LOWER COOK INLET PINK SALMON FORECAST FOR 1991

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Regional Information Report[1] No. 2H90-15
Alaska Department of Fish and Game
Division of Commercial Fisheries, Central Region
333 Raspberry Road
Anchorage, Alaska 99518-1599

October 1990

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ACKNOWLEDGEMENT

Linda Brannian reviewed the manuscript and provided valuable comments.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Total numbers of pink salmon (*Oncorhynchus gorbuscha*) returning to 12 Lower Cook Inlet streams or drainage systems was forecasted to be 1,365,689 in 1991. Log-log regression of return on escapement were used as models. Upper and lower 80% confidence limits for the forecast were 336,911 and 5,865,447. Total projected harvest was 1,030,559 pink salmon with a lower and upper range of 178,564 and 5,399,038. Port Chatham and the Ursus-Rocky Cove complex runs are forecast to be below their escapement goals.

KEY WORDS: *Oncorhynchus gorbuscha*, pink salmon, forecast, Lower Cook Inlet.

INTRODUCTION

This was the second year that a forecast of pink salmon (*Oncorhynchus gorbuscha*) run size was made for Lower Cook Inlet (Figure 1). Individual forecasts were made for 1991 runs to 12 harvest areas with historical records of commercial harvest and spawning escapement (Table 1). Forecasts for areas with hatchery returns (e.g. Tutka) made by the Division of Fisheries Rehabilitation, Enhancement, and Development are not included in this report but will be presented in a statewide forecast (Geiger and Savikko in press). The objective of this report is to explain the methods used to forecast for 1991 wild stocks runs to Lower Cook Inlet.

METHODS

The forecast for the Lower Cook Inlet management area was the sum of individual forecast for various harvest areas. Each area specific forecast of run size was the number of pink salmon expected to return in 1991 from the 1989 escapement. The harvest estimate was obtained by subtracting the escapement goal from the forecasted run size. If the forecasted run size is less than the escapement goal, the harvest estimate would be zero.

Forecasts of run size was made using model coefficients estimated from a log-log regression of return on escapement (Yuen 1989):

$$return_t = e^{a + b\,[\ln(escapement_{t-2})]},$$

where

$return_t$ = $catch_t$ + $escapement_t$
$escapement_{t-1}$ = parent year escapement for return in year t
a,b = regression coefficients,
e = 2.1783,
ln = natural logarithm, and
t = year.

Escapement and return data by brood year was based upon annual catch and escapement numbers presented in the Lower Cook Inlet Finfish Annual Management Report (e.g. Schroeder and Morrison 1990) (Appendices A-L). There were at least 15 areas in Lower Cook Inlet with long term records of pink salmon commercial harvest. Within these areas, there were 29 creeks, lagoons, and rivers with escapement goals (Table 1). Some harvest areas have only one spawning stream while others have multiple spawning streams and escapement goals. The assignment of spawning streams to harvest areas can be found in Table 1.

Although data were available from 1960 to 1990, not all years were used for each forecast. To determine which years to include for the final forecast, cross validations were made for each stream. To do this, a brood year was removed from the data file, a model was built from the remaining data, and a forecast was made for the excluded brood year. This was repeated systematically for all brood years. All brood years with cross validation errors in excess of 999% were classified as outliers and were removed from the data file. Cross validation was then repeated until there were no errors greater than 999%.

Area specific 80% confidence intervals were derived from the cross validation errors in the following manner,

$$\text{confidence interval} = e^{(\ln(\text{forecast}) \pm t\text{SE})}$$

where $t_{\alpha/2=0.1,n-1}$ = two-tailed Student's t distribution, P=20%, n-1 degrees of freedom,

n = number of cross validations or brood years in final data set,

$SE = \sqrt{(\sum_{i=1}^{n}[\text{error}_i]^2)}$, and

error_i = ln(cross validation for brood year i) - ln(observed run in year i+2).

The upper and lower range of the total Lower Cook Inlet forecast was then the sum of the respective confidence limits and escapement goal ranges. The point forecast used the average of the escapement range. If a range of escapement goals was not in effect, (Ursus and Rocky Cove, Resurrection Bay, and Rocky Bay) then the same escapement goal was used for the point and range forecasts (Table 3).

Cumulative probability distribution of forecast errors was based on the frequency distribution of the actual run size/cross validation forecast ratio. The frequency distribution was in increments of 0.2.

RESULTS

Ten of the 12 data sets had outliers that were excluded from the final spawner - return model. Five of the 12 log-log regression models were not statistically significant where $\alpha = 0.25$ (Humpy Creek, Seldovia Bay, Dogfish Bay, Port Chatham, Nuka Bay) (Figures 2-13 and Table 2). The forecasted run for 12 Lower Cook Inlet streams and drainage systems totaled 1,365,689. The lower end of the forecast range was 336,911 while the upper end of the range was 5,865,447. The corresponding projected catches were 1,030,559, 178,564, and 5,399,038. The point forecast for Port Graham and Rocky Bay were less than their escapement goals (Table 3).

DISCUSSION

This is the second year that the log-log models were used. The 1989 forecast were 49% greater than the actual 1990 pink salmon run (Table 4). Nine of the individual stream or drainage system forecasts were within their, albeit, wide 80% confidence intervals. Similar overforecast errors were also observed for hatchery stocks. However, reasons for the poor run of pink salmon in 1990 are not clear at this time.

The log-log regression model used to prepare the forecasts in this report have performed poorly in the cross validation. The frequency distribution of cross validation errors suggest that there is a 62% change that the 1991 run will be greater than the forecast. The individual probabilities of the 1991 runs being equal to or greater than the forecast is presented in Table 5.

Two drainage systems, Port Chatham and the Ursus and Rocky Cove complex had their largest escapements on record in 1989 and their runs were forecast beyond the range of data used to build the models. Consequently, the 1990 forecast should be used with caution. The very wide 80% confidence interval provide a measure of the uncertainty of the forecast.

LITERATURE CITED

Geiger, H.J. and H. Savikko. in press. Preliminary Forecasts and Projections for 1991 Alaska Salmon Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report. Juneau.

Schroeder, T.R. and R. Morrison. 1990. 1989 Lower Cook Inlet Annual Finfish Management Report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2H90-03. Homer.

Yuen, H.J. 1989. A comparison of Lower Cook Inlet pink salmon forecast methods. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2H89-10. Homer.

Table 1. Pink salmon harvest areas and streams with escapement goals in Lower Cook Inlet.

Harvest Area	Corresponding Escapement Stream(s)	Forecast
Humpy Creek	Humpy Creek	yes
Halibut Cove	none (hatchery releases)	no
Tutka Bay	Tutka Lagoon & hatchery release	no
Seldovia Bay	Seldovia River	yes
Port Graham Bay	Port Graham River	yes
Dogfish Bay	Dogfish Lagoon	yes
Port Chatham	Port Chatham Creeks	yes
Windy Bay	Windy Left & Windy Right Creeks	yes
Rocky Bay	Rocky River	yes
Port Dick Bay	Port Dick & Island Creek	yes
Nuka Bay	South Nuka, Desire Lake Creek, James Lagoon	yes
Resurrection Bay	Bear, Salmon, Mayor, Clear, Thumb, Humpy & Tonsina Creeks	yes
Bruin Bay	Bruin Bay River & Amakdedori Creek	yes
Rocky and Ursus Coves	Sunday and Brown's Peak Creek	yes
Iniskin and Cottonwood Bays	none (interception catches)	no
other	Big Kamishak, Little Kamishak, China Poot, Aialik Lagoon	no

Table 2. Pink salmon regression coefficients, sample sizes, SE, and outliers.

Area	a	b	SE of coefficient	Outliers[a]	n	r^2	F ratio
Humpy Creek	9.30953	0.19936	0.20286	67	28	0.036	0.97[b]
Seldovia Bay	5.46577	0.52524	0.27707	none	29	0.117	3.59[b]
Port Graham	5.51088	0.48470	0.16160	none	29	0.250	9.00
Dogfish Bay	4.11278	0.54722	0.28005	62,83,87	14	0.241	3.82[b]
Port Chatham	7.57148	0.27388	0.22588	61,70,72	18	0.084	1.47[b]
Windy Bay	0.64976	0.98979	0.13301	70	28	0.680	55.37
Rocky Bay	2.23786	0.78490	0.10997	63	28	0.662	50.94
Port Dick Bay	4.23537	0.76183	0.16619	70,72,85,86	25	0.477	21.01
Nuka Bay	8.26752	0.28611	0.18676	61,70,72,86	21	0.110	2.35[b]
Resurrection Bay	4.53397	0.64767	0.17834	86	15	0.504	13.19
Bruin Bay	4.47615	0.67927	0.15396	63,81,86	17	0.565	19.47
Ursus and Rocky Cove	4.80122	0.56492	0.14914	72,88	24	0.395	14.35

[a] Brood year.
[b] F ratio not significant, $\alpha = 0.25$.

Table 3. Pink salmon forecasts, 80% confidence limits, projected harvests, and estimated escapement shortfalls for 1991, Lower Cook Inlet.

Location	1989 escapement	lower range			point			upper range			escapement shortfall		
		forecast	esc goal	harvest	forecast	esc goal	harvest	forecast	esc goal	harvest	lower	point	upper
Humpy Creek	93,000	33,997	25,000	8,997	108,038	37,500	70,538	343,325	50,000	293,325	0	0	0
Seldovia Bay	26,200	13,760	25,000	0	49,478	30,000	19,478	177,915	35,000	142,915	11,240	0	0
Port Graham	19,100	9,289	20,000	0	29,400	30,000	0	93,053	40,000	53,053	10,711	600	0
Dogfish Bay	200	185		185	1,110		1,110	6,671		6,671	0	0	0
Port Chatham	31,700	9,412	10,000	0	33,191	12,500	20,691	117,047	15,000	102,047	588	0	0
Windy Bay	31,800	13,819	40,000	0	54,785	50,000	4,785	217,199	60,000	157,199	26,181	0	0
Rocky Bay	10,300	3,772	50,000	0	13,231	50,000	0	46,410	50,000	0	46,228	36,770	3,590
Port Dick	62,100	100,179	20,000	80,179	309,672	60,000	249,672	957,257	100,000	857,257	0	0	0
Nuka Bay	59,200	21,584	10,000	11,584	90,358	15,000	75,358	378,265	20,000	358,265	0	0	0
Resurrection Bay	9,000	8,296	30,000	0	33,895	30,000	3,895	138,484	30,000	108,484	21,704	0	0
Bruin Bay	352,000	93,950	25,000	68,950	514,735	37,500	477,235	2,820,131	50,000	2,770,131	0	0	0
Ursus & Rocky Cove	223,000	28,669	20,000	8,669	127,799	20,000	107,799	569,691	20,000	549,691	0	0	0
	917,600	336,911	275,000	178,564	1,365,689	372,500	1,030,559	5,865,447	470,000	5,399,038	116,653	37,370	3,590

Table 4. Forecast and actual pink salmon runs, Lower Cook Inlet, 1990.

Location	1990 Forecast			actual	error
	lower end of forecast interval	forecast	upper end of forecast interval		
Humpy Creek	26300	82900	261400	27042	2.07
Seldovia Bay	10200	39600	152700	31292	0.27
Port Graham	5400	18400	62700	20053	-0.08
Dogfish Bay	226	1060	4969	7067	-0.85[a]
Port Chatham	8189	32514	129096	49925	-0.35
Windy Bay	1895	7742	31634	14618	-0.47
Rocky Bay	9900	31400	99500	18250	0.72
Port Dick Bay	28578	102087	364681	243988	-0.58
Nuka Bay	15006	62838	263137	18647	2.37
Resurrection Bay	2237	7367	24263	9706	-0.24
Bruin Bay	65634	190916	555338	19797	8.64[b]
Ursus and Rocky Cove	36467	115091	363229	3380	33.05[b]
	210032	691915	2312647	463765	0.49

[a] Actual run size greater than upper bound of forecast interval.
[b] Actual run size less than lower bound of forecast interval.

Table 5. Probability of 1991 run being equal to or greater than forecast.

Location	Probability of Forecast or Greater
Humpy Creek	.68
Seldovia Bay	.58
Port Graham	.66
Dogfish Bay	.71
Port Chatham	.55
Windy Bay	.57
Rocky Bay	.54
Port Dick	.64
Nuka Bay	.62
Resurrection Bay	.66
Bruin Bay	.59
Ursus and Rocky Cove	.63

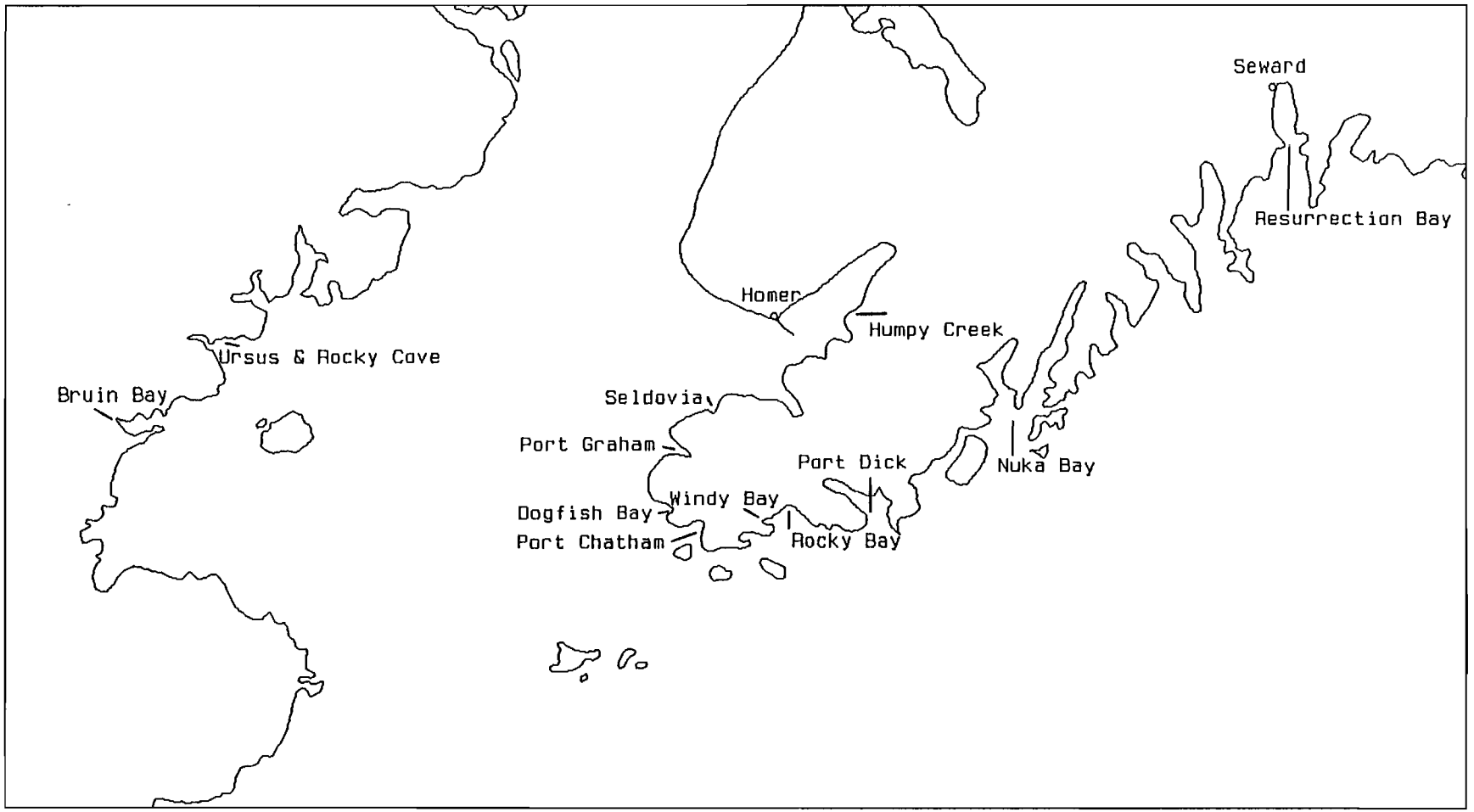

Figure 1. Pink salmon streams in Lower Cook Inlet with formal forecast.

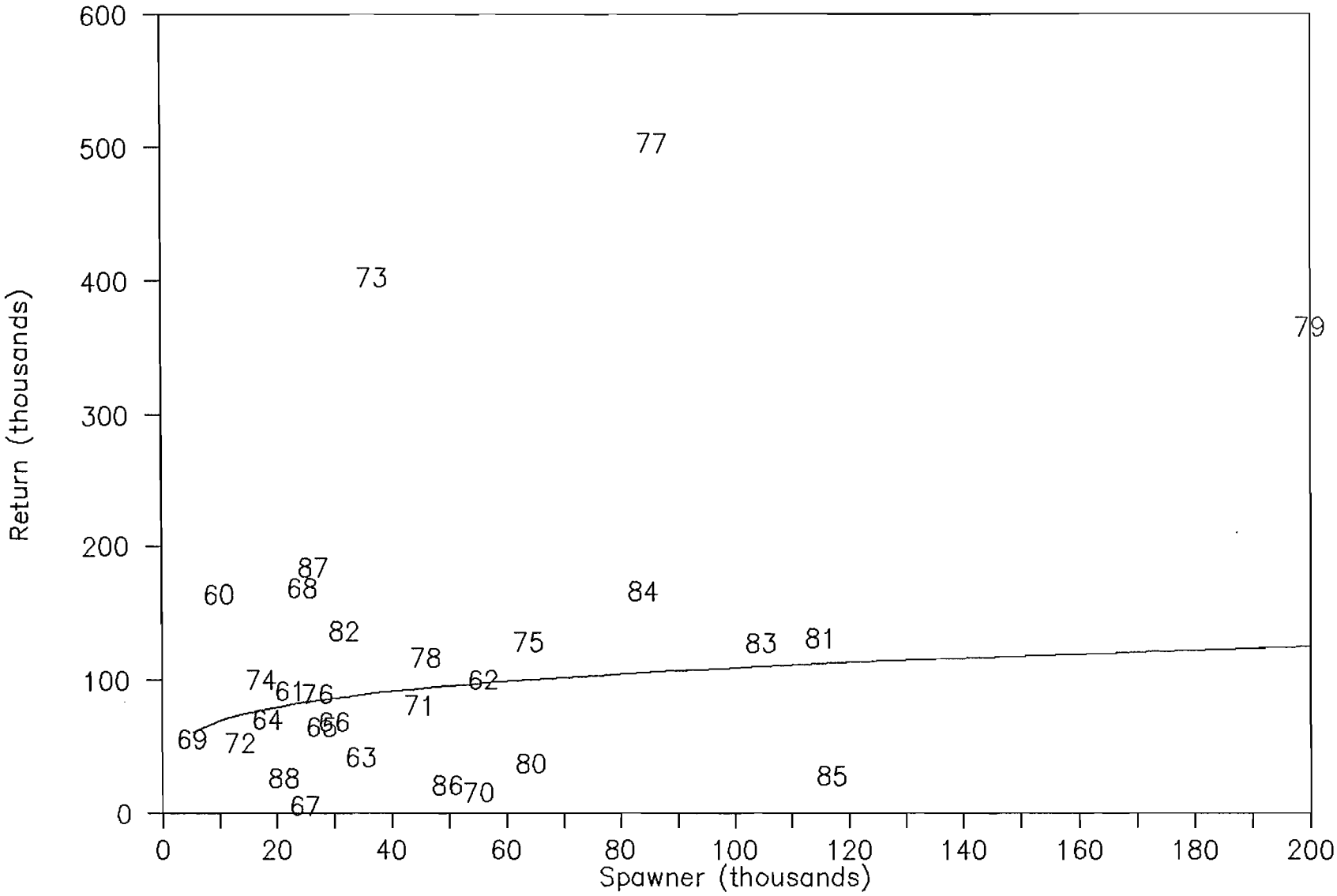

Figure 2. Humpy Creek spawner–return relationship.

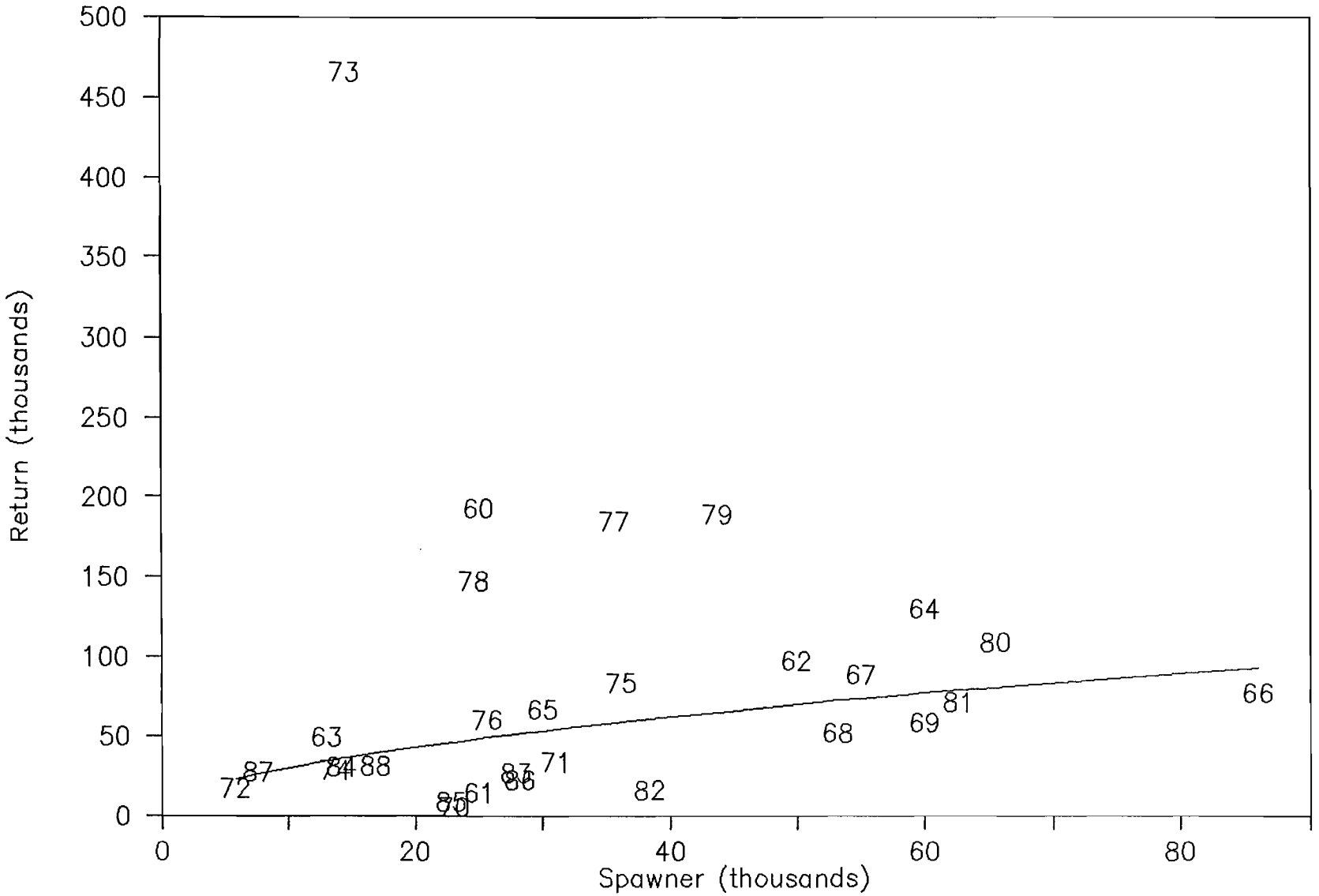

Figure 3. Seldovia Bay spawner–return relationship.

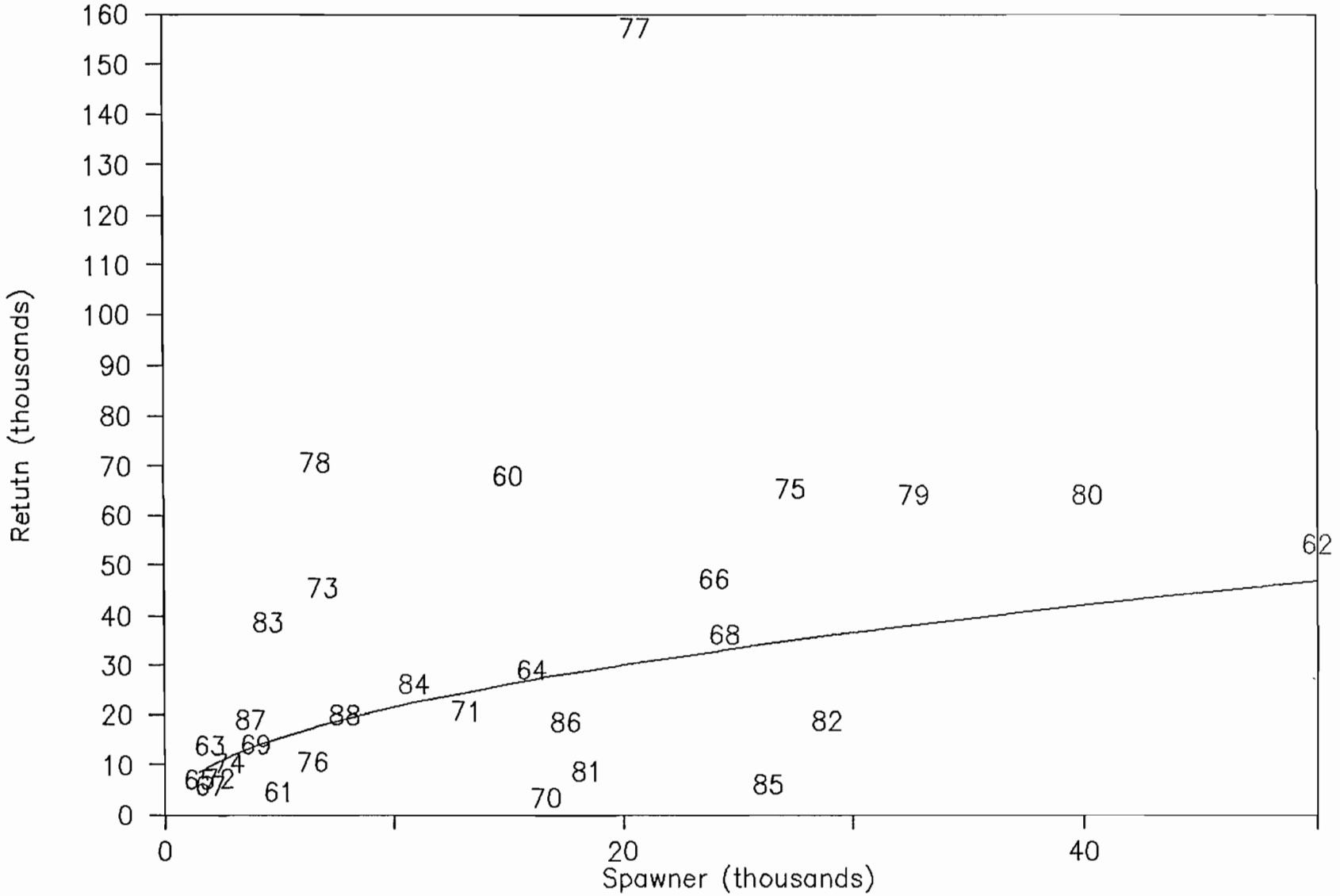

Figure 4. Port Graham spawner–return relationship.

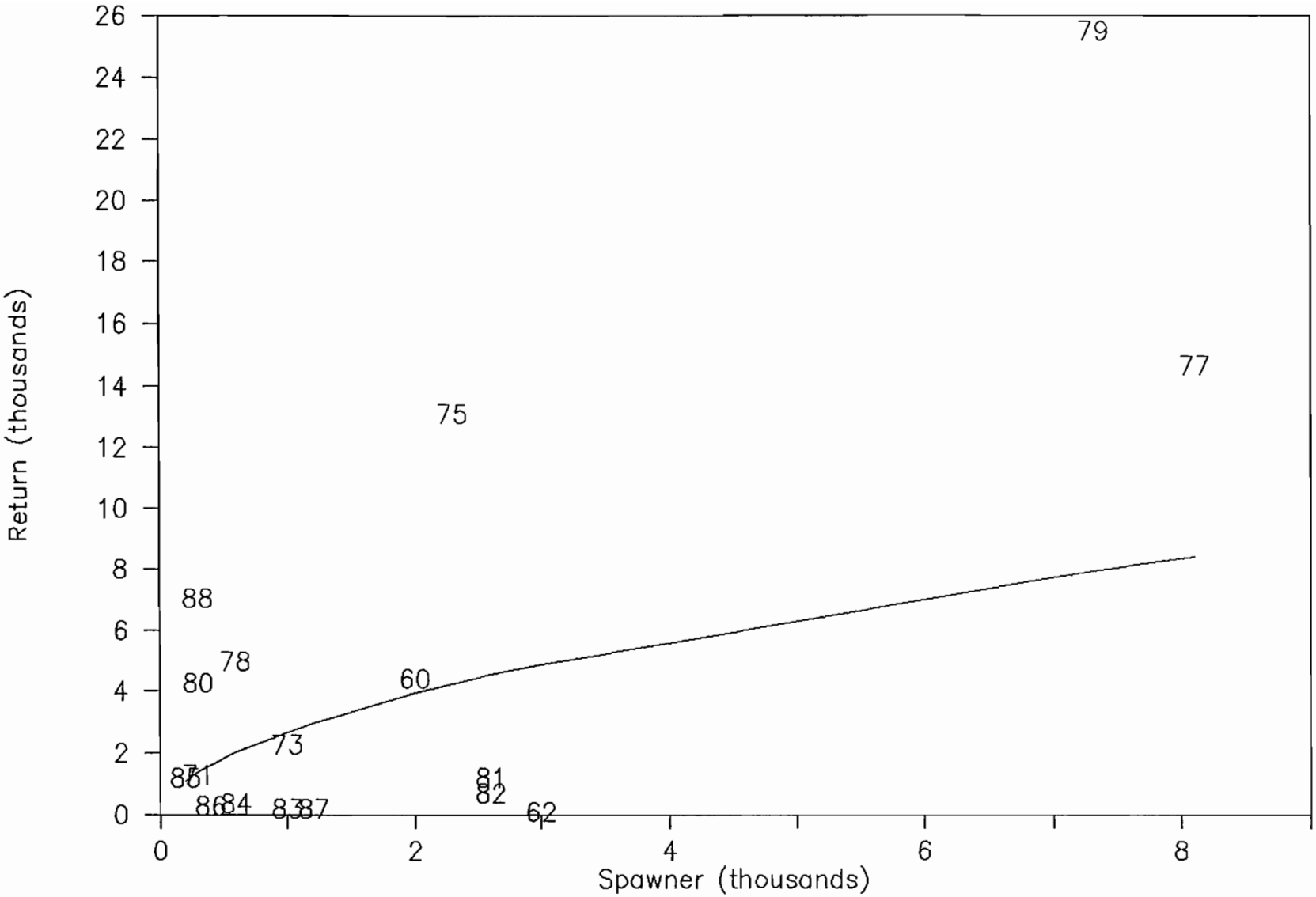

Figure 5. Dogfish Bay spawner–return relationship.

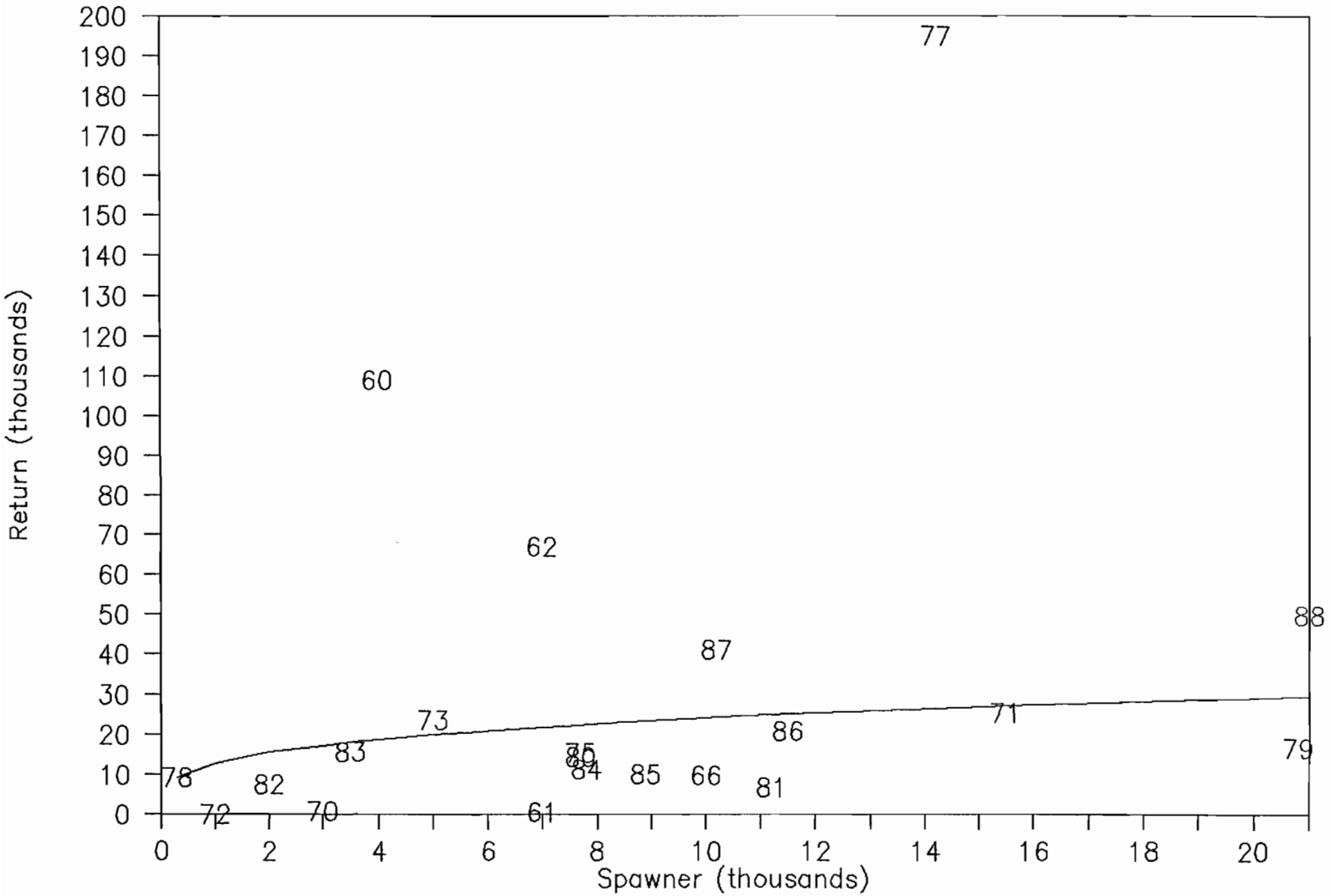

Figure 6. Port Chatham spawner–return relationship.

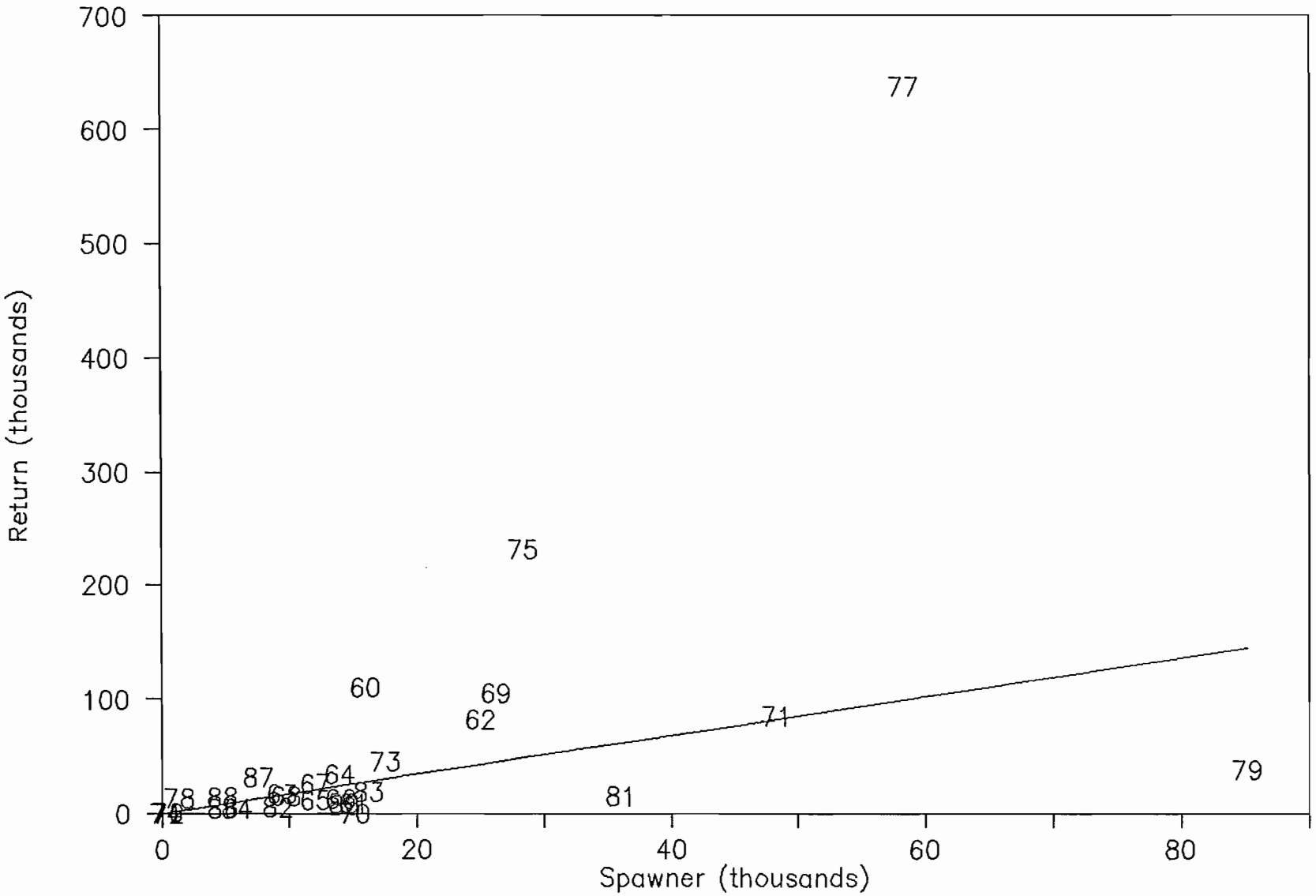

Figure 7. Windy Bay spawner–return relationship.

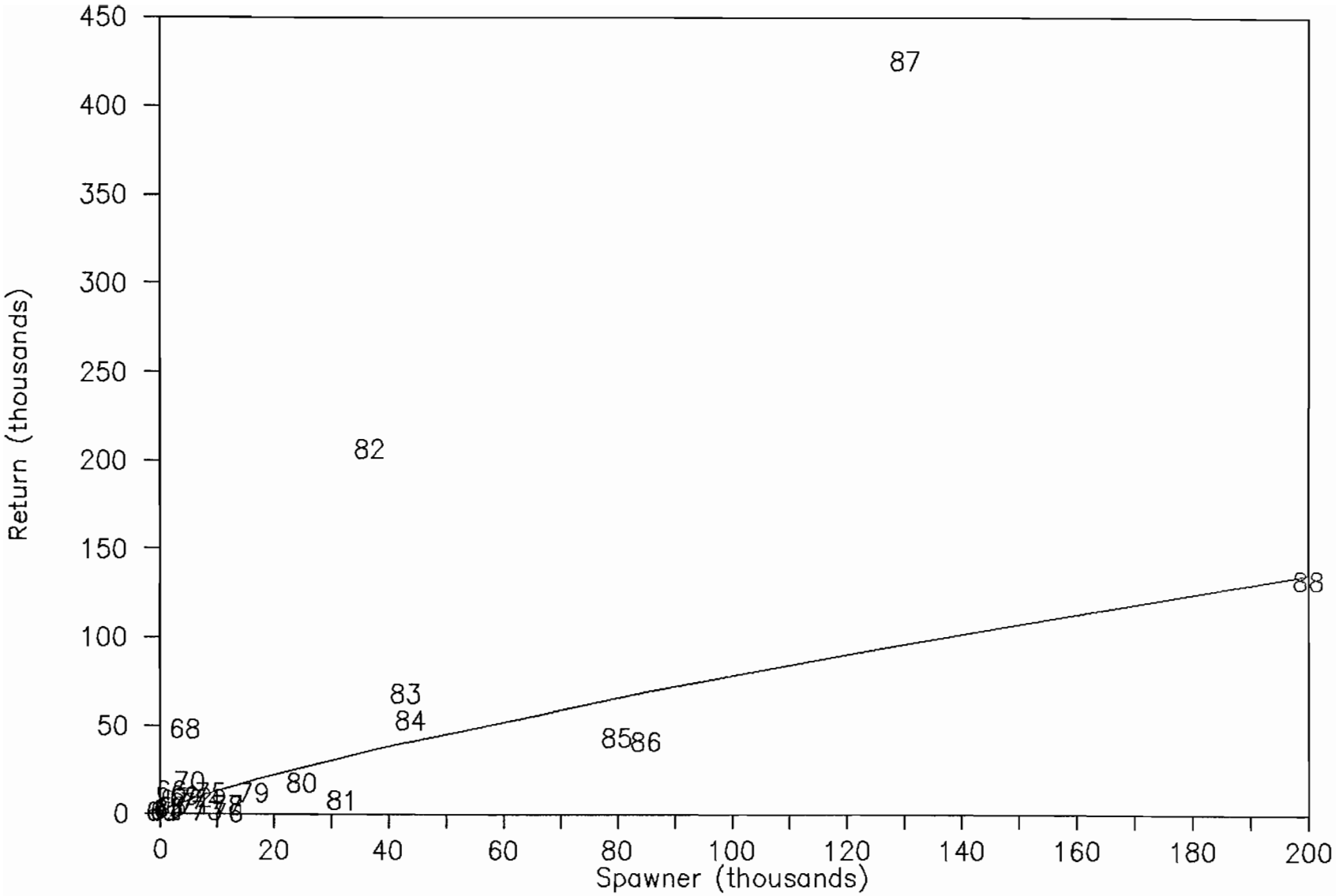

Figure 8. Rocky Bay spawner–return relationship.

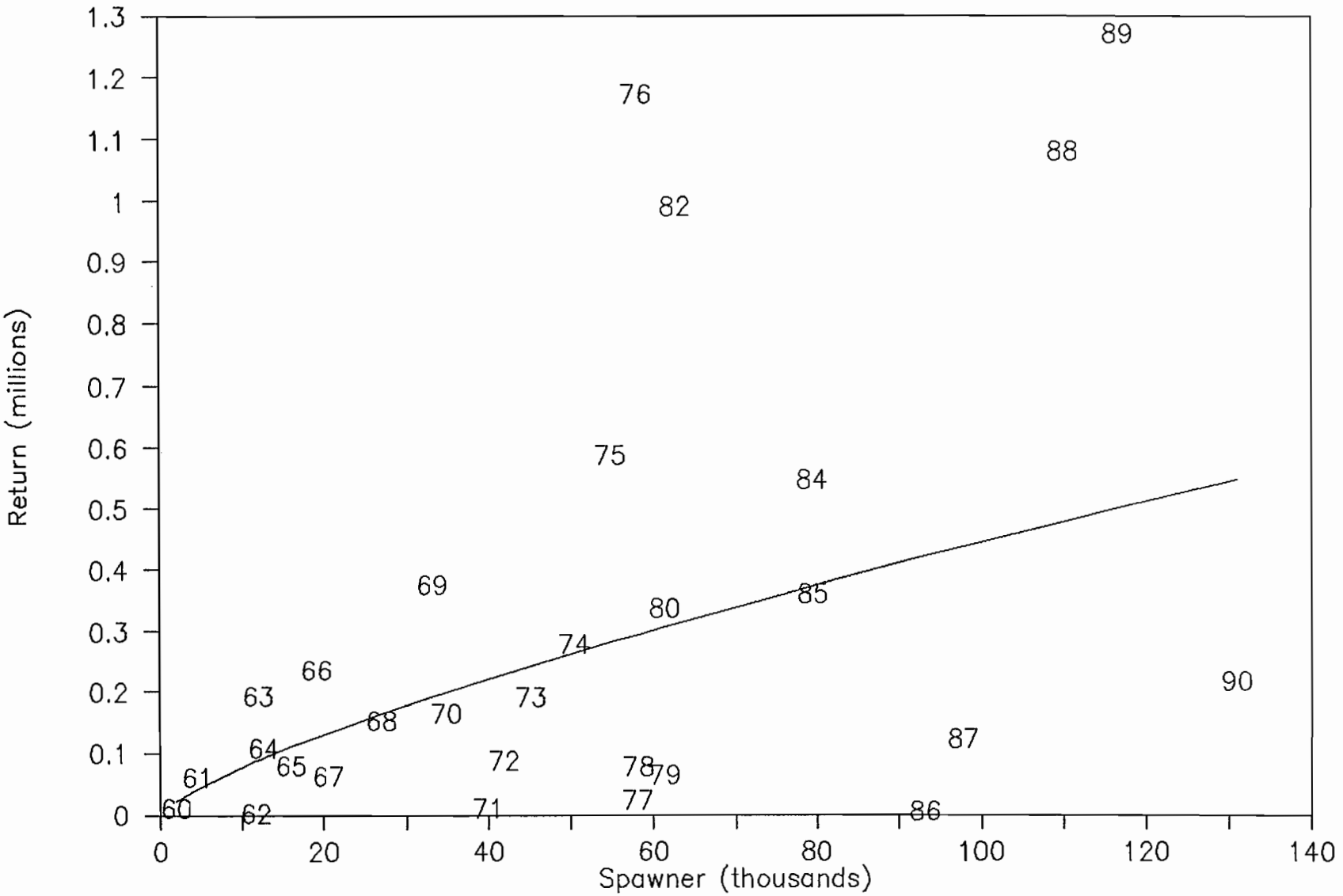

Figure 9. Port Dick spawner–return relationship.

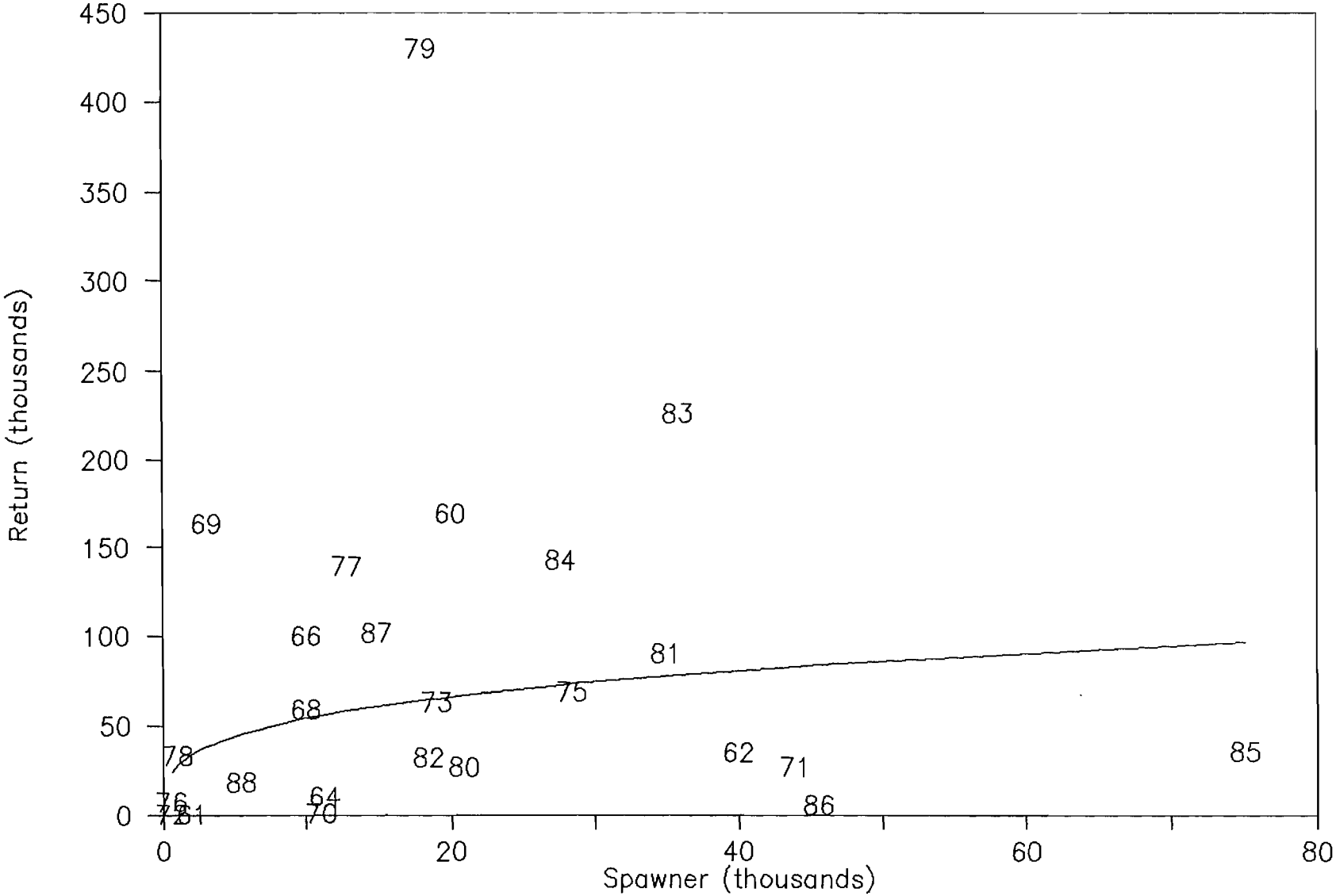

Figure 10. Nuka Bay spawner–return relationship.

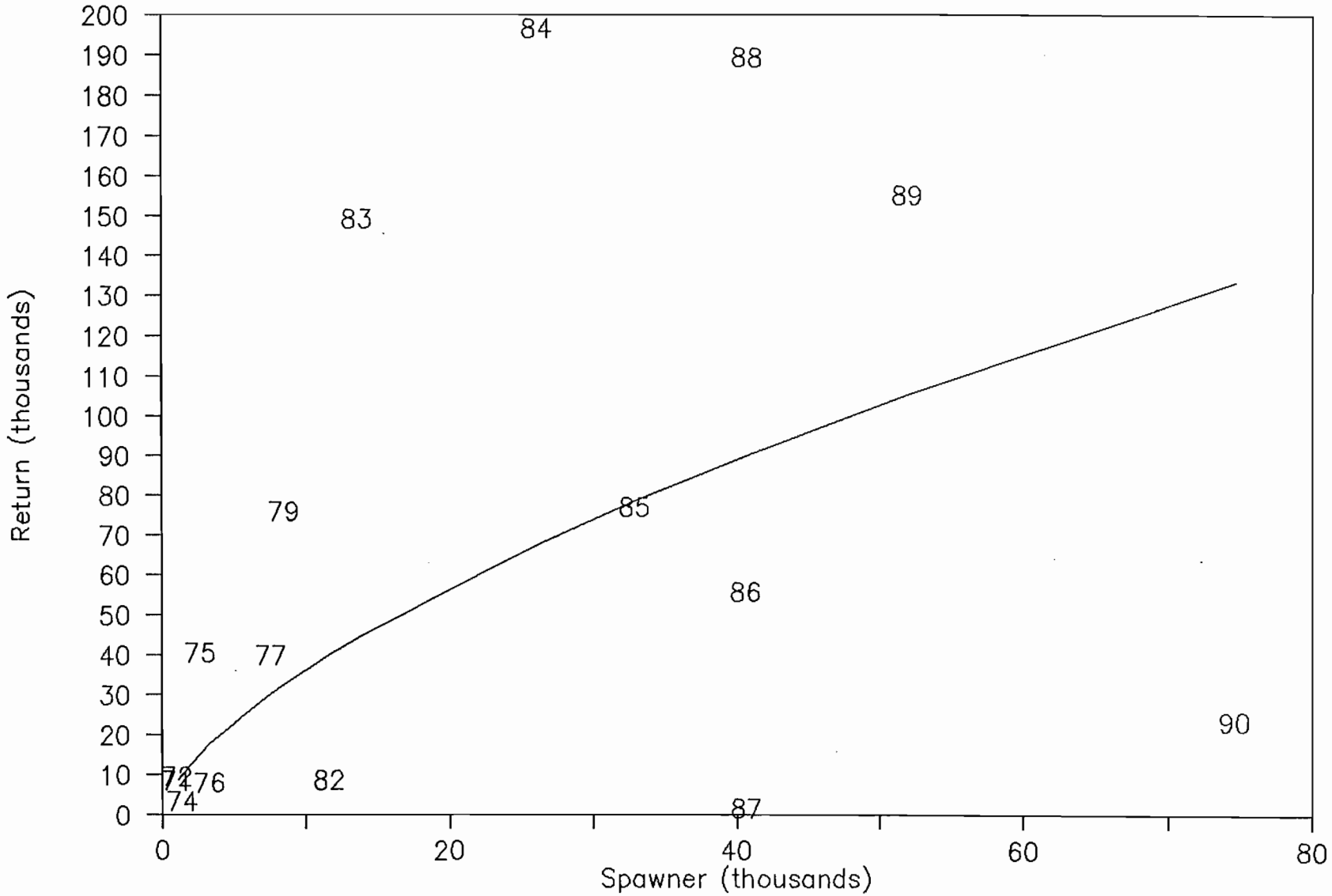

Figure 11. Resurrection Bay spawner–return relationship.

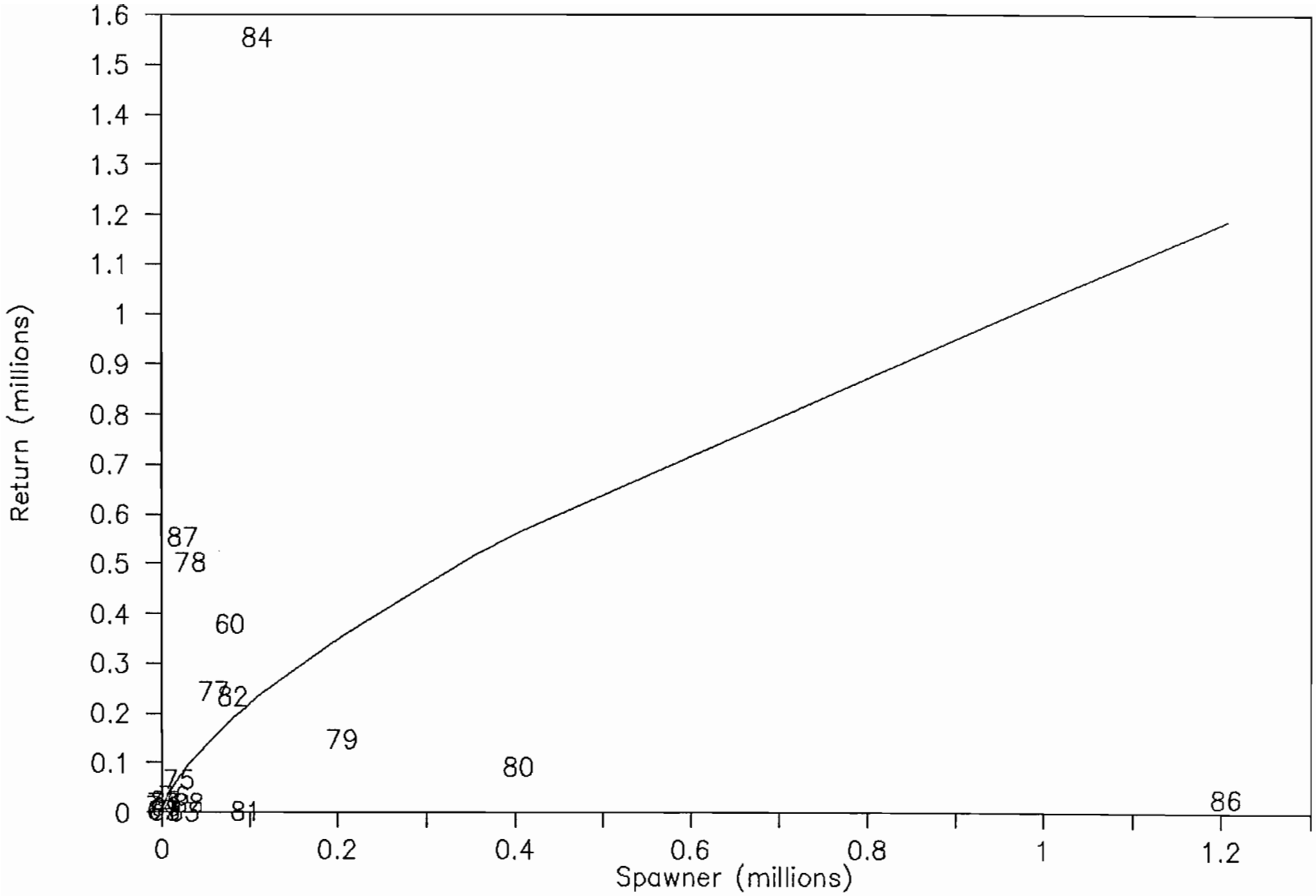

Figure 12. Bruin Bay spawner–return relationship.

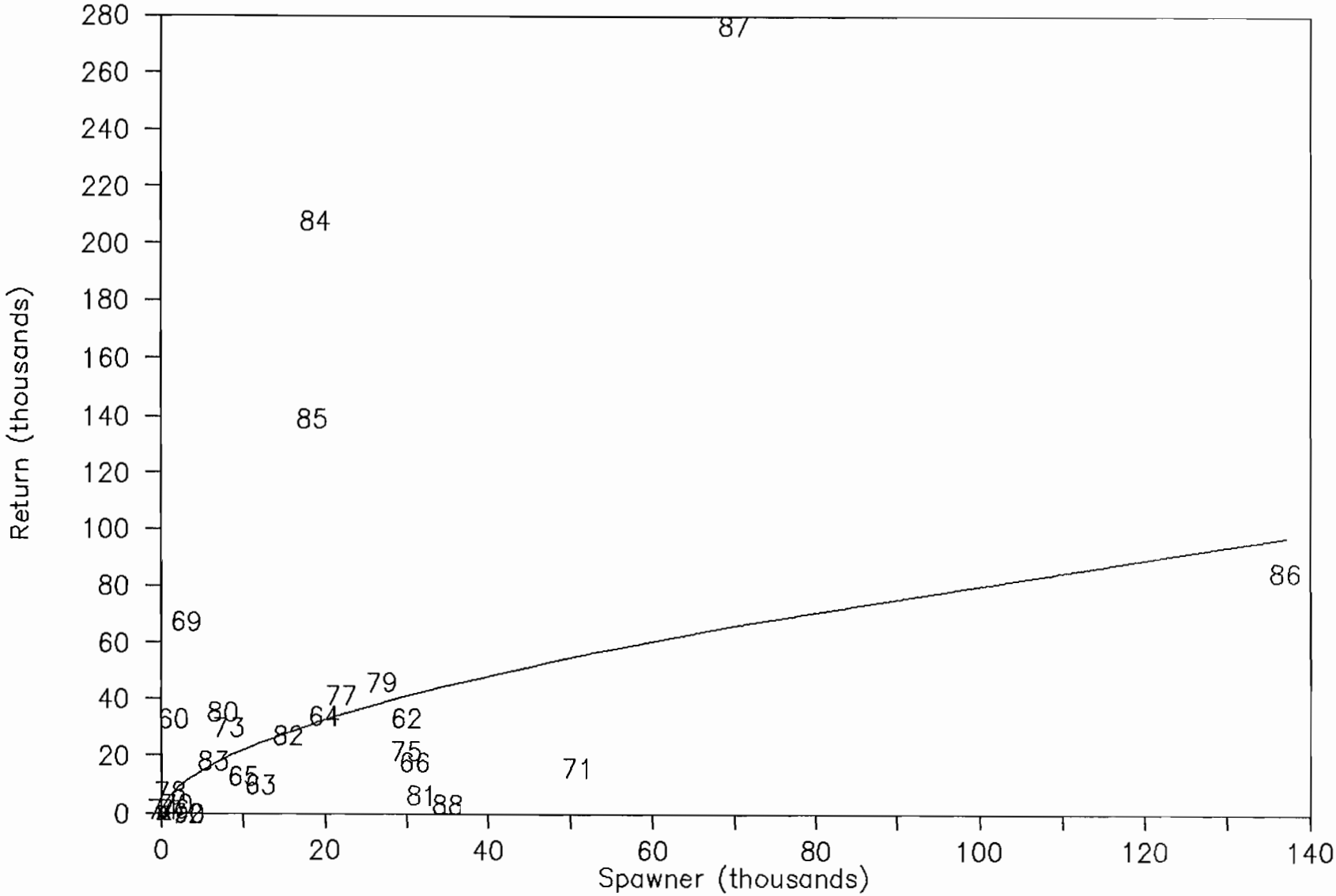

Figure 13. Ursus and Rocky Cove spawner–return relationship.

Appendix A. Escapement and return data used to forecast 1991 pink salmon returns to Humpy Creek.

Brood Year	Escapement	Return
60	10,000	164,800
61	22,600	92,100
62	56,000	100,900
63	34,700	41,800
64	18,500	70,700
65	28,000	65,400
66	30,000	68,600
68	24,700	169,300
69	5,400	56,400
70	55,200	15,900
71	45,000	81,200
72	13,800	52,800
73	36,900	403,300
74	17,400	100,300
75	64,000	128,700
76	27,200	90,100
77	86,000	504,000
78	46,100	117,700
79	200,000	365,900
80	64,400	37,900
81	115,000	131,700
82	31,900	137,700
83	104,800	128,400
84	84,200	166,400
85	117,000	28,600
86	49,700	21,400
87	26,600	184,400
88	21,400	27,000

Appendix B. Escapement and return data used to forecast 1991 pink salmon returns to Seldovia.

Brood Year	Escapement	Return
60	25,000	192,800
61	25,000	14,600
62	50,000	97,400
63	13,000	49,200
64	60,000	130,100
65	30,000	66,700
66	86,000	76,800
67	55,000	88,800
68	53,200	52,000
69	60,000	58,400
70	23,000	6,000
71	31,100	33,900
72	5,800	17,200
73	14,500	465,800
74	13,700	28,600
75	36,200	83,300
76	25,600	60,400
77	35,700	184,500
78	24,600	147,200
79	43,700	189,100
80	65,500	108,700
81	62,700	71,200
82	38,400	16,400
83	27,900	26,600
84	14,200	31,000
85	22,800	8,800
86	28,200	22,400
87	7,600	27,300
88	16,900	31,292

Appendix C. Escapement and return data used to forecast 1991 pink salmon returns to Port Graham.

Brood Year	Escapement	Return
60	15,000	68,100
61	5,000	4,700
62	50,000	54,400
63	2,000	13,900
64	16,000	29,100
65	1,500	7,100
66	24,000	47,400
67	2,000	6,000
68	24,400	36,200
69	4,000	14,200
70	16,600	3,500
71	13,200	20,900
72	2,400	7,300
73	7,000	45,600
74	2,800	10,400
75	27,300	65,400
76	6,500	10,700
77	20,600	157,400
78	6,700	70,700
79	32,700	64,300
80	40,200	64,300
81	18,400	8,700
82	28,900	18,900
83	4,600	38,800
84	10,900	26,300
85	26,300	6,100
86	17,500	18,600
87	3,800	19,100
88	7,900	20,053

Appendix D. Escapement and return data used to forecast 1991 pink salmon returns to Dogfish Bay.

Brood Year	Escapement	Return
60	2,000	4,400
71	300	1,300
73	1,000	2,300
75	2,300	13,100
77	8,100	14,700
78	600	5,000
79	7,300	25,500
80	300	4,300
81	2,600	1,200
82	2,600	700
84	600	400
85	200	1,200
86	400	300
88	300	7,067

Appendix E. Escapement and return data used to forecast 1991 pink salmon returns to Port Chatham.

Brood Year	Escapement	Return
60	4,000	109,200
62	7,000	67,100
66	10,000	10,000
71	15,500	25,600
73	5,000	23,700
75	7,700	15,600
77	14,200	195,200
78	300	9,500
79	20,800	17,000
80	7,700	14,600
81	11,200	6,800
82	2,000	7,800
83	3,500	15,900
84	7,800	11,500
85	8,900	10,200
86	11,500	21,000
87	10,200	41,400
88	21,000	49,925

Appendix F. Escapement and return data used to forecast 1991 pink salmon returns to Windy Bay.

Brood Year	Escapement	Return
60	16,000	110,500
61	15,000	9,400
62	25,000	82,500
63	9,400	17,400
64	13,900	34,100
65	12,000	12,000
66	14,000	13,100
67	12,000	26,200
68	9,700	15,900
69	26,200	105,700
71	48,400	86,000
72	500	200
73	17,500	46,500
74	200	400
75	28,400	231,600
76	400	1,400
77	58,400	637,900
78	1,400	14,200
79	85,200	38,900
80	14,200	9,100
81	36,000	16,200
82	9,100	5,900
83	16,200	19,100
84	5,900	4,700
85	14,300	7,600
86	4,700	4,700
87	7,600	31,800
88	4,700	14,618

Appendix G. Escapement and return data used to forecast 1991 pink salmon returns to Rocky Bay.

Brood Year	Escapement	Return
60	130,000	425,900
61	2,000	13,400
62	200,000	133,200
64	80,000	44,000
65	300	1,000
66	44,000	53,900
67	1,000	1,000
68	43,100	68,800
69	1,000	1,700
70	32,000	8,200
71	1,600	2,200
72	8,200	1,500
73	2,000	4,400
74	1,500	2,700
75	4,400	48,300
76	2,700	8,200
77	36,700	207,200
78	8,200	7,800
79	85,000	41,500
80	6,400	6,600
81	25,000	17,900
82	6,600	9,000
83	16,600	12,100
84	9,000	12,000
85	12,100	4,500
86	12,000	5,400
87	4,500	10,300
88	5,400	18,250

Appendix H. Escapement and return data used to forecast 1991 pink salmon returns to Port Dick Bay.

Brood Year	Escapement	Return
60	58,200	1,173,300
61	16,000	80,500
62	55,000	587,800
63	61,500	65,800
64	61,500	338,800
65	50,500	280,400
66	42,000	88,300
67	20,500	63,600
68	33,300	376,500
69	12,100	192,500
71	97,900	123,500
73	26,900	153,200
74	2,000	12,700
75	62,900	991,600
76	12,700	108,900
77	109,900	1,081,400
78	45,300	191,600
79	116,600	1,271,900
80	58,300	78,900
81	131,000	219,400
82	34,900	164,200
83	79,400	548,800
84	79,600	362,200
87	4,600	62,100
88	19,200	235,762

Appendix I. Escapement and return data used to forecast 1991 pink salmon returns to Nuka Bay.

Brood Year	Escapement	Return
60	20,000	169,800
62	40,000	35,100
64	11,300	10,000
66	10,000	100,200
68	10,000	59,400
69	3,000	163,700
71	44,000	27,100
73	19,000	63,800
75	28,400	69,100
76	600	7,300
77	12,800	139,700
78	1,000	33,700
79	18,000	430,100
80	20,900	27,100
81	35,000	90,800
82	18,400	32,000
83	35,800	225,900
84	27,600	143,400
85	75,100	35,800
87	14,900	102,200
88	5,400	18,647

Appendix J. Escapement and return data used to forecast 1991 pink salmon returns to Resurrection Bay.

Brood Year	Escapement	Return
60	1,400	3,400
62	3,300	8,200
68	7,600	40,200
72	1,100	8,500
74	8,500	76,000
76	40,600	55,800
78	26,100	196,500
80	40,700	189,300
81	2,700	40,700
82	51,900	155,200
83	13,600	149,300
84	32,900	77,200
85	74,700	23,400
87	11,600	9,000
88	1,100	9,706

Appendix K. Escapement and return data used to forecast 1991 pink salmon returns to Bruin Bay.

Brood Year	Escapement	Return
60	78,000	380,000
67	500	5,000
69	5,000	11,700
73	2,000	20,000
74	600	13,500
75	20,000	66,200
76	13,500	33,900
77	60,000	246,300
78	33,900	504,400
79	206,000	148,400
80	403,800	94,600
82	81,300	235,200
83	4,200	4,500
84	110,000	1,555,700
85	4,500	25,600
87	24,400	554,800
88	30,000	19,847

Appendix L. Escapement and return data used to forecast 1991 pink salmon returns to Ursus and Rocky Cove.

Brood Year	Escapement	Return
60	1,500	33,200
62	30,000	33,500
63	12,000	10,000
64	20,000	33,900
65	10,000	13,000
66	31,000	18,000
69	3,000	67,400
70	2,000	3,200
71	51,000	16,100
73	8,200	30,000
74	200	1,500
75	30,000	22,000
76	1,500	1,200
77	22,000	41,400
78	1,100	7,500
79	27,000	46,000
80	7,500	35,700
81	31,900	6,400
82	15,500	27,300
83	6,400	18,400
84	18,800	208,100
85	18,400	139,300
86	137,000	84,900
87	69,900	276,800