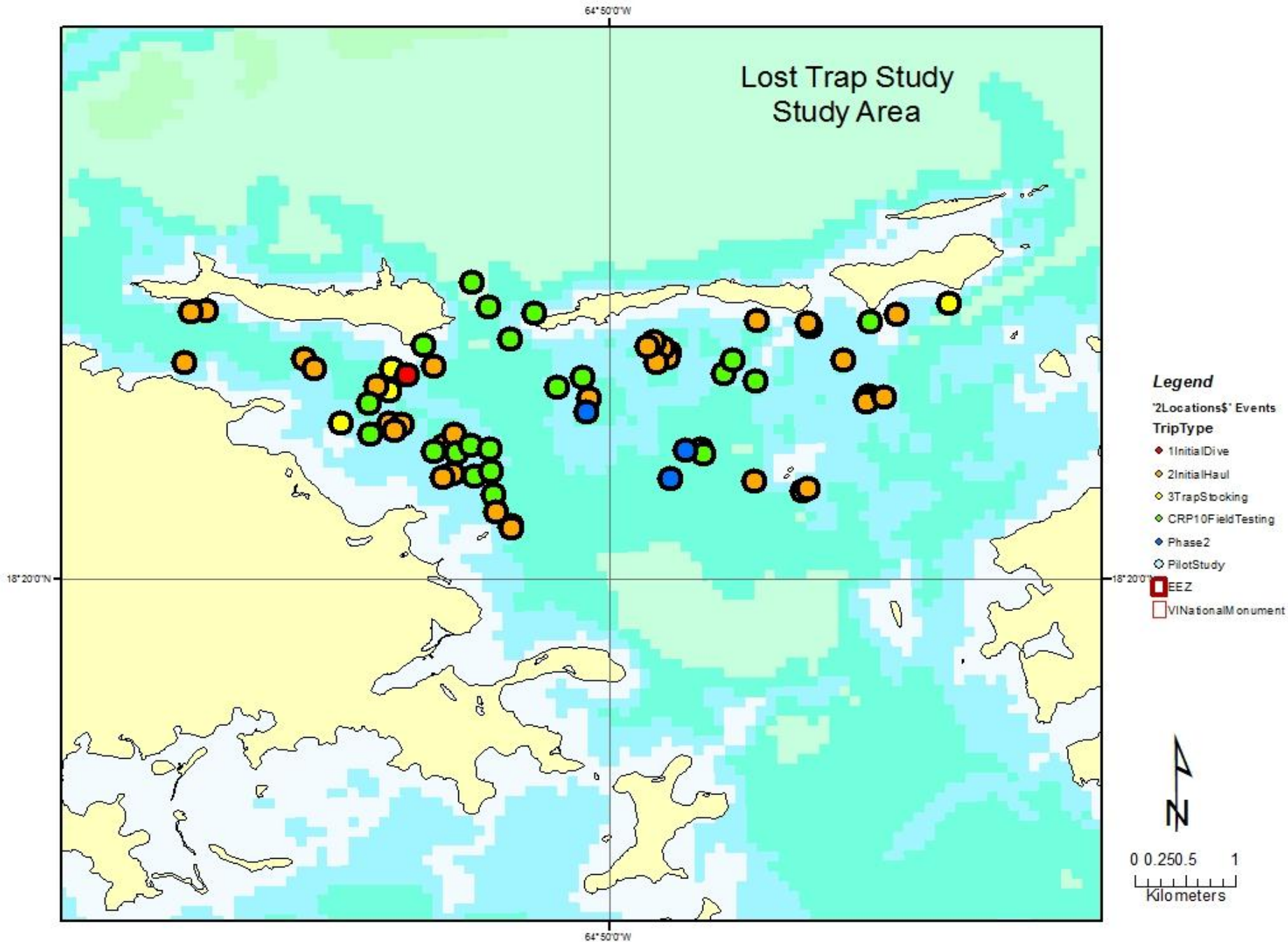


1.3/8 by 5.75 inch Vent

Experimental Design (cont.)

1. Each trap string inspected by diving (species counts).
2. Estimate fish required for stocking.
3. Haul non-experimental traps to collect fish necessary to supplement for stocking.
4. Haul experimental traps, measure (TL) all fish and examine for fin clips.
5. Stock traps with fish from experimental and non-experimental traps that have been fin clipped.
6. Traps set for 1, 3, 5, 7 days before being revisited.

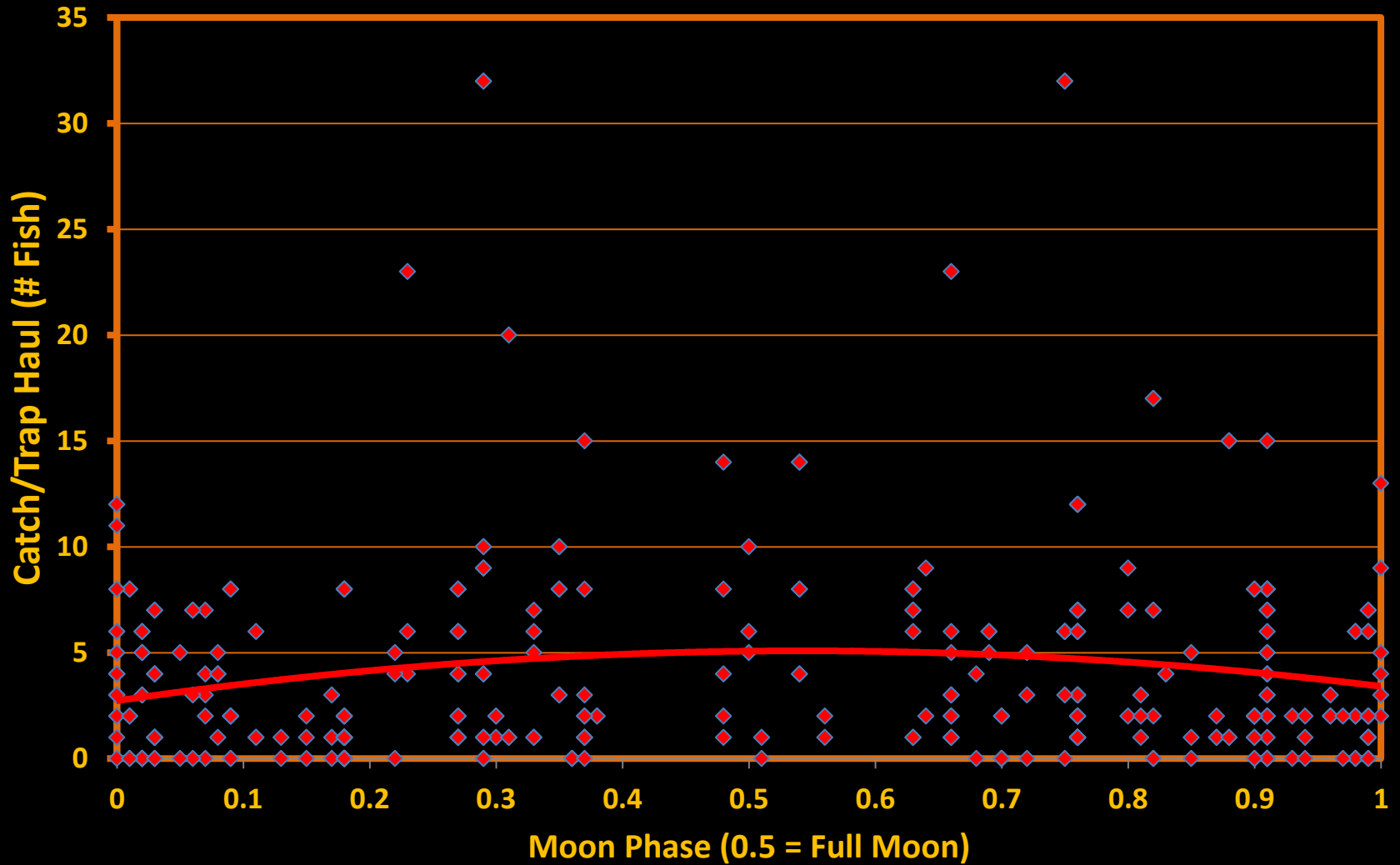
Lost Trap Study Study Area



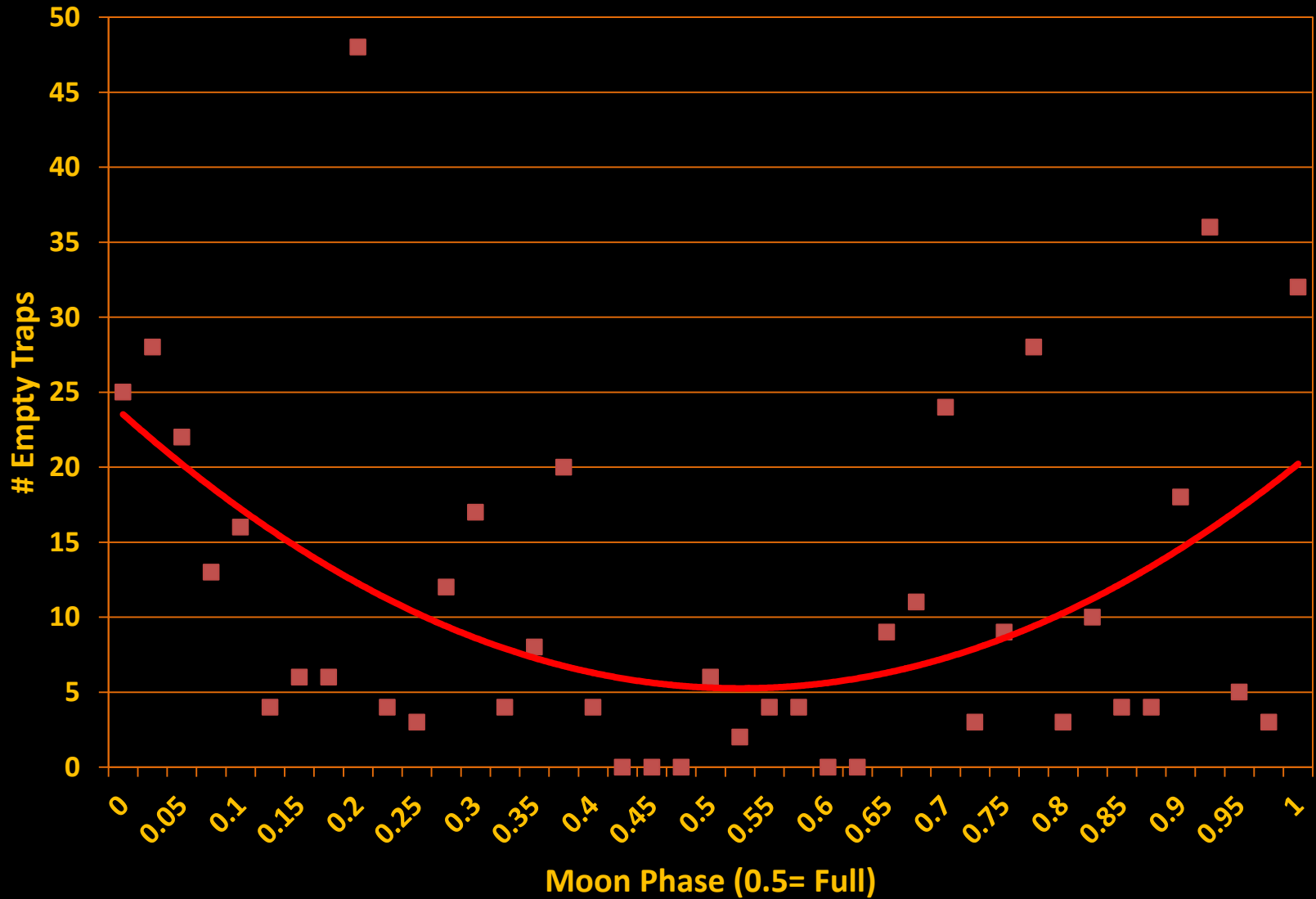
Summary of Trap Hauls

Vent Type	Initial Dive	Initial Haul	Trap Stocking	Phase 1 Field Testing	Phase 2 Field Testing
Control	54	62	46	30	38
1 by 5.75 Vent	68	76	52	46	38
1 in Edge	68	76	52	43	-
1.5 by 5.75 Vent	68	76	52	41	38
1.75 by 5.75 Vent	68	76	52	45	-
1.375 by 5.75 Vent	-	-	-	-	38
1.375 by 9.75 Vent	-	-	-	-	38
Total	322	366	254	205	190

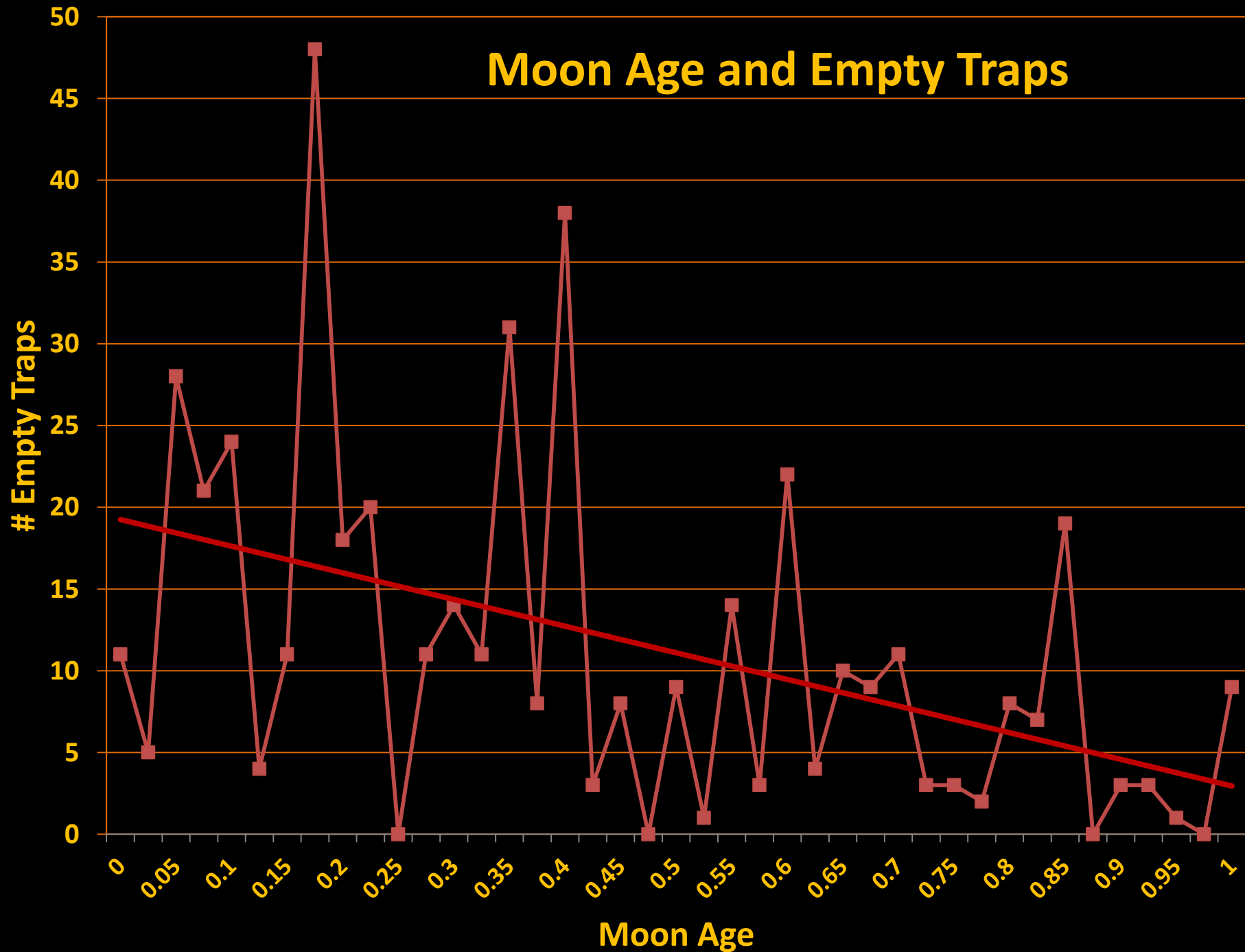
Catch/Trap Haul and Moon Phase (Control Traps only)



Empty Traps and Moon Phase



Moon Age and Empty Traps



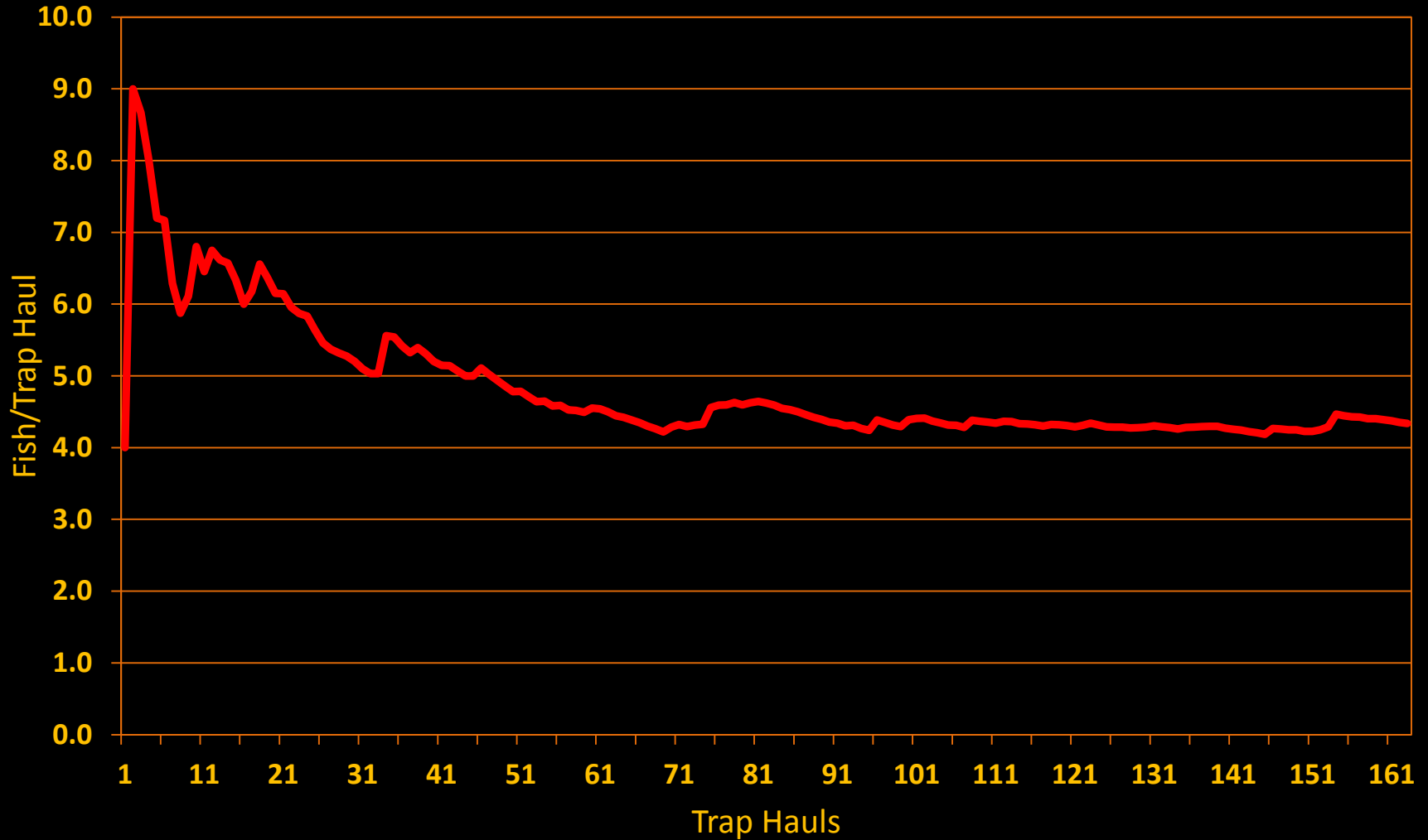
Pilot Study Trap Hauls

Vent Type	Trap Hauls
Control	198
1 by 4 Vent	209
1 by 6 Vent	206
3 by 4 Vent	204
Total	817

Pilot Study : Catch/Trap Haul

Vent Size (inches)	# Fish	Trap Hauls	Empty	Fish/Trap Haul
Control	1016	212	34	5.13
1 by 4	1088	221	27	5.16
1 by 6	946	221	39	4.55
2 by 4	169	225	125	0.81

Sample Size Requirements



Fish Used in Stocking Traps

(n=1285)

ANGELFISH,FRENCH	3	MACKEREL,CERO	1
ANGELFISH,GRAY	40	MARGATE	1
ANGELFISH,QUEEN	7	PARROTFISH,REDTAIL	16
BLUE TANG	478	PARROTFISH,STOPLIGHT	63
BUTTERFLYFISH,BANDED	67	PORGY,PLUMA	32
BUTTERFLYFISH,FOUREYE	2	PORGY,SAUCEREYE	44
BUTTERFLYFISH,SPOTFIN	9	PORGY,SHEEPSHEAD	1
CONEY	10	PORKFISH	1
DOCTORFISH	59	PUFFER,BANDTAIL	1
FILEFISH,SCRAWLED	9	ROCK BEAUTY	8
FILEFISH,WHITESPOTTED	5	SAILORS CHOICE	2
GOATFISH,YELLOW	1	SCHOOL MASTER	99
GRUNT,BLUE STRIPED	68	SEA BREAM	1
GRUNT,CAESAR	2	SNAPPER,DOG	2
GRUNT,FRENCH	3	SNAPPER,GRAY(GREY)	5
GRUNT,WHITE	93	SNAPPER,LANE	7
HIND,RED	62	SNAPPER,MAHOGANY	2
HOGFISH,SPANISH	1	SNAPPER,MUTTON	1
JACK,BAR	1	SNAPPER,YELLOWTAIL	18
MACKEREL,CERO	1	SQUIRRELFISH,LONGSPINE	1
MARGATE	1	SURGEON,OCEAN	2
PARROTFISH,REDTAIL	16	TRIGGERFISH,QUEEN	59

The mix of species was not significantly different between the various vent sizes when compared to the total by a KS test.

Average Length of Stocked Fish

SUMMARY : Average TL of stocked fish not significantly different between vent sizes.

Groups	Count	Sum	Average	Variance		
Control	44	10,379	236	710		
1 by 6 Vent	52	11,584	232	580		
1 in Edge	52	11,926	229	1,156		
1.5 by 6 Vent	51	11,632	228	769		
1.75 by 6 Vent	52	12,387	238	1,618		
	249					
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3,745	4	936	0.96	0.43	2.41
Within Groups	238,896	244	979			
Total	242,642	248				

Mortality in Trap Hauls

Vent Type	Species Name	Fin Clip
1.5 by 6 Vent	COWFISH,SCRAWLED	NO
Control	PORGY,SAUCEREYE	NO
Control	ANGELFISH,QUEEN	NO
1.75 by 6 Vent	TRIGGERFISH,QUEEN	NO
1.5 by 6 Vent	PARROTFISH,STOPLIGHT	NO
1.5 by 6 Vent	GRUNT,BLUE STRIPED	NO
1 in Edge	ANGELFISH,GRAY	NO
1.75 by 6 Vent	SNAPPER,MUTTON	NO
1.5 by 6 Vent	BLUE TANG	NO
1.5 by 6 Vent	COWFISH,SCRAWLED	NO
Control	ANGELFISH,GRAY	NO
1.75 by 6 Vent	COWFISH,HONEYCOMB	NO
1 by 6 Vent	BUTTERFLYFISH,BANDED	Yes
1.5 by 6 Vent	GRUNT,BLUE STRIPED	Yes
Control	GRUNT,BLUE STRIPED	Yes
1 by 6 Vent	BLUE TANG	Yes
Control	PARROTFISH,STOPLIGHT	Yes

Mortality of Fin Clipped fish was 0.38% (5 out of 1285 fin clipped fish).

Mortality of non-Fin Clipped fish was 0.49% (12 out of 2465 non clipped fish).

“CPUE” Comparison Between Vent Types: Initial Haul

SUMMARY: There is a significant ($p < 0.01$) difference between catch per trap haul for the different vents.

Vents	Trap Hauls	Sum of Fish	Average/ Trap Haul	Variance		
Control	62	170	2.74	2.72		
1 by 6	75	206	2.71	2.58		
1 in. edge	76	198	2.61	2.51		
1.5 by 6	74	129	1.70	0.93		
1.75 by 6	73	100	1.32	0.59		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	129	4	32.28	17.6	<.01	2.40
Within Groups	662	359	1.83			
Total	791	363				

Initial Haul: Average Sizes by Vent Type

SUMMARY: Average sizes of fish in Initial Haul marginally not significantly different all set lengths combined.

Vent Type	Count	Sum	Average	Variance		
Control	62	13,293	266	15,096		
1 by 6	75	16,646	234	2,433		
1 in. edge	76	15,736	258	4,831		
1.5 by 6	74	13,012	260	6,040		
1.75 by 6	73	9,844	246	5,139		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	38,434	4	9,608	1.512	0.199	2.41
Within Groups	1,696,264	359	6,353			
Total	1,734,698	363				

Empty Traps

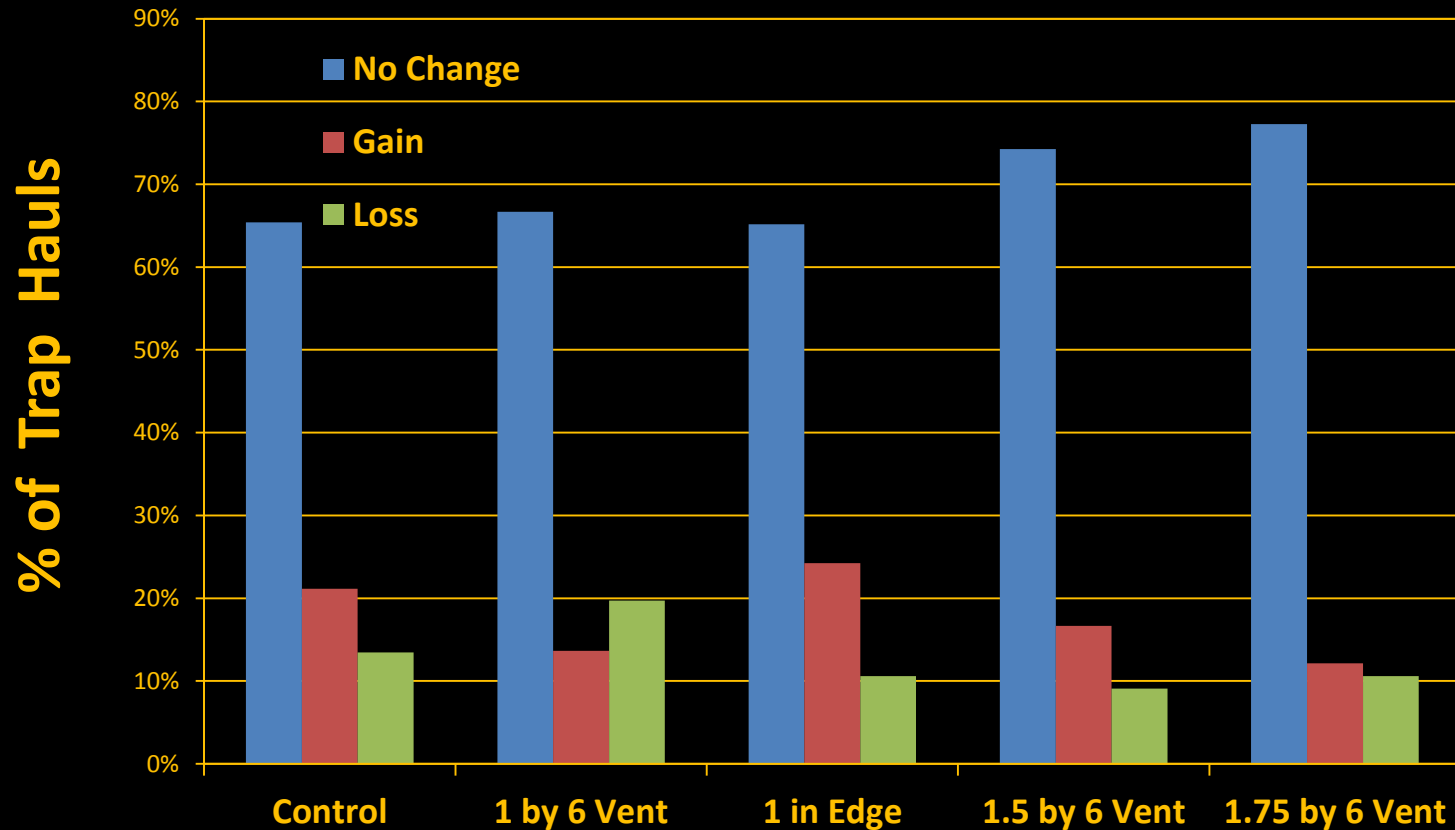
Vent Type	Initial Dive	Initial Haul
Control	7	11
1 by 6 Vent	8	8
1 in Edge	13	12
1.5 by 6 Vent	19	21
1.75 by 6 Vent	22	24

Anova-Single Factor: Change in Numbers between Initial Dive and Haul

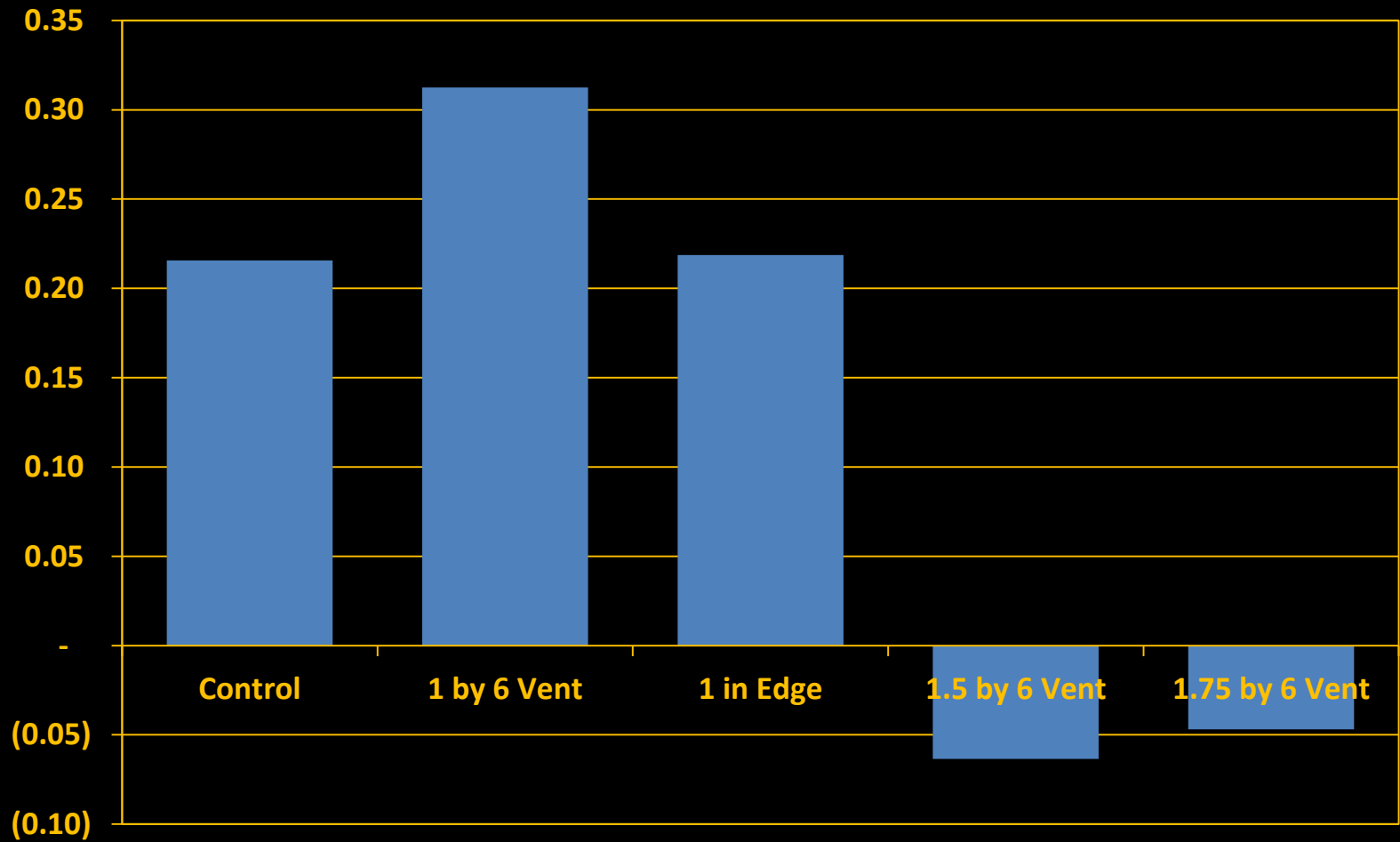
SUMMARY: Change in numbers between Initial Dive and Haul is not significantly different for the various vents

Groups	Count	Sum	Average	Variance		
Control	36	2	0.06	21.14		
1 inch Vent	49	-19	-0.39	10.45		
1 inch Edge	49	-15	-0.31	10.01		
1.5 inch Vent	49	40	0.82	8.65		
1.75 inch Vent	47	30	0.64	2.93		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	57.59	4	14.40	1.43	0.23	2.41
Within Groups	2272.13	225	10.10			
Total	2329.72	229				

Changes in Numbers During Trap Hauling (Initial Dive vs Initial Haul)



Net Change in Numbers Between Dive and Haul



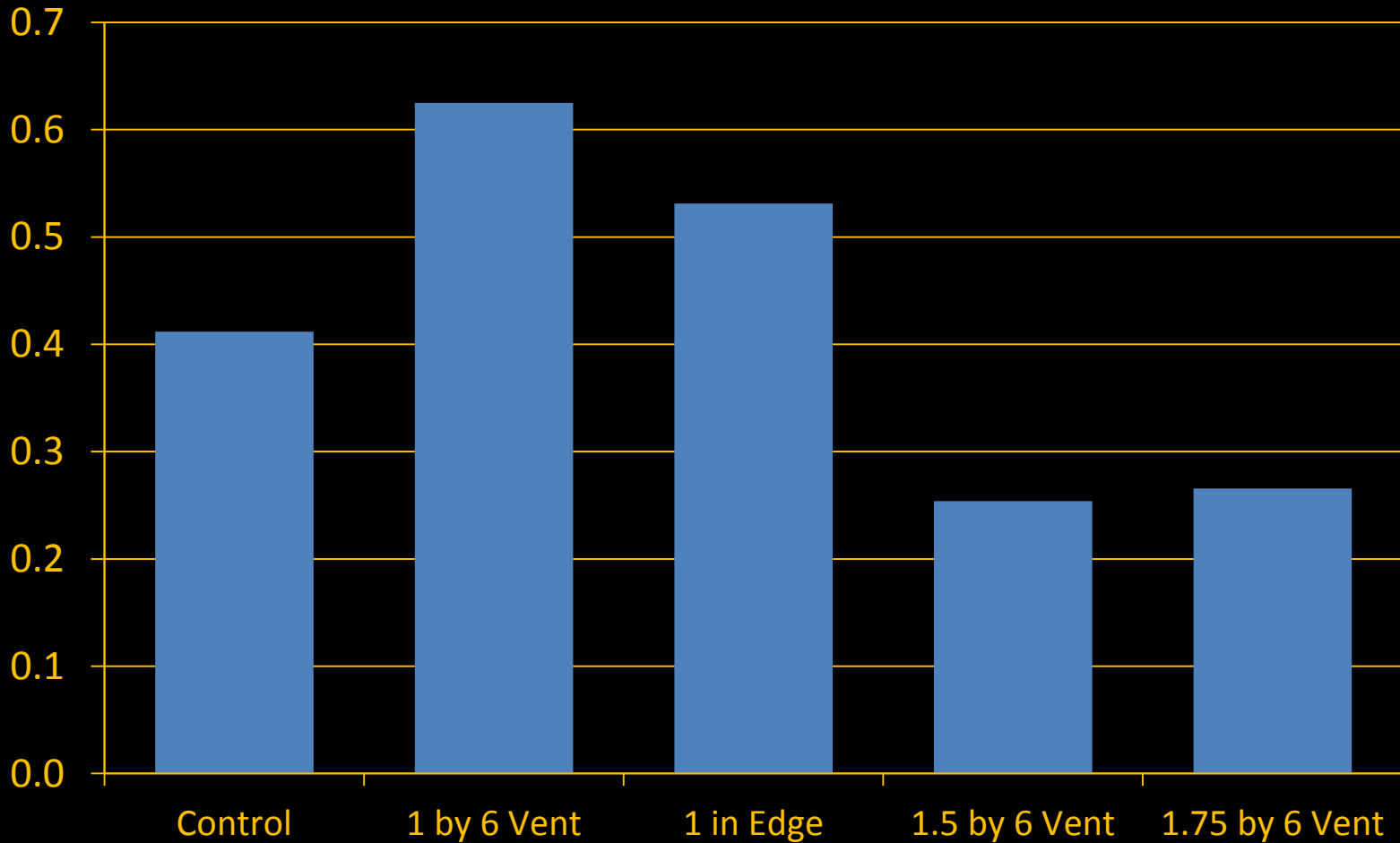
“Escapement” During Trap Hauls

Vent Type	Initial Dive	Escapees	% "Escapement"
Control	207	23	11%
1 by 6 Vent	249	43	17%
1 in Edge	252	37	15%
1.5 by 6 Vent	148	16	11%
1.75 by 6 Vent	108	19	18%
Total	964	138	14%

* Assumes that escapement does not include recruitment between dive and haul.

Escapees Between Dive and Haul

Escapes/TrapHaul



Anova: Single Factor: Only escaped fish included

SUMMARY: There is a significant (0.01 level) difference between escapement for the vents.

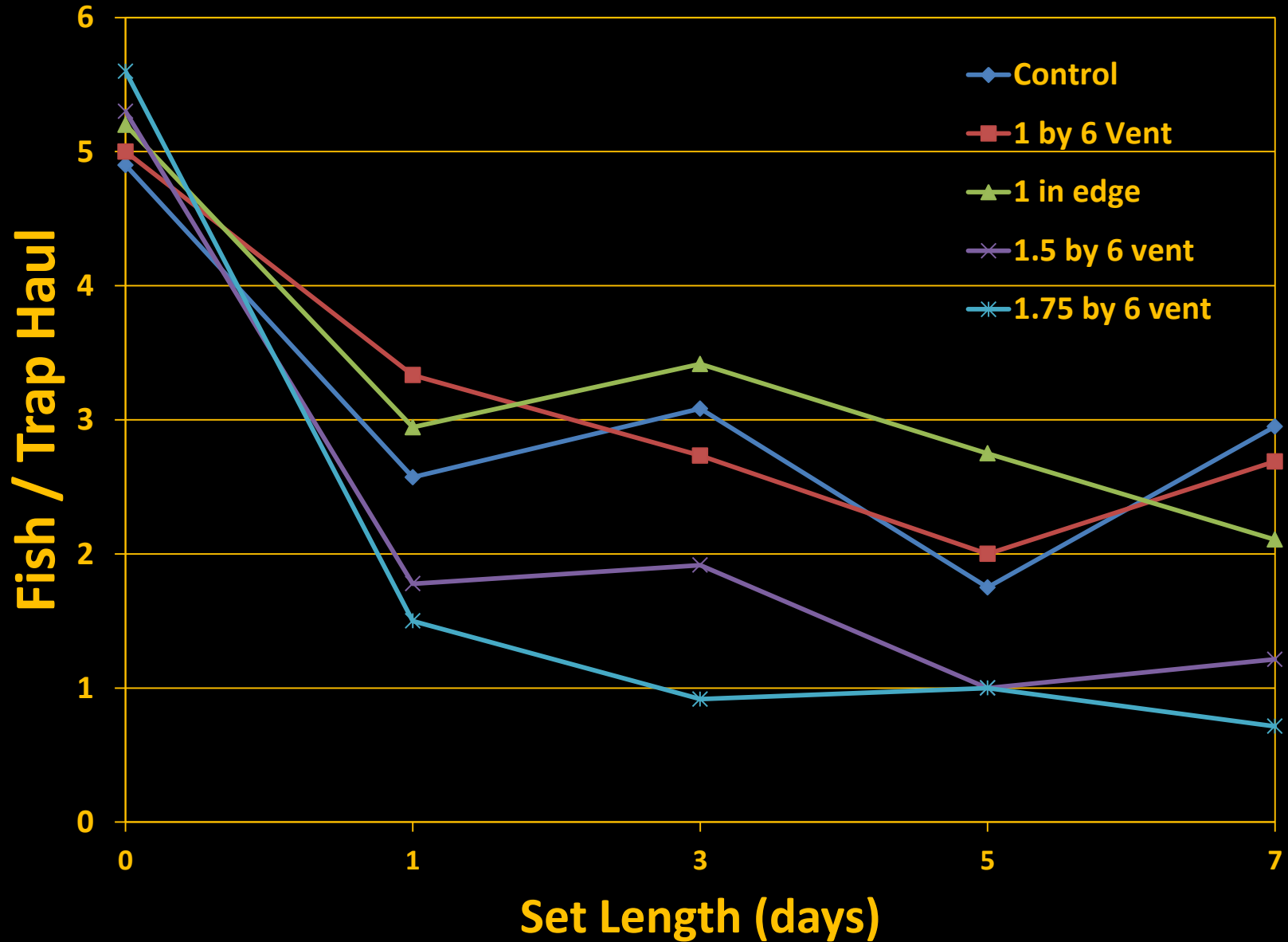
Groups	Count	Sum	Average	Variance		
Control	36	-47	-1.31	7.25		
1 inch Vent	49	-61	-1.24	5.98		
1 inch Edge	49	-48	-0.98	4.73		
1.5 inch Vent	49	-20	-0.41	1.12		
1.75 inch Vent	47	-3	-0.06	0.10		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	53.37	4.00	13.34	3.63	0.01	2.41
Within Groups	826.32	225.00	3.67			
Total	879.69	229.00				

Species Escapement During Hauling

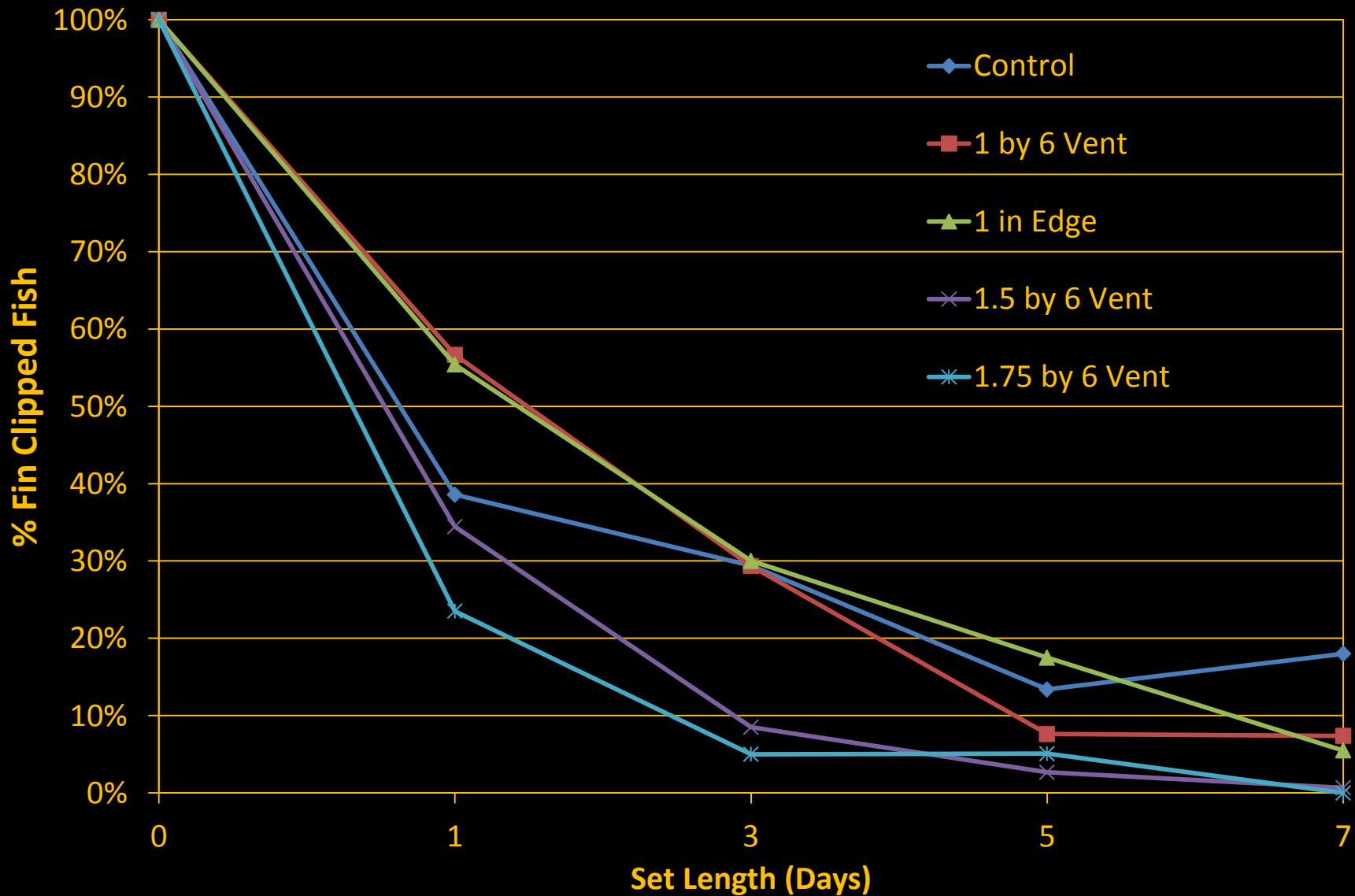
(Most Common Species)

Species Name	Initial Dive	Escaped During Initial Haul	% Escape
BUTTERFLYFISH,BANDED	25	8	32%
PORGY,SAUCEREYE	10	3	30%
GRUNT,BLUE STRIPED	119	23	19%
PARROTFISH,STOPLIGHT	21	4	19%
BLUE TANG	189	26	14%
COWFISH,HONEYCOMB	21	3	14%
SCHOOL MASTER	77	9	12%
COWFISH,SCRAWLED	56	6	11%
DOCTORFISH	9	1	11%
HIND,RED	57	5	9%
GRUNT,WHITE	51	4	8%
TRIGGERFISH,QUEEN	16	1	6%
LOBSTER,CARIB. SPINY	38	1	3%
TRUNKFISH,SMOOTH	32	1	3%
ANGELFISH,GRAY	29	1	3%
TRUNKFISH,SPOTTED	19	-	0%
PORGY,PLUMA	14	-	0%
ANGELFISH,QUEEN	10	-	0%
Total for all species	892	101	11%

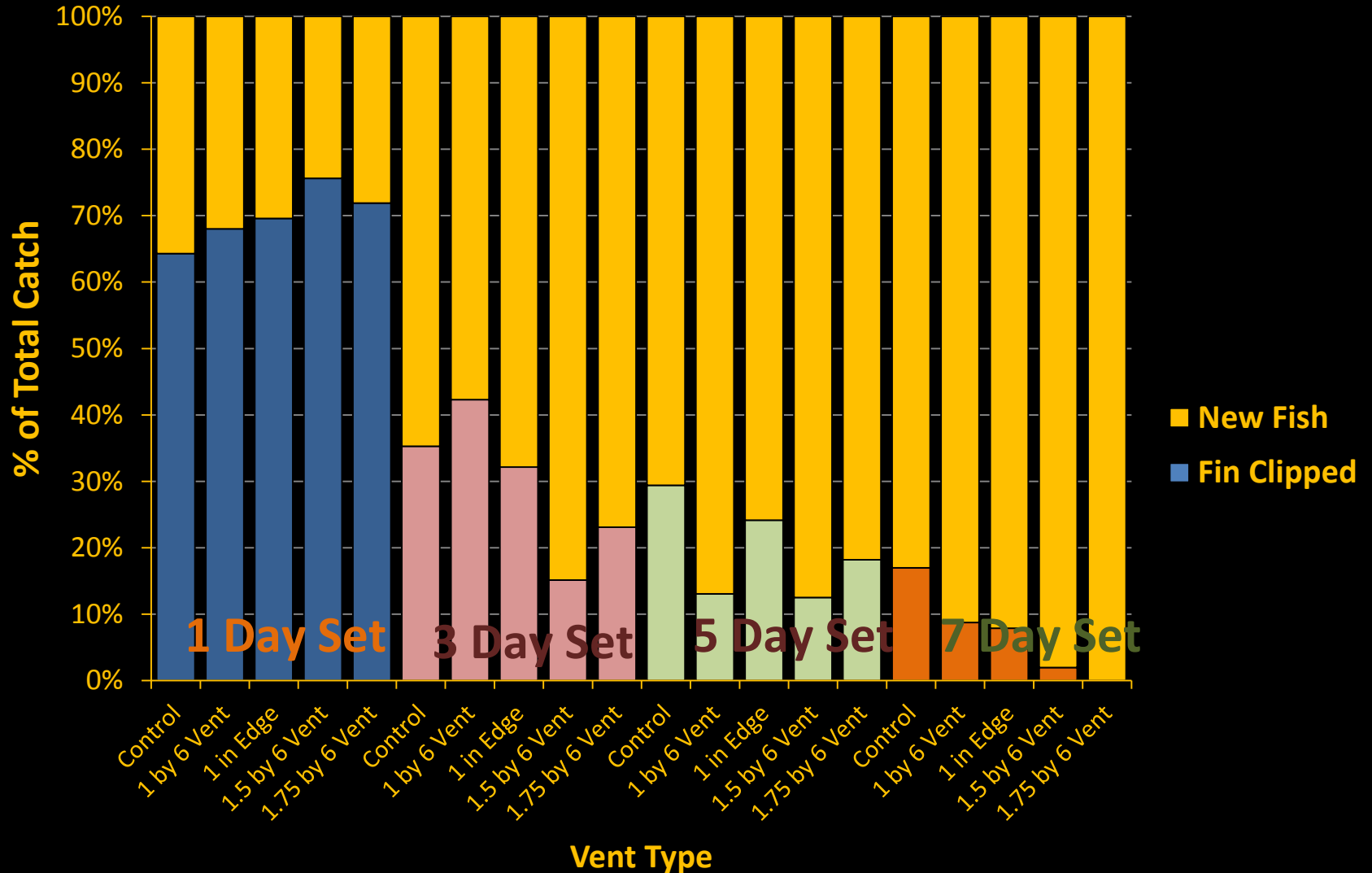
"Catch"/Trap Haul and Set Length



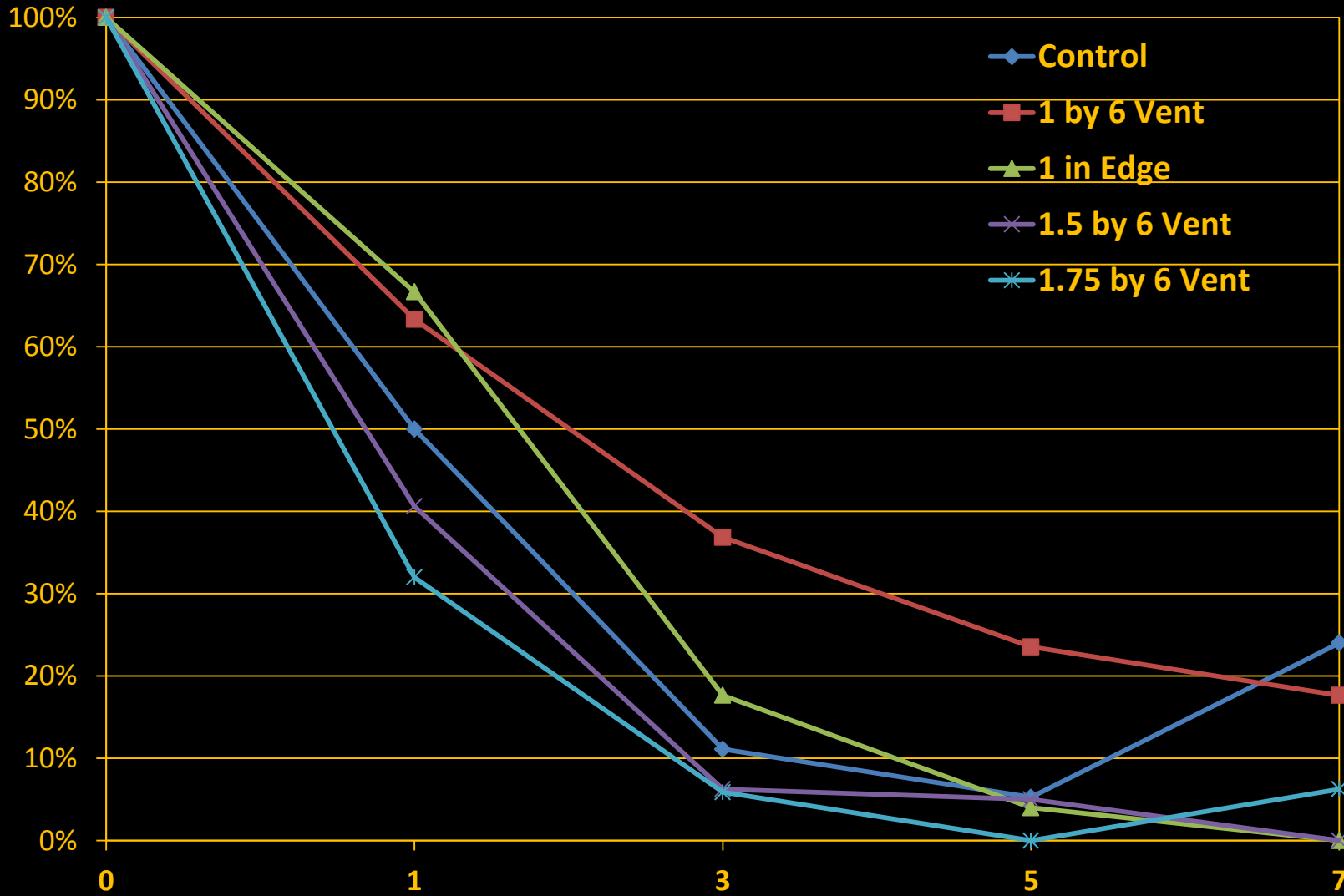
Retention of Fin Clipped Fish



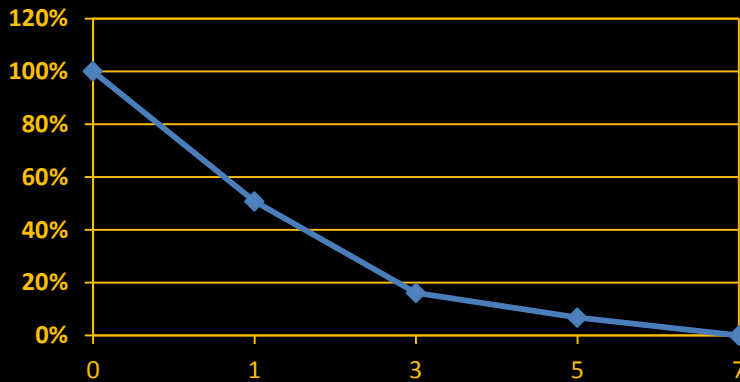
Retention of Fin Clipped Fish in Trap Hauls



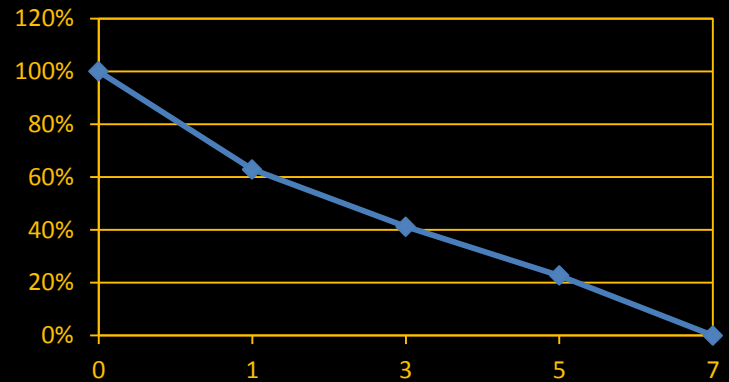
Blue Tang



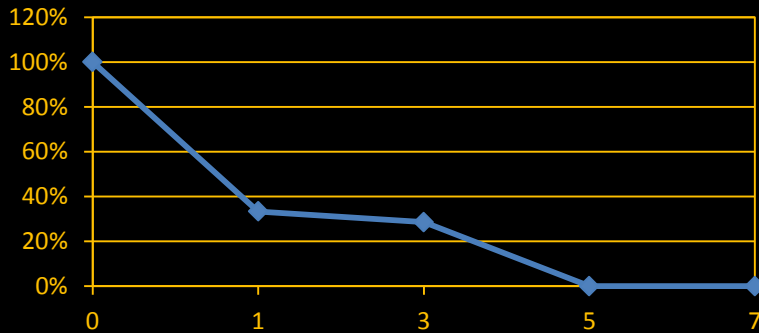
BLUE TANG



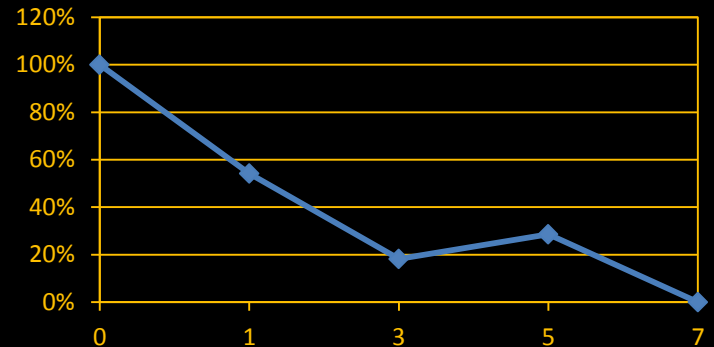
SCHOOL MASTER



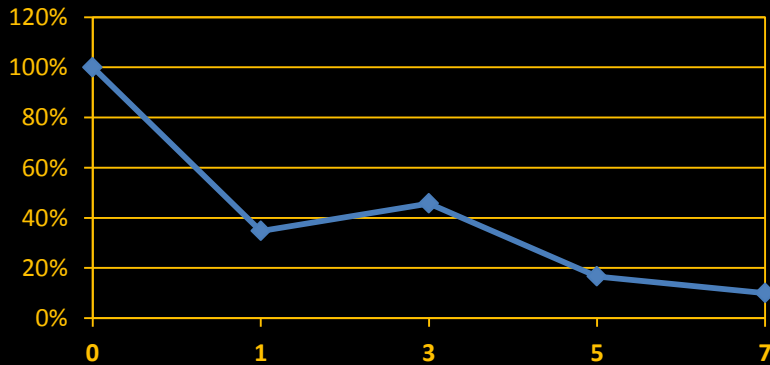
DOCTORFISH



HIND, RED



GRUNT, WHITE



Retention of fin clipped fish in traps over set lengths ranging from 1 to 7 days.

Change in Species Composition

Vent	Set Length (Days)			
	1	3	5	7
Control	n.s.	n.s.	p<0.01	n.s.
1 by 6 Vent	n.s.	n.s.	n.s.	n.s.
1 in Edge	n.s.	n.s.	n.s.	p<0.05
1.5 by 6 Vent	p<0.15	p<.2	p<0.01	.05 <p>.01
1.75 by 6 Vent	p<0.15	p<.1	p<0.01	p<.01

The species mix in larger vent sizes varied significantly from the species mix that they were stocked with. This is largely not true with the smaller vent sizes. These were tested by comparing with original species for each vent and set length mix by KS test.

Total Length of Stocked Fish Compared to Initial Haul

SUMMARY : Total length of stocked fish was significantly smaller than those in initial haul.

Groups	Count	Sum	Average	Variance		
Initial Haul	276	69,637	252	7,258		
Stocked Fish	248	59,328	239	986		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	22,349	1	22,349	5.21	0.02	3.86
Within Groups	2,239,462	522	4,290			
Total	2,261,811	523				

Initial Haul: Average TL Comparison by Set Length

SUMMARY : Total Length and Set Length-Marginally non-significant at .05 level. All vent types combined.						
Set Length (Days)	Count	Sum	Average	Variance		
1	64	15,805	247	1,786		
3	53	13,403	253	3,055		
5	30	8,882	296	5,559		
7	99	24,909	252	13,603		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	55,800	3	18,600	2.55	0.06	2.64
Within Groups	1,765,660	242	7,296			
Total	1,821,461	245				

Summary

- Traps with larger (by width) vent sizes are empty more frequently.
- There appears to be continual movement into and out of traps as evidenced by changes in numbers between dive and haul (seldom as much as an hour).
- The vents exhibited significantly different “escapement” rates during hauling.
- Larger vent sizes retained significantly fewer fish.
- Average length of fish in trap hauls was significantly larger than stocked fish.
- Larger vent sizes did not appear to retain larger fish.

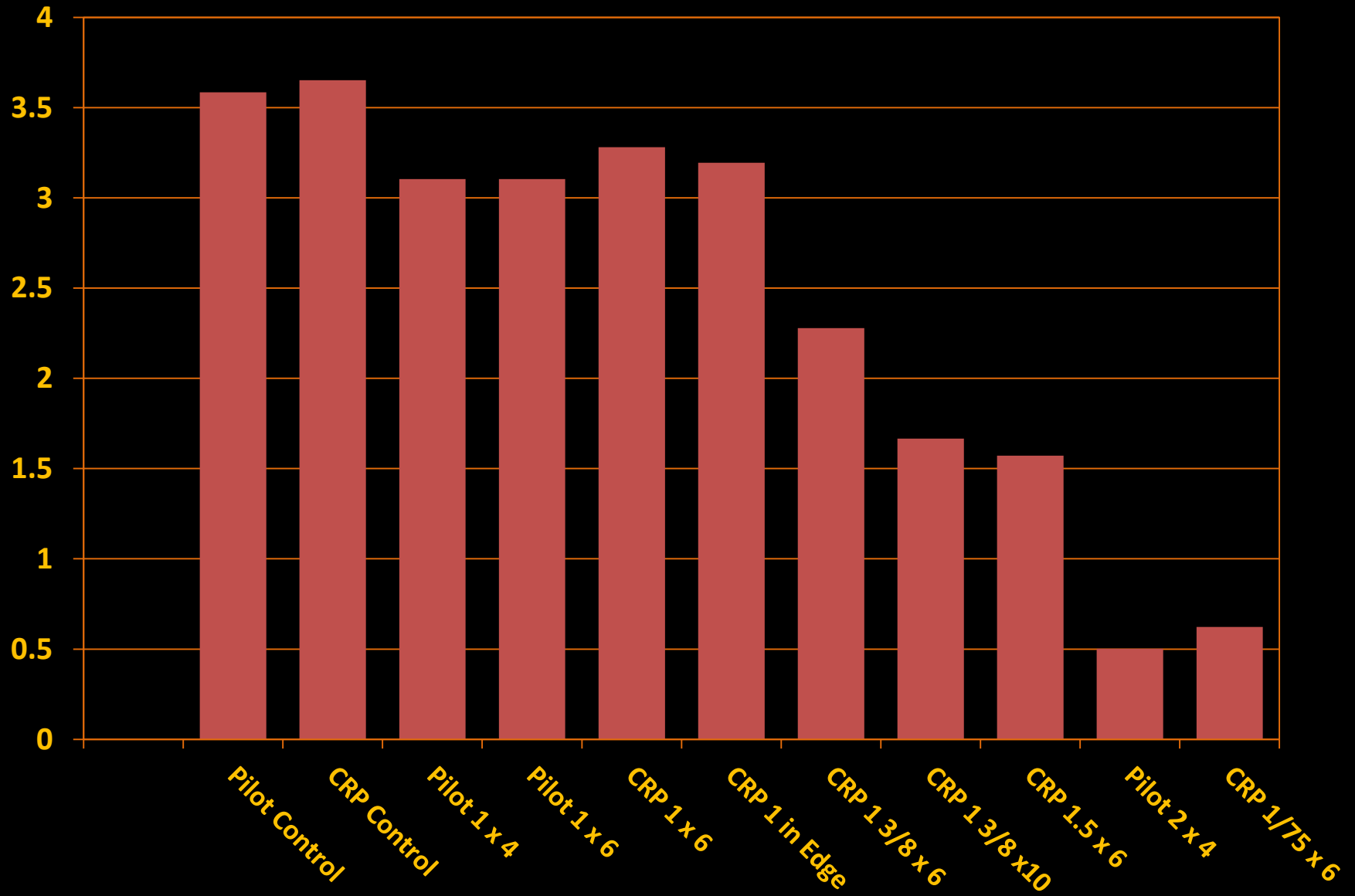
Summary: Continued

- Larger fish were found in longer sets ($p < .06$)
- 40-80% of the stocked fish left during the first day. Highest escapement was in traps with the widest vents.
- For all vent sizes most (90-100%) of the stocked fish were gone within 7 days.
- Larger vent sizes had faster exit rates.
- No species-specific tendencies were observed in exit although the larger vent sizes exhibited significant changes in species composition at all set lengths.

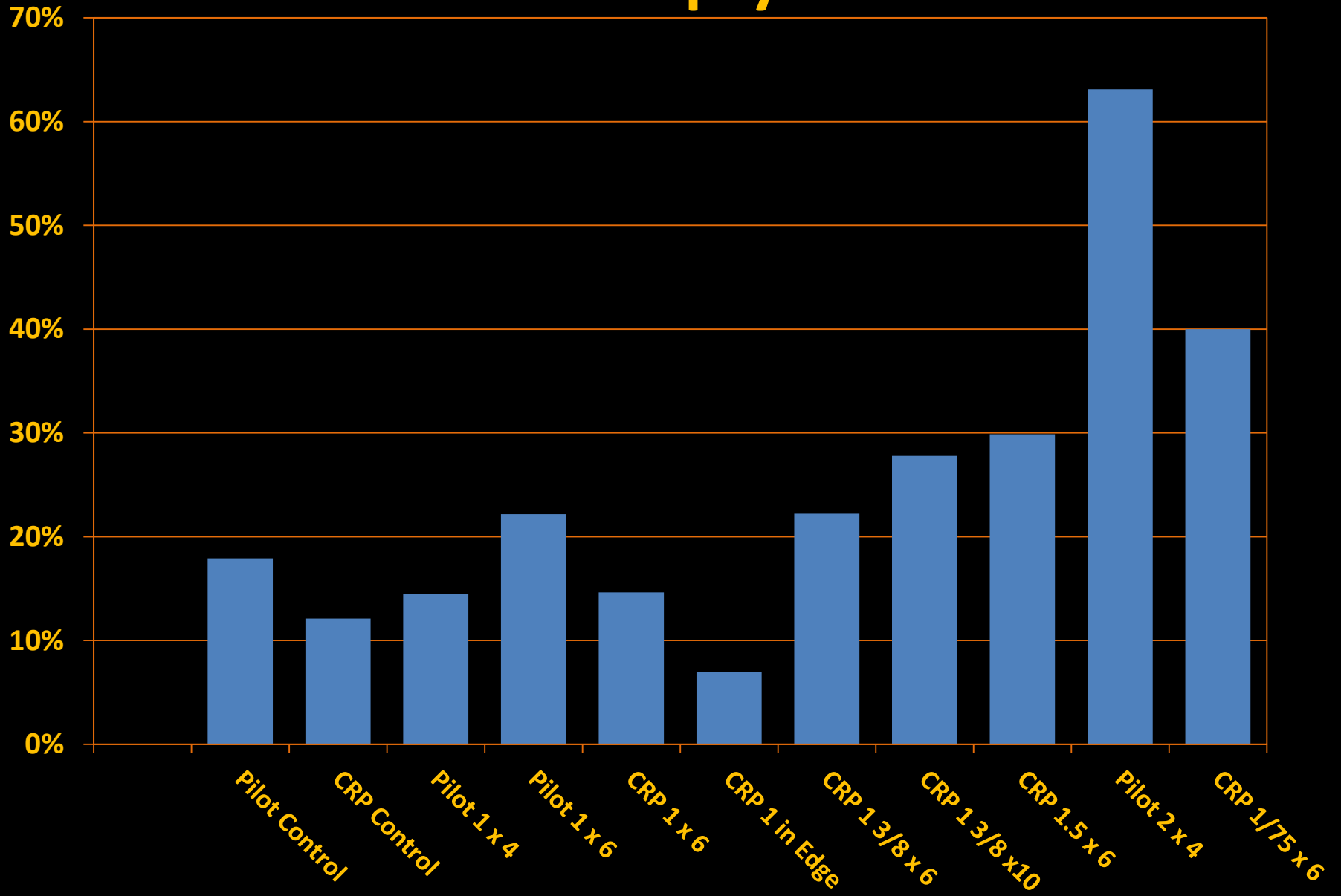
Preliminary Field Testing Results

1. Phase 1 field testing with vents from diving studies.
2. Phase 2 Field testing.
 - 1 by 5.75, 1 3/8 by 5.75, 1 3/8 by 9.75, 1.5 by 5.75 and control traps.
 - 6 Fishermen with 10 trap strings
 - After around 10 hauls rotate to other fishermen.
3. Phase 3 Test selected designs for location and orientation, possibly color.

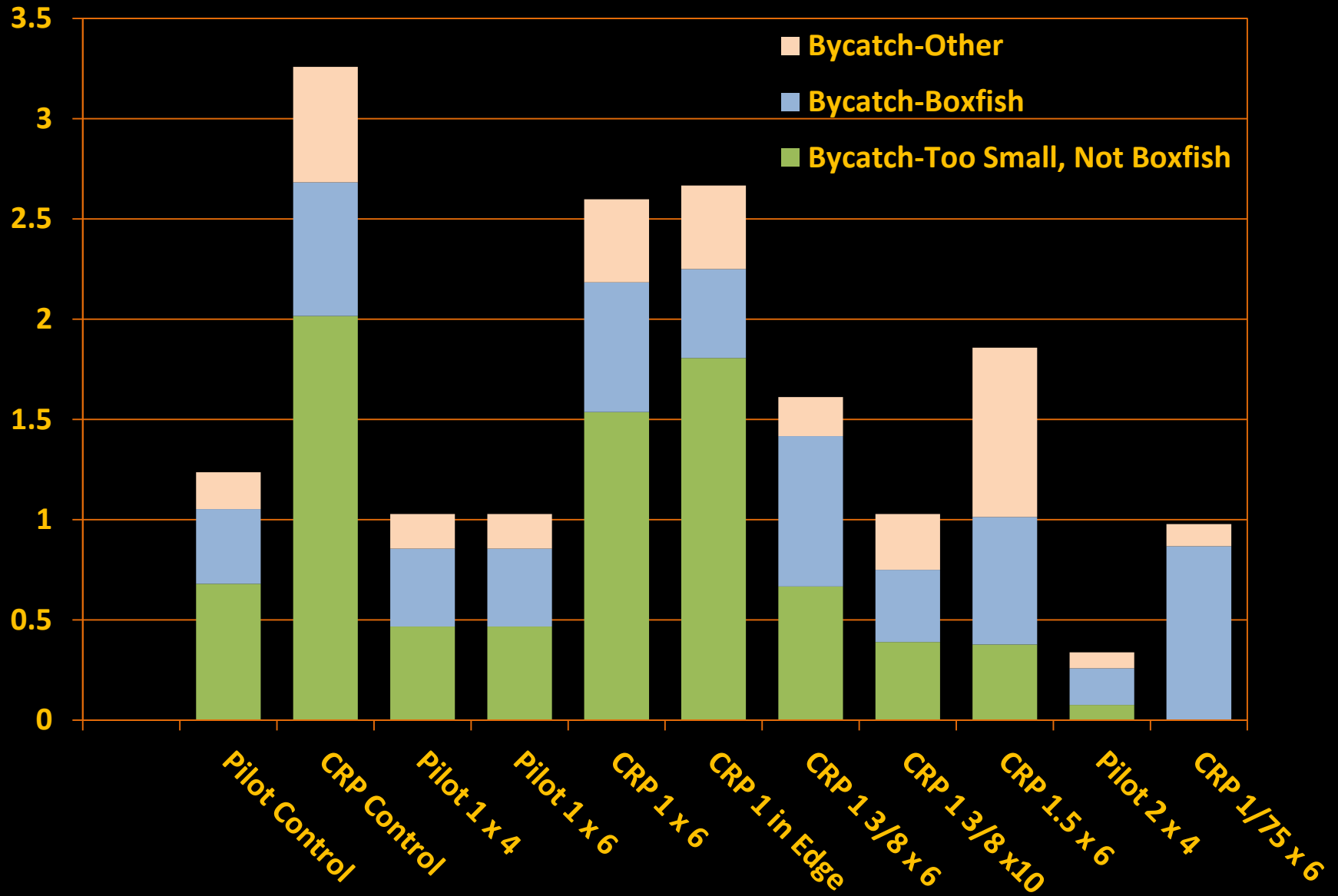
Commercial Catch (#Fish/Trap Haul)



% Empty



Bycatch/Trap Haul



Optimize CPUE, Bycatch and Size

