Fishery Data Series No. 11-03

Biodegradable Twine Report to the Alaska Board of Fisheries

by

William Gaeuman

February 2011

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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By
William Gaeuman
Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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William Gaeuman,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
211 Mission Road, Kodiak, AK, USA

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ABSTRACT

To satisfy the provisions of 5 AAC 39.145 *Escape Mechanism for Shellfish and Bottomfish Pots*, pot gear in Alaska crab and bottomfish fisheries commonly includes an escape mechanism consisting of an opening closed by a single length of untreated 100% cotton twine no larger than 30-thread. Following implementation of the Bering Sea/Aleutian Islands (BSAI) crab fisheries rationalization program, soak times increased in the Aleutian Islands golden king crab (AIGKC) fishery, and reports of premature failure of the regulatory 30-thread twine led Alaska Department of Fish and Game (ADF&G) to conduct both an empirical time-to-failure analysis of the regulatory 30-thread twine and an experimental study comparing the biodegradation rate of the regulatory size twine with that of 60-thread twine (Barnard 2008). In the 2008/09 and 2009/10 eastern and western AIGKC fisheries, observers recorded regulatory twine failure rates of 1.8–8.8% during routine monitoring of biotwine status during pot-lift sampling. While the data indicate a positive association both between twine failure and soak time, and between reduced catch of retained males and twine failure, expected catch reduction under current fishing practices was estimated to be no more than 1% given soak times less than 30 days. In response to a March 2008 Alaska Board of Fisheries request, ADF&G additionally initiated a study comparing 96-thread cotton twine with the regulatory 30-thread cotton twine for use in the AIGKC fishery. Attributing twine failure to the forces associated with pot retrieval during active fishing, twine failure probability at 30 days soak time was estimated to be less than 1% for the 96-thread twine, compared to 13% for the 30-thread twine. More generally, it was estimated that the odds of failure for the 96-thread twine are approximately 6% of the odds of regulatory twine failure, after accounting for soak time.

Key words: Alaska Department of Fish and Game, Aleutian Islands, crab pot escape mechanisms, cotton twine biodegradation, ghost fishing, golden king crab *Lithodes aequispinus,* logistic model, maximum likelihood estimation, AD Model Builder.

INTRODUCTION

Regulations that govern harvest of Alaska's crab resources were adopted by the Alaska Board of Fisheries (BOF) as being both consistent with the sustained yield principle and in the best interests of the people and economy of Alaska. A documented (e.g., Kimker 1990) threat to Alaska's crab resources is ghost fishing, which occurs when unrecoverable pots continue to capture and confine animals that likely die. Currently, regulation 5 AAC 39.145 *Escape Mechanism for Shellfish and Bottomfish Pots* is in place to limit the potential for ghost fishing and the needless death of crabs and other animals. This regulation stipulates, in part, that crab pots must contain an appropriately located opening at least 18 in long that is then "laced, sewn, or secured together by a single length of untreated, 100 percent cotton twine, no larger than 30 thread," which may be knotted only at the ends. If a pot becomes lost, the length of cotton twine will eventually decay through a process of biodegradation, permitting captured animals to escape. The regulation also allows for an alternative mechanism using a galvanic timed-release (GTR) device designed to release within 30 days. This document focuses on the use of untreated all-cotton twine of a specified size in accordance with the general provisions of regulation 5 AAC 39.145 (1), in which context it will be referred to as "biotwine."

Since implementation of crab rationalization in August 2005, soak times in the Bering Sea/Aleutian Islands (BSAI) crab fisheries have generally increased. This is particularly true in the Aleutian Islands golden king crab (AIGKC) *Lithodes aequispinus* fishery, which is managed separately east and west of 174° W long. Average soak time of observer-sampled pots in the combined AIGKC fishery was 8 days in 2004/05 prior to rationalization (Burt and Barnard 2006). In 2005/06, following rationalization, soak time more than doubled to 20 days (Barnard and Burt 2007), and last season, 2009/10, soak time was nearly 3 times as high at 24 days (ADF&G Crab Observer Database). Very long soak times have become common in this fishery, particularly in the west, where in 2009/10 a third of all observer sampled pots had soak times of 30 days or more and 10% of sampled pot soak times exceeded 40 days. By contrast, average observer sample pot soak time in the 2009/10 Bristol Bay red king crab fishery was less than 3 days.

Concomitant with longer soak times, industry concerns arose about loss of captured crabs due to failure of the regulatory biotwine during fishing. These concerns prompted the Alaska Department of Fish and Game (ADF&G) to investigate biotwine failure rates in the AIGKC fishery and the possible effects of biotwine failure on loss of captured crabs. Throughout the 2006/07 and 2007/08 AIGKC fishery seasons, ADF&G onboard crab observers collected data later analyzed in a time-to-failure study of the regulatory 30-thread biotwine, and in Sept–Dec 2007, ADF&G researchers in Kodiak conducted controlled biodegradation studies comparing the tensile strength of the regulatory biotwine to that of 60-thread all-cotton twine under exposure to sea water. Barnard (2008) describes the details of those efforts and presents results of his analyses of the data. Barnard's work confirmed previous studies (Kimker 1990) suggesting that the 60-thread twine degrades significantly more slowly than the regulatory 30-thread twine, and he estimated increased soak times of 1–24 days before biotwine failure in the AIGKC fishery with a change to the heavier 60-thread twine.

The Alaska BOF reviewed Barnard's (2008) report in March 2008. At that time, the BOF also rejected a proposal to allow use of 120-thread twine in the AIGKC fishery, but subsequently requested ADF&G to investigate the suitability of 96-thread twine for use in the fishery. As a result, ADF&G initiated routine monitoring of biotwine status by onboard observers in the AIGKC fisheries. In addition, ADF&G assigned observers in the AIGKC fishery to collect data providing a direct comparison of the 96-thread twine with the regulatory 30-thread biotwine with respect to failure during active fishing. This report details the methods used in these two initiatives, summarizes the data collected, and presents analysis and results. It concludes with an outline of key considerations with respect to biotwine specification in the AIGKC fishery.

METHODS

OBSERVER MONITORING OF BIOTWINE STATUS

ADF&G crab observers began routine monitoring of biotwine status in 2008/09 as part of standard pot-lift sampling protocol. Observers recorded whether pot biotwine was intact after the pot was hauled and emptied by circling "Y" or "N" in the appropriate location on the Species Composition Form (Appendix A). Data from completed Species Composition Forms thus provide information about possible associations between soak time, biotwine status, and catch, in addition to other variables. It is important to note that in the AIGKC fishery, pot biotwine is typically replaced after each haul whether or not it has failed, which is generally not the case in other BSAI crab fisheries with shorter soak times.[1]

BIOTWINE COMPARISON STUDY

In 2009/10, ADF&G assigned crab observers in the AIGKC fishery to collect data intended to allow comparison of 96-thread cotton twine with the regulatory 30-thread biotwine with respect to performance under actual commercial fishing conditions. Project protocol required the observer to 1) select with the crew's assistance a single string of at least 20 pots; 2) select and tag for identification 20 of the pots in the string; 3) arrange that the crew fit 10 of the tagged pots with the regulatory biotwine and 10 pots with the 96-thread twine; and 4) track the status of all

[1] M. Salmon, Fisheries Biologist II, ADF&G Crab Observer Program, Dutch Harbor, personal communication, 2010.

twine lengths over a sequence of consecutive deployments. Each time the string was retrieved, the observer recorded information about string position, soak time, and depth, pot gear type, and the condition of each length of biotwine and its location on the pot. In the event of biotwine failure, the crew replaced it with a length of the same twine type; otherwise, it was not replaced. Observers were supplied with special Biodegradable-Twine Monitoring Forms, pot identification tags, and all twine used in the study. Instructions for data collection and for completing the Biodegradable-Twine Monitoring Form as described in the 2009 ADF&G Crab Observer Training and Deployment Manual[2] can be found in Appendix B.

Analysis of the comparison-study data was predicated on the assumption that, as Barnard (2008) suggests, biotwine failure during active prosecution of a commercial crab pot fishery is primarily the result of forces generated in pot deployment and retrieval as opposed to, for example, spontaneous failure due to biodegradation while resting on the sea floor. It was also assumed that biotwine failure as a result of those forces depends on cumulative soak time only, independently from one retrieval occasion to the next, and that these forces are large in comparison to any relevant differences between individual lengths of biotwine. Under these assumptions, letting p_{ij} denote the failure probability of the i^{th} length of biotwine at the j^{th} haul, the log-odds of failure was modeled as

$$\log(\frac{p_{ij}}{1-p_{ij}}) = \alpha_0 + \alpha_1(T_{ij} - 30) + \alpha_2 I_i + h_j,$$

where α_0, α_1, and α_2 are unknown model parameters to be estimated, T_{ij} is the cumulative soak time in days, I_i is an indicator of twine type equal to 0 if the i^{th} length is 30-thread twine and 1 if 96-thread, and h_j designates the random effect of the j^{th} haul. The likelihood of a particular outcome observed for the i^{th} length of biotwine over a sequence of k hauls $j \geq 1, j+1, \ldots, j+k$ is thus given by the product $(1-p_{ij})(1-p_{ij+1})\ldots p_{ij+k}$ if failure occurs and by the product $(1-p_{ij})(1-p_{ij+1})\ldots(1-p_{ij+k})$ otherwise. Of particular interest is the parameter α_2, which quantifies the multiplicative effect on the odds of biotwine failure that can be attributed to the use of 96-thread twine rather than the regulatory 30-thread twine. The parameter α_0 relates to the mean probability of 30-thread biotwine failure at 30-days soak time, whereas α_1 quantifies the association between biotwine failure probability and increased soak time, here assumed unrelated to twine type. Parameter estimates were obtained by way of a maximum likelihood approach (Pawitan 2001) using the software AD Model Builder (ADMB Project 2009). Haul effects were assumed normal with mean zero and variance determined by a diffuse inverse-gamma prior distribution.

RESULTS

OBSERVER MONITORING OF BIOTWINE STATUS

Observers in the AIGKC fishery east and west of 174° W long recorded biotwine status of, respectively, 613 and 977 sampled pots during 2008/09, and 409 and 893 sampled pots during 2009/10 (Table 1). Observed biotwine failure rates ranged from 1.8% in the 2008/09 eastern fishery to 8.8% in the 2009/10 eastern fishery. Soak times in the eastern and western fisheries differ markedly, with median observer-sampled pot soak times of 14 and 15 days in the two

[2] ADF&G Crab Observer Program, Dutch Harbor, unpublished.

eastern fisheries compared to 22 and 23 days in the two western fisheries. Soak times of all but about 2% of sampled pots in the two eastern fisheries were less than 30 days, whereas in the west, about one third (33.4%) and one quarter (25.4%) of pots sampled in 2008/09 and 2009/10 had soak times exceeding 30 days (ADF&G Crab Observer Database). Moreover, in the two western fisheries, increased biotwine failure rates are strongly associated with longer soak times (Table 1; Figures 1 and 2). Whereas the 2009/10 failure rate in the western fishery was less than 1% for soak times under 30 days, it was 8.4% for soak times of 30 days or more; and in 2008/09 the failure rate in the western fishery was 2.2% for soak times under 30 days, compared to 14.9% for longer soak times. In the eastern fisheries, on the other hand, where very few observed soak times exceed 30 days (just 10 in 2008/09 and 8 in 2009/10), there is little evidence of an association one way or the other (Table 1; Figures 3 and 4).

Observed pot catch rates (CPUE) for legal retained crabs are generally lower among pots with failed biotwine (Table 1; Figures 1–4). The difference is most extreme in the 2009/10 western fishery, where CPUE for pots with failed biotwine (6.3 crabs per pot) is less than a quarter what it is for pots with intact biotwine (26.6 crabs per pot). The exception is the 2009/10 eastern fishery, where no real difference is apparent. The 2009/10 eastern fishery is anomalous also in having the highest overall observed biotwine failure rate in spite of comparatively modest observed soak times.

BIOTWINE COMPARISON STUDY

Observers on 5 commercial crab vessels collected twine comparison data, monitoring 120 pots in 6 strings and recording a total of 337 observations on 130 single lengths of biotwine in 17 hauls (Table 2). Three strings of pots were deployed in the 2009/10 eastern AIGKC fishery and 3 in the 2009/10 western AIGKC fishery. Between-haul soak times ranged from 5 to 36 days, with cumulative soak times of up to 100 (36 + 33 + 31) days (Table 3). Biotwine failure was observed in 34 instances, with 29 failures occurring among the 70 observed lengths of 30-thread twine compared to 5 failures among the 60 observed lengths of 96-thread twine. Appendix C archives the raw data.

Because estimated variance associated with the random haul effects was not statistically distinguishable from zero (0.815, s.e. = 0.448), the simpler model excluding those effects was used for inference. Model parameter estimates, asymptotic standard errors, and associated multiplicative effects for the two nonconstant parameters are listed in Table 4. Based on estimated parameters, biotwine failure probability after a cumulative soak time of 30 days is an estimated 13% ($1/[1+\exp(-\hat{\alpha}_0)]\times 100\%$) for 30-thread twine compared to less than 1% ($1/[1+\exp(-\hat{\alpha}_0-\hat{\alpha}_2)]\times 100\%$) for 96-thread twine (Figure 5). Note that the first estimate is in line with AIGKC fishery observed regulatory biotwine failure rates, which include 14.9% for soak times exceeding 30 days in the 2008/09 western fishery (Table 1). More generally, the model estimate of α_2 suggests that the odds of biotwine failure during active fishing are reduced by around 94% with the use of 96-thread twine in place of 30-thread twine, irrespective of soak time (Table 4). This effect manifests itself in Figure 5 as a horizontal shift of 53 days between the two curves. Finally, the model estimate of α_1 suggests that the for both twine types the odds of biotwine failure increase multiplicatively by about 6% with each additional day of soak time, for an appropriate range of soak times, e.g., less than 100 days. Including random haul effects in the inferential model had little substantive impact on results.

DISCUSSION

Interpretation of results described in this report requires recognition of two distinct concerns. The first is biotwine failure during active fishing in the AIGKC fishery and its possible impact on catch rates. The other is the potential waste of Alaska's crab and other marine resources as a result of ghost fishing by lost pots. There is a tradeoff between the two.

Data collected by crab observers monitoring biotwine status as part of pot lift sampling provide information about the relationship between biotwine failure, soak time, and catch in the AIGKC fishery. Although there is evidence of reduced catch of legal male golden king crabs associated with biotwine failure during active fishing, the data generally testify to a low biotwine failure rate at soak times less than 30 days. The exception, as previously observed, is the 2009/10 eastern fishery, where 35 of the 36 observed biotwine failures in that fishery were recorded by a single observer over a single 7-day period, strongly suggesting influence of some unknown confounding factor and giving good reason for skepticism about the representativeness of those observations. Combined observed biotwine failure rate in the other 3 fisheries was just 1.5% in 1,928 sampled pots with soak times under 30 days. Assuming the overall average observed CPUEs of 25.9 legal retained crabs per pot for pots with intact biotwine and 11.6 legal retained crabs per pot for pots with failed biotwine, the observed 1.5% failure rate suggests an expected total catch loss of less than 1% in terms of number of legal retained crabs per pot.

Estimated failure rates for the regulatory 30-thread biotwine from the 2009/10 biotwine comparison data appear to be somewhat higher than indicated by the empirical data. However, that these data are based on just 6 strings of 10 pots fitted with each of the 2 types of twine necessarily limits the scope of inference with respect to estimating overall fishery biotwine failure rates. Rather, the data are better suited for direct comparison of the 2 types of twine and were collected with that objective in mind. In consonance with previous studies, the data show the heavier 96-thread twine has lower odds of failure during active fishing, after accounting for soak time. Moreover, the data also provide further evidence of a clear link between biotwine failure and cumulative time of exposure to sea water.

ADF&G onboard observers and dockside samplers recorded a total of 120 lost pots in 777 days of fishing during the 2008/09 and 2009/10 AIGKC fisheries (ADF&G Crab Observer Database). Barnard (2008) notes that the intent of regulation 5 AAC 39.145 is to prevent lost crab and bottomfish pots from retaining captured crabs longer than 30 days and cites studies by Paul et al. (1994) and Kimker (1994) as providing a rationale for this timeframe based on mortality of captured crabs. Even so, both Barnard's work and the previous studies indicate that complete biodegradation of the regulatory 30-thread twine can require soak times considerably longer than 30 days and that biodegradation of twines with higher thread count requires still longer soak times. In light of this evidence, there is good reason to believe that use of twine of higher thread count would result in significantly longer biodegradation times with consequent increased ghost fishing by lost pots. At the same time, the results presented here clearly suggest that fishing practices such as routinely replacing biotwine and limiting pot soak times can mitigate substantially any catch losses associated with failure of the currently mandated 30-thread twine during active fishing.

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TABLES AND FIGURES

Table 1.–Regulatory 30-thread biotwine status data from observer sampled pot lifts in the 2008/09 and 2009/10 eastern and western Aleutian Islands golden king crab fisheries.

		Biotwine status		
Fishery[a]		Intact	Failed	% Failed
2008/09 East	Number of pots	602	11	1.8
	<30 days soak time	592	11	1.8
	≥30 days soak time	10	0	0
	Median soak time (days)	14	14	–
	CPUE[b]	28.8	8.1	–
2008/09 West	Number of pots	924	53	5.4
	<30 days soak time	712	16	2.2
	≥30 days soak time	212	37	14.9
	Median soak time (days)	21	39	–
	CPUE[b]	25.0	8.9	–
2009/10 East	Number of pots	373	36	8.8
	<30 days soak time	365	36	9.0
	≥30 days soak time	8	0	0
	Median soak time (days)	15	18	–
	CPUE[b]	25.5	24.4	–
2009/10 West	Number of pots	867	26	2.9
	<30 days soak time	594	1	0.2
	≥30 days soak time	273	25	8.4
	Median soak time (days)	23	44	–
	CPUE[b]	26.6	6.3	–

[a] The AIGKC fishery is managed as separate fisheries east and west of 174° W long.
[b] Legal retained crabs per pot lift.

Table 2.–Biotwine-failure comparison data based on 6 longline pot strings from 5 vessels participating in the 2009/10 eastern and western Aleutian Islands golden king crab fisheries.

Vessel ID	Pot-string[a] ID	Deployments	30-thread twine: Lengths of twine	30-thread twine: Number of observations	30-thread twine: Observed failures	96-thread twine: Lengths of twine	96-thread twine: Number of observations	96-thread twine: Observed failures
1	1	2	10	20	10	10	20	0
1	2	2	10	20	0	10	20	0
2	3	3	20	30	13	10	30	1
3	4	3	10	30	0	10	30	3
4	5	3	10	30	0	10	30	0
5	6	4	10	38	6	10	39	1
Totals		17	70	168	29	60	169	5

Note: The condition of each observed length of biotwine was recorded at each pot-string retrieval. Except in three instances, failed twine was replaced with another length and its status recorded after any subsequent retrievals.

[a] Each observed longline pot string consisted of 10 pots fitted with 30-thread twine and 10 pots fitted with 96-thread twine. Two strings of pots came from a single vessel. The other four strings came from different vessels.

Table 3.–Biotwine-failure comparison data collected during the 2009/10 eastern and western Aleutian Islands golden king crab fisheries showing sequence of between-haul soak times associated with each string of crab pots by vessel and twine type.

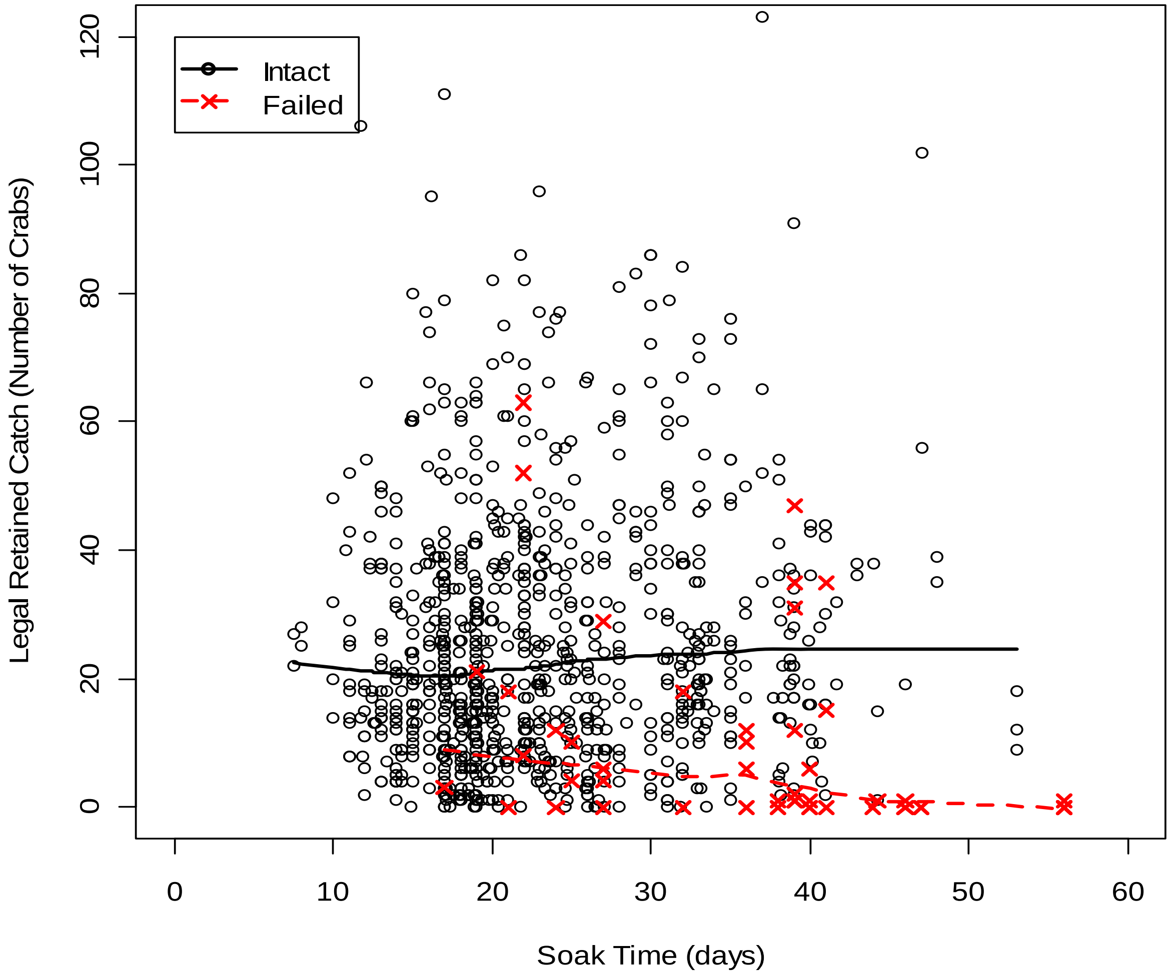
			Number of failures	
Vessel	String	Sequence of soak times (days)	30-thread	96-thread
1	1	(20, 6)	10	0
1	2	(21, 20)	0	0
2	3	(36, 33, 31)	13[a]	1
3	4	(17, 13, 22)	0	3
4	5	(5, 4, 7)	0	0
5	6	(15, 13, 15, 15)	6	1
Total			29	5

[a] 4 of the 13 failed lengths of twine were introduced into the haul sequence as replacement lengths after the initial haul, three owing to previous biotwine failure and one for reasons unrelated to failure.

Table 4.–Model parameter estimates, asymptotic standard errors, and associated multiplicative effect on odds of failure.

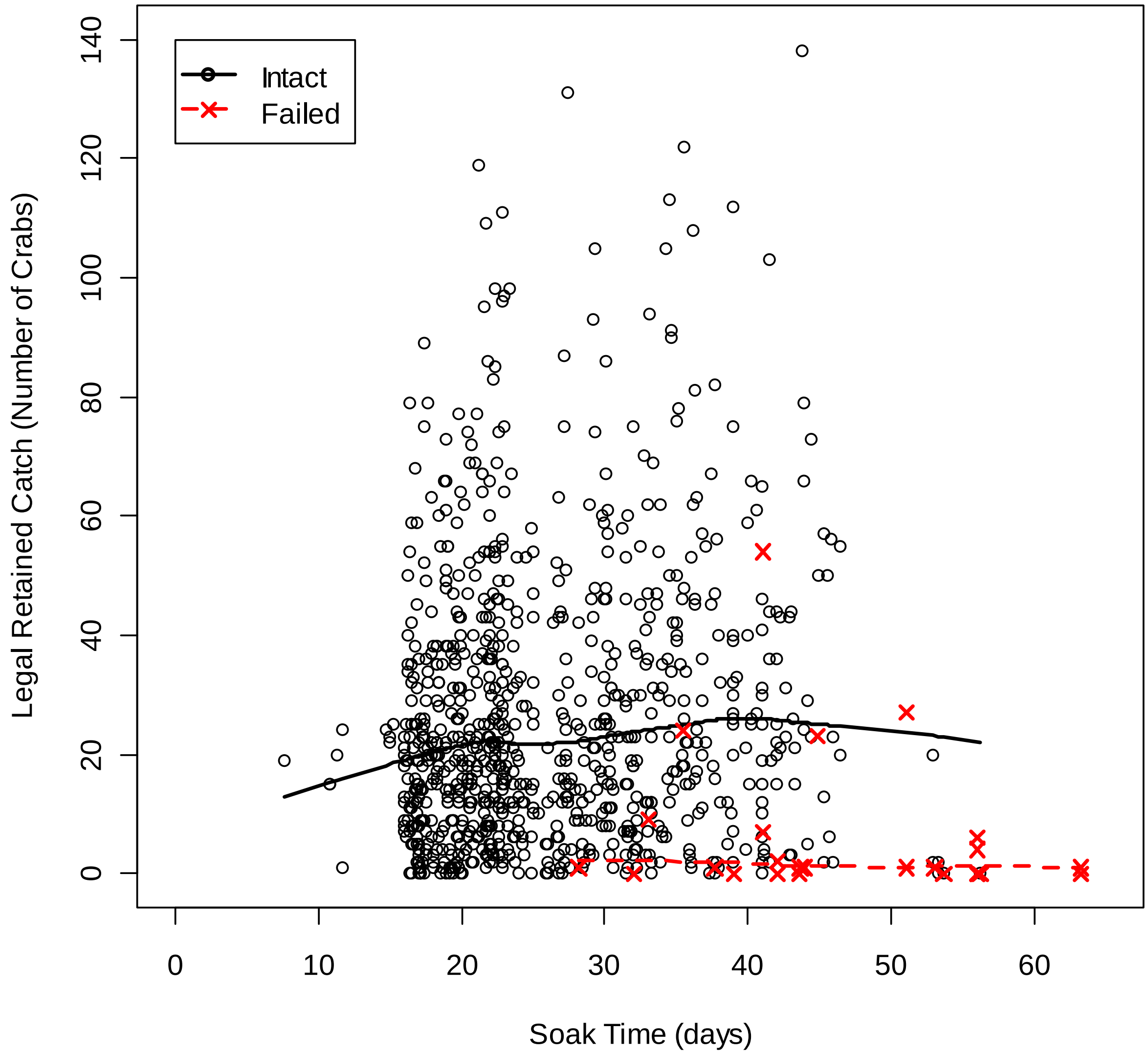
Parameter	Estimate	SE	Multiplicative effect[a]
α_0	-1.8678	0.24204	--
α_1	0.0584	0.01018	1.060
α_2	-2.8450	0.62282	0.058

[a] For a parameter α, the associated multiplicative effect on the odds is computed as $\exp(\alpha)$.



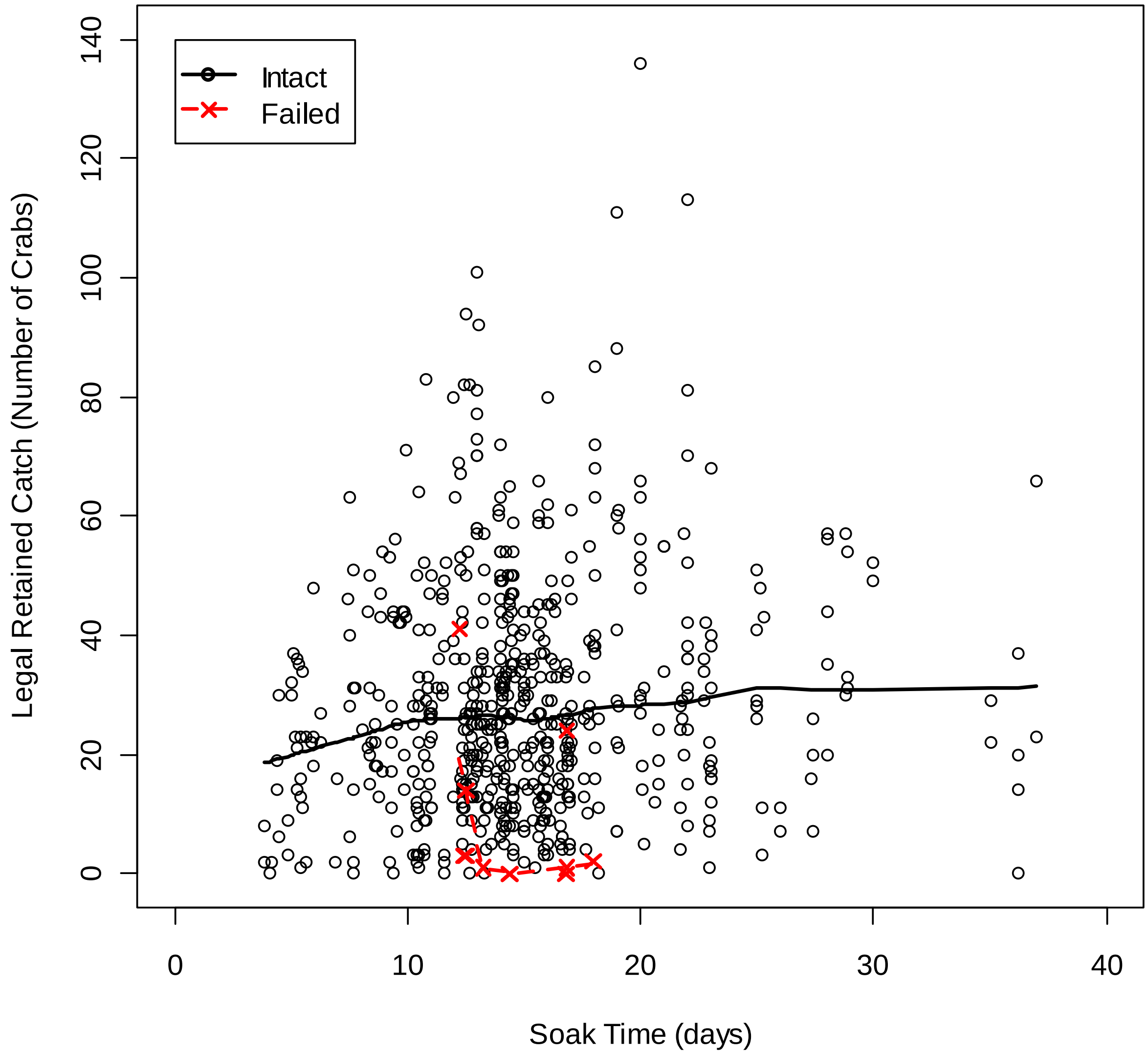
Note: Curves are lowess fits to the observed data points.

Figure 1.–Legal retained catch vs. soak time for observed pot lifts in the 2008/09 western Aleutian Islands golden king crab fishery.



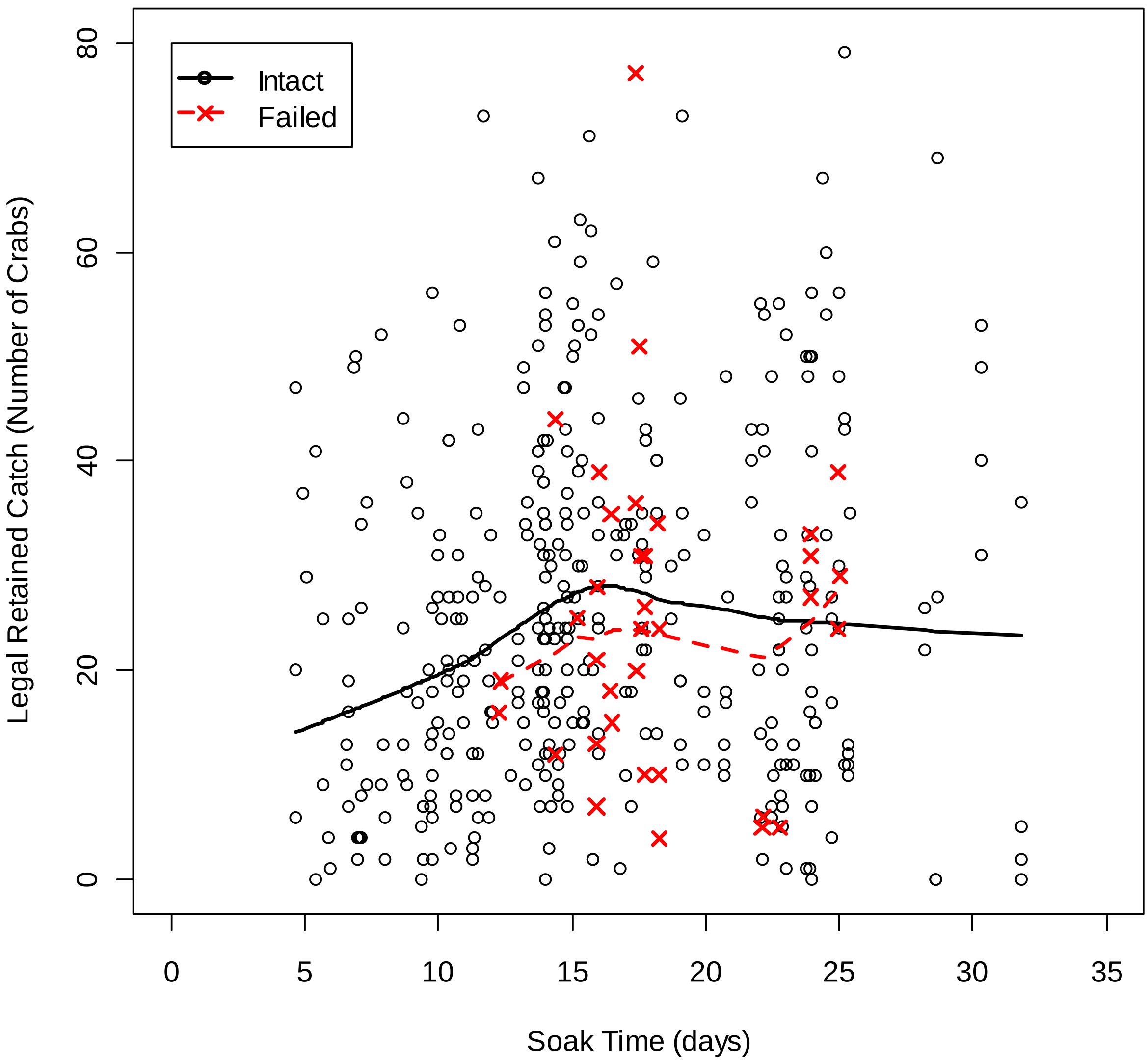
Note: Curves are lowess fits to the observed data points.

Figure 2.–Legal retained catch vs. soak time for observed pot lifts in the 2009/10 western Aleutian Islands golden king crab fishery.



Note: Curves are lowess fits to the observed data points.

Figure 3.–Legal retained catch vs. soak time for observed pot lifts in the 2008/09 eastern Aleutian Islands golden king crab fishery.



Note: Curves are lowess fits to the observed data points. Note the high catches among pots with failed biotwine compared to those in the other 3 fisheries (Figures 1–3).

Figure 4.–Legal retained catch vs. soak time for observed pot lifts in the 2009/10 eastern Aleutian Islands golden king crab fishery.

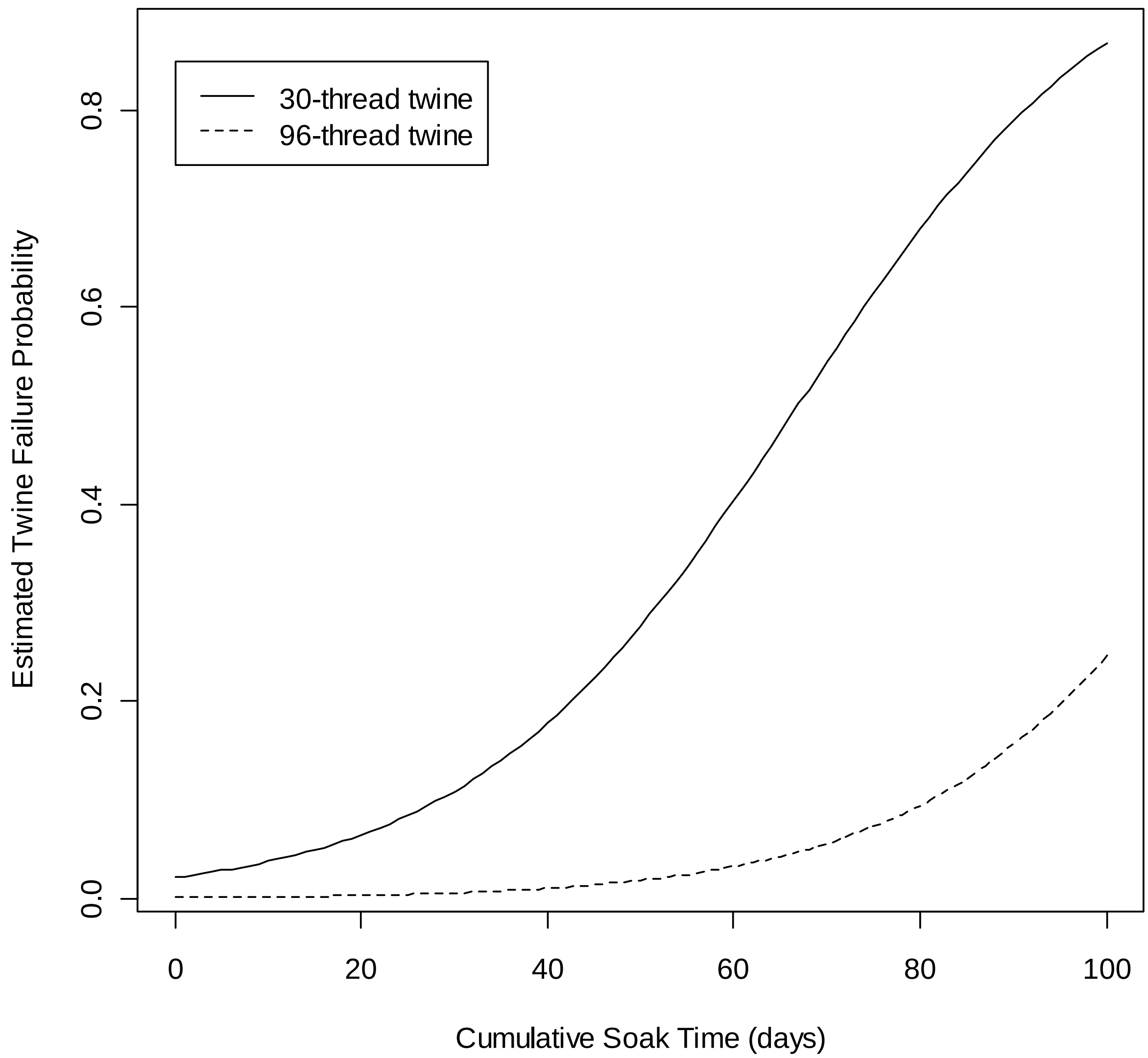


Figure 5.–Estimated probability of biotwine failure during pot retrieval for 30-thread and 96-thread twine as a function of cumulative soak time, based on biotwine comparison data collected by ADF&G crab observers in the 2009/10 Aleutian Islands golden king crab fishery.

APPENDIX A. ADF&G CRAB OBSERVER DEEP WATER CRAB SPECIES COMPOSITION FORM

Appendix A.–ADF&G crab observer deep water crab species composition form.

Deep Water Crab Species Composition Form

Observer Name: ____________ Latitude: ____________ (dd°mm.mm) Longitude: ____________ (ddd°mm.mm) E W

Vessel Name: ____________ Soak Time: ________ (hours) Statistical Area: ____________

ADF&G Number: ____________ Depth: ________ (fathoms) Rings = ______ (inches) Mesh = ______ (inches)

Fishery Code: ____________ Gear Code: ________ Bio-Twine Intact: Y N

Sample Date: ____________ (mm/dd/yy)

Seq. Pot Number: ____________

Species Name	Species Code	Sex (0 = unknown, 1 = male, 2 = female, 3 = herm.)	Legal Size (1 = legal, ret., 2 = legal, not ret., 0 = sublegal)	Total Number	Comments (No. C&F Measurement Forms: ______)
C. tanneri male (legal, ret.)	933	1	1		
C. tanneri male (legal, not ret.)	933	1	2		
C. tanneri male (sublegal)	933	1	0		
C. tanneri female	933	2	~~~		
C. angulatus male (legal, ret.)	934	1	1		
C. angulatus male (legal, not ret.)	934	1	2		
C. angulatus male (sublegal)	934	1	0		
C. angulatus female	934	2	~~~		
L. couesi male (legal, ret.)	924	1	1		
L. couesi male (legal, not ret.)	924	1	2		
L. couesi male (sublegal)	924	1	0		
L. couesi female	924	2	~~~		
golden king male (legal, ret.)	923	1	1		
golden king male (legal, not ret.)	923	1	2		
golden king male (sublegal)	923	1	0		
golden king female	923	2	~~~		
Pacific cod	110	~~~			
Snail		~~~	~~~		
Starfish unidentified	20	~~~	~~~		

Alaska Department of Fish and Game - Shellfish Observer Program - Deep Water Crab Species Composition Form (Rev. April 3, 2008)

APPENDIX B. BIOTWINE COMPARISON PROTOCOL AND FORM INSTUCTIONS

BIODEGRADABLE TWINE MONITORING IN A LONGLINED STRING

This project is assigned to all observers on vessels in the Aleutian Islands golden king crab fishery. This project is mandatory.

The objective of this project is to record data that will be used to assess the decomposition time for both the regulatory 30-thread and the experimental 96-thread biodegradeable twines.

All crab pots used in Alaskan waters are required to have one sidewall with an opening of at least 18 inches that is secured by a single length of untreated, 100%-cotton twine of at most 30 threads (5 AAC 39.145). The longevity of this biodegradable cotton twine is being evaluated for longlined pots used in the Aleutian Islands golden king crab fisheries.

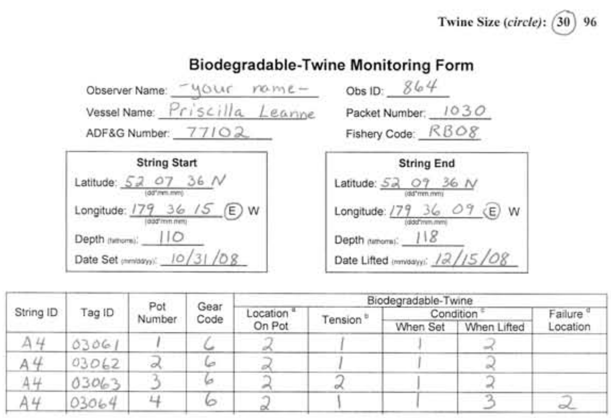
Sampling protocol consists of selecting one string of gear, monitoring it throughout your deployment and recording dates and times of biotwine failure.

Sampling Guidelines

With cooperation from the captain, select a string of at least 20 pots to monitor. To facilitate keeping track of individual pots, you will attach an ADF&G-provided tag with a unique number to each pot. The pots in this string should stay together throughout your deployment.

All pots in the string will have their biotwine replaced by the crew using twine provided by ADF&G (10 pots with each twine size). The biotwine will remain on the pots until failure, and failed twine will be replaced with the ADF&G-provided twine.

All data for this project will be recorded on the Biodegradable Twine Monitoring form. Begin a new form each time a monitored string is set. Checking the tension may be done visually.



Twine Size (*circle*): (30) 96

Biodegradable-Twine Monitoring Form

Observer Name: -your name-
Obs ID: 864
Vessel Name: Priscilla Leanne
Packet Number: 1030
ADF&G Number: 77102
Fishery Code: RB08

String Start
Latitude: 52 07 36 N (dd°mm.mm)
Longitude: 179 36 15 (E) W (ddd°mm.mm)
Depth (fathoms): 110
Date Set (mm/dd/yy): 10/31/08

String End
Latitude: 52 09 36 N (dd°mm.mm)
Longitude: 179 36 09 (E) W (ddd°mm.mm)
Depth (fathoms): 118
Date Lifted (mm/dd/yy): 12/15/08

String ID	Tag ID	Pot Number	Gear Code	Biodegradable-Twine Location [a] On Pot	Tension [b]	Condition [c] When Set	Condition [c] When Lifted	Failure [d] Location
A4	03061	1	6	2	1	1	2	
A4	03062	2	6	2	1	1	2	
A4	03063	3	6	2	2	1	2	
A4	03064	4	6	2	1	1	3	2

FIGURE 10-7. Example of the Biodegradable Twine Monitoring Form.

Instructions for the Biodegradable Twine Monitoring Form

Twine Size - Fill out a separate form for each twine size (30-thread and 96-thread). Circle the twine size in the top right hand corner of each form.

Observer Name - First and last name of observer.
Vessel Name - Name of sampled vessel.
ADF&G Number - ADF&G number of sampled vessel.
Obs. ID - Observer identification number.
Packet Number - Fishery-specific packet number assigned at briefing.
Fishery Code - Four-character code used to identify the fishery.

String Start - First tagged pot in string.
Latitude (N) - Latitude of the first pot in the string of gear in degrees and decimal minutes.
Longitude - Longitude of the first pot in the string of gear in degrees and decimal minutes. Circle E or W to indicate the appropriate hemisphere.
Depth - Depth of the first pot in the string of gear in whole fathoms.
Date Set - MM/DD/YY the string of gear was set.
String End - Last tagged pot in string.
Latitude (N) - Latitude of the last pot in the string of gear in degrees and decimal minutes.
Longitude - Longitude of the last pot in the string of gear in degrees and decimal minutes. Circle E or W to indicate the appropriate hemisphere.
Depth - Depth of the last pot in the string of gear in whole fathoms.
Date Lifted - MM/DD/YY the string of gear was lifted.

String ID - Unique identifier for the string of pots selected for monitoring.
Tag ID - Unique identification number (from buoy tag) of individual pots in the string.
Pot Number - Sequential number (position) of the pot on the string.
Gear Code - Code which represents the size and shape of the sampled pot. Note any pot dimensions or shapes not on the gear code list.

Biodegradeable Twine
Location On Pot - Location on the pot where the biotwine is installed.
Tunnel (1)
Fixed Sidewall (2)
Door (3)
Tension - Relative tension of the biotwine at the time the pot is set.
Loose (1) = biotwine is not under tension.
Tight (2) = biotwine is under tension.
Condition - Condition of the biotwine when the pot is set and lifted.
New (1) = biotwine has just been replaced.
Intact (2) = biotwine is not new and has not yet failed (in use.)
Failed (3)= biotwine has broken.
Failure Location - Location of the pot when biotwine failed. Leave blank if twine is intact.
When Pulled (1) = biotwine failed before put was lifted.
On Deck (2)= biotwine failed during normal operations on deck.

APPENDIX C. ADF&G OBSERVER-COLLECTED BIOTWINE COMPARISON DATA.

Appendix C.–ADF&G observer-collected biotwine comparison data.

These data were collected during the 2009/10 Aleutian Islands golden king crab fishery by ADF&G onboard observers on 5 commercial crab fishing vessels. Observers monitored 20 pots in each of a total of 6 longline pot strings over a series of up to 4 consecutive pot deployments. Ten of the monitored pots in each string were fit with the regulation 30-thread twine and the other 10 monitored pots with 96-thread twine. Each row in the data table tracks biotwine status of a single type of twine (30-thread or 96-thread) on a single pot. Except in 3 cases in pot string 6, failed twine was replaced with another length of the same type prior to any subsequent deployments. A single length of 30-thread twine in pot string 3 was replaced after the first deployment for reasons unrelated to failure. S1 and S2 respectively denote biotwine status (1 = new, 2 = in use, 3 = failed) at the time of deployment and after pot retrieval. Soak times are in days.

			Deployment 1			Deployment 2			Deployment 3			Deployment 4		
Vessel	Pot String	Twine Size	Soak Time	S1	S2	Soak Time	S1	S2	Soak Time	S1	S2	Soak Time	S1	S2
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	30	20	1	2	6	2	3	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	1	96	20	1	2	6	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--

-continued-

Vessel	Pot String	Twine Size	Deployment 1 Soak Time	S1	S2	Deployment 2 Soak Time	S1	S2	Deployment 3 Soak Time	S1	S2	Deployment 4 Soak Time	S1	S2
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	30	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
1	2	96	21	1	2	20	2	2	--	--	--	--	--	--
2	3	30	36	1	2	33	2	3	31	1	3	--	--	--
2	3	30	36	1	2	33	2	3	31	1	3	--	--	--
2	3	30	36	1	2	33	2	3	31	1	3	--	--	--
2	3	30	36	1	2	33	2	3	31	1	2	--	--	--
2	3	30	36	1	2	33	2	3	31	1	2	--	--	--
2	3	30	36	1	2	33	2	3	31	1	2	--	--	--
2	3	30	36	1	2	33	2	3	31	1	2	--	--	--
2	3	30	36	1	2	33	2	3	31	1	2	--	--	--
2	3	30	36	1	2	33	2	3	31	1	2	--	--	--
2	3	30	36	1	2	33	1	2	31	2	3	--	--	--
2	3	96	36	1	2	33	2	2	31	2	3	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
2	3	96	36	1	2	33	2	2	31	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--

-continued-

			Deployment 1			Deployment 2			Deployment 3			Deployment 4		
Vessel	Pot String	Twine Size	Soak Time	S1	S2	Soak Time	S1	S2	Soak Time	S1	S2	Soak Time	S1	S2
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	30	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	2	--	--	--
3	4	96	17	1	2	13	2	2	22	2	3	--	--	--
3	4	96	17	1	2	13	2	2	22	2	3	--	--	--
3	4	96	17	1	2	13	2	2	22	2	3	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	30	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--

-continued-

Appendix C.–Page 4 of 4.

			Deployment 1			Deployment 2			Deployment 3			Deployment 4		
Vessel	Pot String	Twine Size	Soak Time	S1	S2	Soak Time	S1	S2	Soak Time	S1	S2	Soak Time	S1	S2
4	5	96	5	1	2	4	2	2	7	2	2	--	--	--
5	6	30	15	1	2	13	2	2	15	2	2	15	2	3
5	6	30	15	1	2	13	2	2	15	2	2	15	2	3
5	6	30	15	1	2	13	2	2	15	2	2	15	2	3
5	6	30	15	1	2	13	2	2	15	2	2	15	2	3
5	6	30	15	1	2	13	2	2	15	2	2	15	2	2
5	6	30	15	1	2	13	2	2	15	2	2	15	2	2
5	6	30	15	1	2	13	2	2	15	2	2	15	2	2
5	6	30	15	1	2	13	2	2	15	2	2	15	2	2
5	6	30	15	1	2	13	2	2	15	2	3	15	--	--
5	6	30	15	1	2	13	2	2	15	2	3	15	--	--
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	2	15	2	2
5	6	96	15	1	2	13	2	2	15	2	3	15	--	--