Effect of Trap Soak-Time on the Trap-Selectivity Profile and By-Kill in Prawn-Trap Fisheries

Christopher S. Wright – Associate Professor, Faculty of Business Administration, Lakehead University, 955 Oliver Rd. Thunder Bay, Ont., P7B 5E1

Peter Panek – Graduate Student, Institute of Fisheries Analysis, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6

Abstract: Canada's Department of Fisheries and Oceans seeks to manage British Columbia's prawn fishery by limiting the season length, vessel entry, and the number of prawn traps per vessel. However, fishers can still adjust their effort by increasing the number of trap lifts during the season.

This study examines the effect of trap soak-time on size-selectivity, looks at how it translates to by-kill, and reviews the traditional management responses. The management recommendations in this paper focus on optimizing the interaction between CPUE, by-kill, enforcement costs, and fisher responses.

Peer's law (the solution to a problem changes the problem) predicts that trying to solve a fishery common-property resource problem only changes the problem's expression. Thus, *limiting entry* changes a *too-many-fishers* issue to a *capital-stuffing* problem, *limiting gear* changes a *capital-stuffing* problem to a *gear-use* issue, and regulating gear use leads to other problems and ever more micro-management. Thus, regulation and related costs have become part of the problem of rent dissipation and poverty in fishery dependent communities.

Efforts to fine-tune regulations in BC's prawn fishery have led to an ever expanding spiral of costly, clumsy, and intrusive regulations, enforcement, and related procedures that dissipate resource rents, frustrate fishers, and ultimately are ineffective in protecting the resource and/or the associated jobs. The best way out of this morass appears to be for managers of sedentary species to confine their efforts to macro-management regulations that focus on limiting the consequences of fishing and ensuring that individual fishers endure the consequences of their actions.

Keywords: Prawn fishery, by-kill, gear-use, selectivity profile, soak-time, rent-dissipation.

1.0 Introduction -- The Nature of The Problem

The Canadian Department of Fisheries and Oceans (DFO) manages fishing effort in British Columbia's (BC) prawn fisheries by clever and well-crafted rules and regulation.

Peer's Law (the solution to a problem changes the problem) predicts that trying to solve a fishery's common-property resource problem only changes the problem's expression. Thus, it is predicable that some fishers have responded to new lift limits by escalating their trap-lifts.

Increased trap-lifts increase fishing effort, aggravates by-kill effects, and imposes a "growth-over-fishing" problem on the prawn trap fishery (Cushing, 1972; Gulland, 1983, pp.9-10; Copes, 1986, pp.51 -53; Hilborn and Walters, 1992, pp.73-74; Boutillier and Bond, 1999, p.1).

Anecdotal data, on prawn by-kill, indicates that large numbers of the small sub-legal prawns drawn to a trap during the early soak hours are driven off as larger prawns move into the trap. Thus, the by-kill (unlanded fishing mortality) should vary inversely with the trap soak-time.

DFO responded to the trap-lift escalation by imposing a *one-lift-limit*/day/trap. However, the process is unfinished -- at dusk, the larger prawns tend to vertically migrate from deep water (≥ 90 metres) to the shallows (25 to 55 metres) and return to deep water before dawn (Boutillier, 1986, p.178).

Thus, the depth at which traps are placed and the timing of the lift during the day likely has a significant effect on how long prawns are retained within the trap (e.g. traps lifted from shallow waters at dawn will have prawns that have been in the trap for 12 hours or less; traps lifted at dusk will have prawns that have been retained in the trap for 12 to 24 hours -- deep water traps will tend to provide the converse).

The tendency to engage in regulatory tag in fisheries has generated an ever expanding spiral of costly, clumsy, and intrusive fishing regulations and/or enforcement that dissipate resource rents, frustrate fishers, and ultimately are ineffective in protecting the resource and/or associated jobs.

This paper examines the regulatory-tag debacle in the BC Prawn (*Pandalus platyceros*) trap fishery by reviewing technical issues in the fishery (e.g. optimum: harvests; size at recruitment to the fishable stock; lift time and soak timing of traps) and then, after considering the behaviours that the fishery managers can expect, makes management recommendations.

2.0 Fishery Background

The trap fishery on BC Prawns (*Pandalus platyceros*) has a long history -- incidental catches were reported in 1887 (Mowat, 1888; Butler, 1980; Boutillier, 1985, p.13). Effort in the BC prawn fishery increased from 50 vessels in 1979 to over 300 in 1984. Licence limitation was implemented in 1990 -- in 1995 258 vessels had licences. Minimum escapement regulation caused the fishing season to decline from 230 days in 1994 to 93 days in 1998. Vessels range from 5 to 35 metres and (until 1995, when traps were limited in the south coast to 300 per vessel) work between 40 and 1,500 traps. In 1995, 78,000 traps were fished in BC's prawn fishery (Mikkeksen, 1996, p.2). "The traps fall into about 13 basic categories with respect to construction material, size and shape" (Boutillier, 1985, p.13). Traps are fished at 15 to 250 metres, are sometimes baited and before 1999 were soaked from 3-96 hours between lifts. A minimum retention size limit (introduced in 1996) increased in 1996 from a carapace length of 32mm to 33mm. BC Prawn landings have risen from 400 tonnes in 1980 to around 1800 tonnes in 1996 and 1997.

2.1 A Simple Economic Model Of The Prawn Fishery

Given the biology of the BC prawn stock, it is likely to behave like a "non-self-regulating" stock throughout the relevant range of managed effort. Thus, a Schaefer Curve (1954, 1957a, and 1957b) is appropriate:

$$H = k(1-e^{-cE}) \qquad (1)$$

K = maximum stock size
c = a parameter

Fitting such a curve requires data for a wide range of effort that avoids short-run stock effects (e.g. fishing-up and fishing-down stocks). Catch and standardized effort data are available for a range of efforts in the Howe Sound areas (28-3,4,5 and part of 28-1) that were closed to fishing in 1988).

TABLE 1: Annual Catch and Effort Data for Howe Sound, BC (Boutillier, 1993, p.3)

YEAR	LIFTS	CATCH #S	CPUE
1985	40,864	428,465	10.49
1986	32,766	327,909	10.32
1987	44,909	427,969	9.53
1988	9,528	62,388	6.55
1989	563	14,415	25.60
1990	1,072	27,907	26.03
1991	861	26,631	30.93
1992	437	13,238	30.29

In terms of estimating a Schaefer curve, data from 1985-87 and 1991-92 is useful and (using rules suggested by Copes, 1978, pp.25-27) the stock rebuilding years of 1988-90 are excluded from the regression -- it is always better to be approximately right than to be precisely wrong. Given that the error term is likely log-normal, the data was regressed using the following restatement of eqn (1):

$$\ln(H) = \ln(k) + \ln(1-e^{-cE}) \qquad (1a)$$

The results of the regression are: $R^2 = 99.73\%$;
Durban-Watson Stat. = 2.9693; LM Stat=0.56576E-09
Parameter -- values: ln(k) = 12.947, c = 0.000074018
-- t-stat: (227.63) (11.120)

$$H = 419576(1 - e^{(-0.00007418E)}) \qquad (1b)$$

In spring 2000, cash buyers on the fishing grounds were offering fishers \$8.50 to \$9.00 per pound for unsorted live and fresh prawns (\$19.26/kg). Assuming a mean weight of 30 grams, the revenue curve for the Howe Sound prawn fishery can be estimated as:

$$R = kPW(1-e^{-cE}) \qquad (2)$$

P = price (\$19.29/kg)
W = mean weight (.030 kg)

$$R = 419576(\$19.29)(.030)(1 - e^{(-0.00007418E)}) \qquad (2a)$$

This simple model measures fishing effort in terms of the number of trap lifts (equally spaced through a fishing day). The cost of fishing effort can be estimated at roughly \$900 per vessel per day. If vessels are limited to 300 traps and one trap-lift/trap/day, then each trap lift costs \$3.00 and Howe Sound's prawn fishery net income can be defined as:

$$Y = kPW(1-e^{-cE}) - ÇE \qquad (3)$$

Ç = cost of fishing effort (\$3/trap-lift)

$$Y = 419576(\$19.29)(.030)(1-e^{(-.00007418E)}) - \$3E \qquad (3a)$$

The MEY harvest is defined by differentiating eqn (3) with respect to fishing effort, setting the differential to nil, and reorganizing the result to:

$$E^* = -\ln(Ç/(ckPW))/c \quad (4)$$

$$E^* = 24{,}186 \text{ lifts per year} \quad (4a)$$

At MEY, in this simple model, the Howe Sound Prawn fishery yields total gross revenues of $202,436 and a net income of $129,878 net income shared by two vessels, fishing a 40-day season. At the Open Access Equilibrium $242,700 of gross revenue are shared by 6.73 vessels, fishing a 40 day season (by definition, net income is nil).

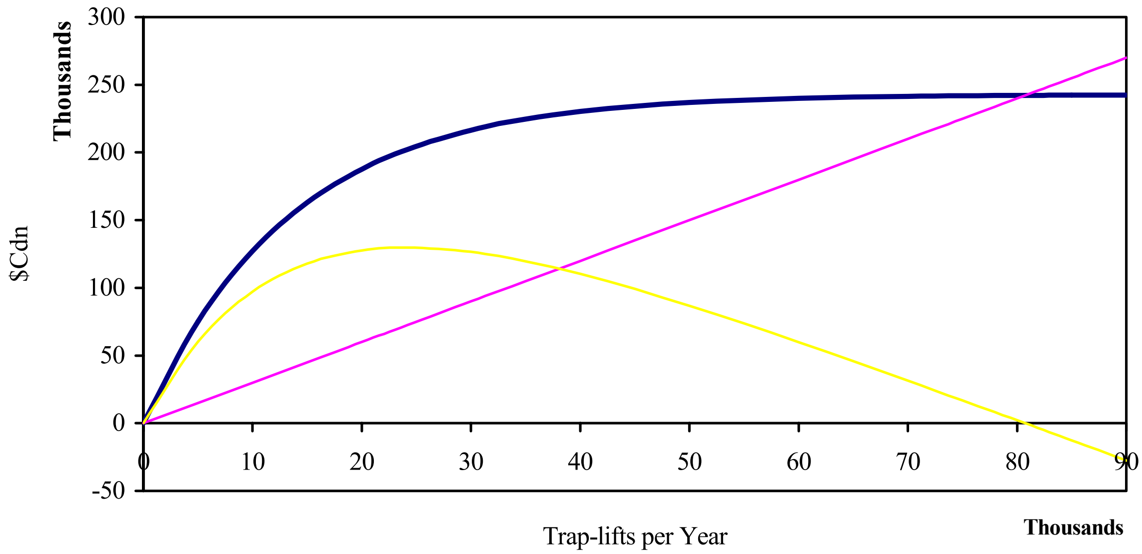

Figure 1: Simple Economic Model of the Howe Sound Prawn Fishery

2.2 Avoiding Growth Over-fishing

In a short-lived species with rapid growth, the part of a cohort surplus to spawning needs should be taken soon after recruitment and recruitment should be set close to the size that maximizes fishing net incomes.

The BC Prawn has a four to five year life span where individuals mature and function first as a male (2+ years), then go through an inter-sexual transition phase to become a female (3+ years) (Mikkelsen, 1996, p.3; Boutillier and Bond, 1999, p.1).

Average length at a given age was estimated using von Bertalanffy's (1934, 1938) equation:

$$l_t = L_\infty(1 - e^{(-K*Age)}) \quad (5)$$

l_t = carapace length at time t in m

Equation (5) was regressed against 1980 and 1982 data for Howe Sound presented by Boutillier (1984) -- NB: growth parameters tend to be area specific.

The results of the regression are: R^2 = 95.95%;
Durban-Watson Stat. = 2.0620; LM Stat = 9.3385E-13
Parameter: L_∞ = 42.897, K = -0.066006
-- t-stat: (22.080) (8.8231)

$$l_t = 42.897(1 - e^{(-0.066006*Age)}) \quad (5a)$$

The conversion from length to weight was done using Bulters (1964) conversion formula (Ricker, 1975, p.207; Boutillier and Sloan, 1988, p.427):

$$\log(W) = 2.93148\log(l) - 3.07787 \quad (6)$$

W = weight in grams
l = carapace length (mm)

Equation (2) can be restated as:

$$W = [l^{(2.93148)}]/1196.38 \quad (6a)$$

A weight index can be formed for a cohort by dividing the weights (per eqn (6a)) by the maximum average weight:

$$W_I = W_t/W_\infty \quad (7)$$

The number of prawns at the end of period t is defined (Ricker, 1975, pp.6-10) by:

$$N_t = N_o e^{-(M+F)} \quad (8)$$

N_t = cohort numbers at t

Prior to recruitment to the fished part of the stock, a cohort has (by definition) a fishing mortality rate of nil and equation collapses to:

$$N_t = N_o e^{-M} \quad (8a)$$

When the instantaneous rate of natural mortality (M) is assumed to be 0.57 (Boutillier, 1993, pp.31-32), eqn (8a) becomes:

$$N_t = N_o e^{-0.57} \tag{8b}$$

and the survival rate for the period becomes:

$$N_t/N_o = e^{-0.57} \tag{9}$$

A cohort's survival index can be defined by setting t_o to zero and modifying eqn (9) to:

$$N_t/N_o = e^{-0.57(t/12)} \tag{9a}$$

A cohort's value index can be formed by multiplying eqn (6a) by the price per kilo and by eqn (9a). This value index can be indexed to one by dividing the entire index by the maximum value. The results of this process are shown in Figure 2 and Table 2.

Recruitment to the fishable stock is set by the regulation on the minimum carapace length (CL) for retention -- currently set at 33 mm (occurs at approximately 22 months). The maximum gross value of the cohort occurs at 25 months (a CL of 34.66 mm). The curve around the optimum is relatively flat (i.e. the value index range 100% ± 5% occurs from 20 months to 30 months).

In this fishery, the optimum recruitment age occurs before the cohort has transformed into females -- DFO avoids recruitment over-fishing by using spawner indexes to set fishing openings and closings. If the size limit were set to delay recruitment to the fishery to after the cohort had transformed into females, the cohort would be 42 months old and its gross value would be 69.0 percent of the optimum value.

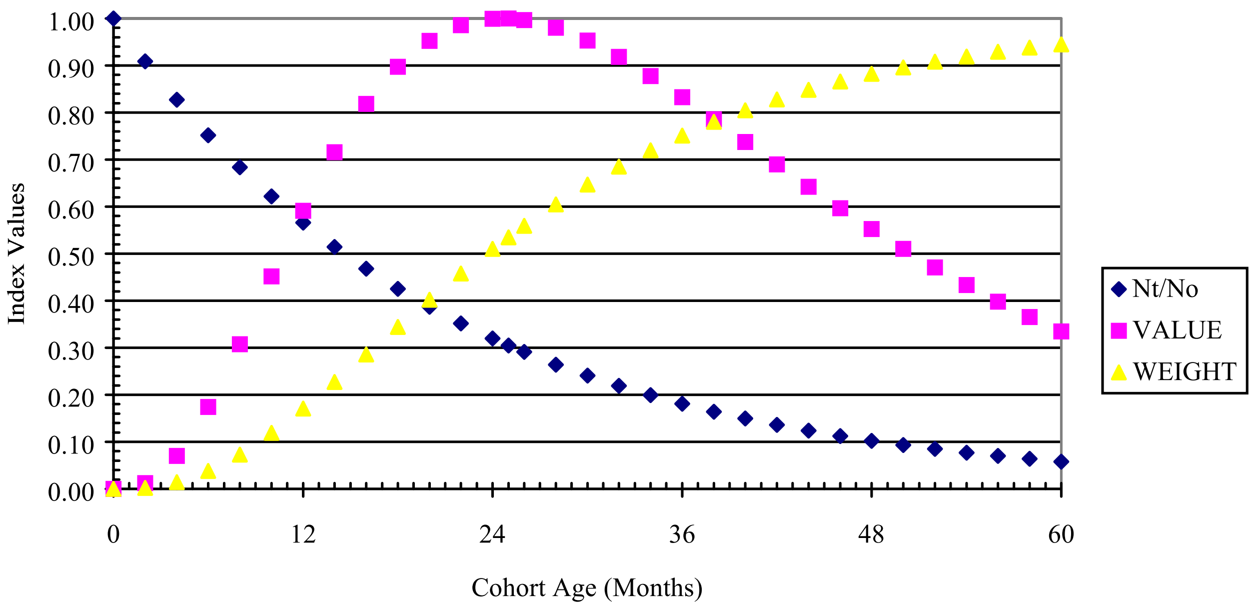

Figure 2: Weight, Survivorship, and Value for a Howe Sound Prawn Cohort

TABLE 2: Indices of Weight, Survivorship, and Value for a Howe Sound Prawn Cohort

AGE IN YEARS	AGE IN MONTHS	PRAWN GENDER	CL (mm) Eqn (5a)	WEIGHT Eqn (6a)	N_t/N_o INDEX	GROSS VALUE 100,000 COHORT	VALUE INDEX	WEIGHT INDEX
0	0	Male	0.00	0.00	1.000	0	.000	.000
	2	Male	5.31	0.11	.909	195	.0122	.002
	6	Male	14.03	1.93	.752	2793	.1739	.038
	8	Male	17.60	3.74	.684	4938	.3075	.073
	10	Male	20.73	6.05	.622	7254	.4517	.119
1	12	Male	23.47	8.70	.566	9495	.5912	.171
	14	Male	25.87	11.58	.514	11490	.7155	.227
	16	Male	27.98	14.57	.468	13142	.8184	.286
	18	Male	29.82	17.57	.425	14412	.8975	.344
	20	Male	31.44	20.51	.387	15300	.9527	.402
	22	Male	32.86	23.34	.352	15833	.9859	.458
2	24	Male	34.10	26.02	.320	16052	.9996	.510
	25	Male	34.66	27.30	.305	16059	1.0000	.535
	26	Male	35.19	28.58	.291	16005	.9967	.559
	28	Male	36.14	30.86	.264	15742	.9803	.605
	30	Male	36.98	32.99	.241	15307	.9532	.647
	32	Change	37.71	34.95	.219	14744	.9181	.685
	34	Change	38.35	36.72	.199	14088	.8773	.720
3	36	Change	39.91	38.32	.181	13370	.8325	.751
	38	Change	39.40	39.76	.164	12615	.7855	.780
	40	Change	39.84	41.05	.150	11844	.7375	.805
	42	Female	40.22	42.20	.136	11073	.6896	.828
	46	Female	40.84	44.15	.112	9579	.5965	.866
4	48	Female	41.09	44.96	.102	8871	.5524	.882
	50	Female	41.32	45.68	.093	8196	.5104	.896
	54	Female	41.68	46.88	.077	6956	.4332	.919
	58	Female	41.96	47.82	.064	5867	.3653	.938
5	60	Female	42.08	48.20	.058	5378	.3349	.945

2.3 By-Kill of Undersize Prawns

As noted previously, anecdotal data on prawn by-kill, indicates that many of the large numbers of small prawns drawn to a trap early in the soak are driven off as larger prawns move into the trap. This premise was examined using data from a 1995/96 experimental fishery in the Desolation Sound area. NB: the 1996 retention limit was a carapace length of 32 mm.

Table 3: Factors Affecting the Retention of Sub-legal Prawns (Mikkelsen, 1996, pp.21-37).

Depth Metres	Over Harvest	Soak Hrs	Cone H	Cone <32mm	Wire H	Wire. <32mm
30.2	0	28.2	49	6 %	87	0 %
82.3	0	20.5	184	15 %	169	6 %
82.3	0	26.8	111	8 %	170	2 %
94.2	0	15.0	105	4 %	134	9 %
105.2	1	18.0	144	27 %	217	15 %
82.3	1	23.2	112	37 %	190	16 %
48.5	1	23.3	160	18 %	151	29 %
88.7	1	19.0	109	28 %	127	32 %

$$U = a(1 + bG) - c(1 + dG)T + g(1 - hG)H \qquad (10)$$

U = percent of sub-legal prawns
G = gear dummy; 1 = cone trap
T = trap set-time in hours
H = harvest (numbers/set)
a,b,c,d,g = parameters

The results of regressing eqn (7) with the first four rows of data in Table 3 (with one outlier being excluded) are:
R^2 = 100.00%;
Durban-Watson Stat.= 2.0056; LM Stat = 5.3192E-15
Parameters: a = .16709, b = 1.0160, c = .0063427,
-- t-stat: (905.10) (164.66) (1227.5)
Parameters: d = .57442, g = .00013511, h = .28142,
-- t-stat: (116.66) (168.00) (19.841)

This result shows a strong inverse relationship between the trap soak-time and the percentage of sub-legal prawns. However, that relationship appears to break down if the area has been over-harvested. This is a sensible result -- in such areas, it is likely that there are few large prawns to drive the smaller prawns from the trap.

Also, there appears to be a robust inverse relationship between the number of prawns in a cone trap and the percentage of sub-legal prawns. A reverse effect, present for wire traps, may indicate that such traps are more likely to catch and retain smaller prawns than cone traps.

Thus, the one trap pull per day appears to be a viable regulation in a well managed prawn fishery but is likely to be irrelevant in areas that have been over-fished.

2.4 Getting the Measure of Fishing Effort

The big problem in managing fisheries is measuring and controlling fishing effort. Ideally, a unit of fishing effort should have a constant or at least a predicable CPUE.

In BC's prawn fishery, CPUE (catch per unit effort) is a function of depth and diel period -- day appears to favour deep-water lifts (≥ 99 feet) and night appears to favour shallow- to mid-water lifts (27 to 55 feet).

TABLE 4: CPUE by Depth and Diel Period for Howe Sound 1977, BC (Boutillier, 1986, p.180)

SOAK TIME	TRAP SET DEPTH M	LIFT DIEL	DAILY CATCH	CPUE ROW	CPUE SECTION
24	91	Both	242.4	6.06	
24	55	Both	169.0	4.23	
24	27	Both	72.0	1.80	4.03
12	91	Day	281.3	7.03	
12	55	Night	166.3	4.16	5.60
6	91	Day	279.7	6.99	
6	91	Day	184.6	4.62	
6	27	Night	123.6	3.09	
6	91	Night	174.6	4.37	4.77
3	91	Day	85.8	2.15	
3	91	Day	141.7	3.54	
3	91	Day	149.9	3.75	
3	91	Day	206.0	5.15	
3	55	Night	89.9	2.25	
3	27	Night	71.2	1.78	
3	91	Night	44.2	1.11	
3	91	Night	99.8	2.50	2.78

A casual comparison of Tables 3 and 4 shows that:

a) Fishers are three to10 times better at fishing than academics,

b) The CPUE tends to vary with the depth of a set,

c) Night lifts have better yields than day lifts for shallow sets and vice versa for deep sets, and

d) Shifting from a three hour set to a six hour set significantly increases yields, shifting to 12-hour sets yields a small increase and there appears to be no increase from shifting to 24-hour sets.

Thus, the ideal set is in deep water (≥ 91 m), is for 6 to 12 hours, and is lifted several hours before dusk. The above information was set into the equation form, but point c (above) was not supported statistically and (for the current data) the best-fit equation was:

$$CPUE = \alpha Depth(Soak)e^{(-\beta Soak)}(\Phi D_1 + \gamma D_2) \quad (11)$$

CPUE = prawns per trap lift

$\alpha = qN$ in most models; where N is stock size
Depth = set depth in m
$(Soak)(e^{-\beta Soak})$ = adjusts for trap set time with a Ricker style curve
Soak = trap soak-time (hours)
D1 = Diel Dummy; 1 = day
D2 = Diel Dummy; 1 = night
β, Φ, γ = parameters

The results of the regression were: $R^2 = 73.25\%$;
Durban-Watson Stat. = 2.2822; LM Stat = 0.74299E-15
Parameter: $\alpha = 0.085041$, $\beta = 0.066173$,
-- t-stat: (7.3007) (8.6283)
Parameter: $\gamma = 0.18170$, $\gamma = 0.14563$
-- t-stat: (6.1012) (7.2705)

$$CPUE = .085041(Depth)(Soak)e^{(-.066173Soak)} (.18170D_1 + .14563D_2) \quad (11a)$$

When eqn (11) is differentiated with respect to soak time the result is:

$$dCPUE/d(soak) = \alpha(Depth)(soak)e^{(-\beta Soak)} (\Phi D_1 + \gamma D_2)(1-\beta Soak) \quad (12)$$

When eqn (12) is set to zero, it can be reorganized to define the soak-time that generates the maximum catch per trap-soak-hour:

$$soak^* = 1/\beta \quad (13)$$

In terms of eqn (11a):

$$soak^* = 1/0.066173 = 15.11 \text{ hrs} \quad (13a)$$

Figure 3 confirms this value. However, given the logical restriction that the soak hours divided into a 24 hour day yields a whole number, the maximum catch per day is generated by a trap soak-time of 12 hours with two lifts per day.

The total catch per trap lift for a trap-soak strategy can be defined by multiplying eqn (11) by the soak time:

$$H_L = \alpha (Depth)(Soak)^2 e^{(-\beta Soak)}(\Phi D_1 + \gamma D_2) \quad (14)$$

When the differential of eqn (14) with respect to soak time is set equal to zero, it can be reorganized to define the soak time that maximizes the catch per trap lift:

$$Soak^\circ = 2/0.066173 = 30.22 \text{ hrs} \quad (15)$$

The total daily catch for a trap-soak strategy can be defined by multiplying eqn (14) by the number of trap lifts per day (i.e. 24/Soak) to give:

$$H_D = \alpha 24 Depth(Soak) e^{(-\beta Soak)}(\Phi D_1 + \gamma D_2) \qquad (16)$$

Given the human tendency to make the length of daily cycles divisible into 24 hours, these relationships indicate when the stock density, the trap set-depth, and the time of day of trap lifts are held constant, in BC's prawn fishery:

a) In lightly fished areas without binding limits on traps per vessel, fishers will tend to lift traps on a 24-hour cycle,

b) If the limit on traps per vessel is binding, fishers will tend to lift traps on a 12 hour cycle, and

c) In an over-crowded fishery or one suffering from sequential overfishing, fishers will tend to race for prawns by lifting traps on a three-hour, four-hour, or six-hour cycle.

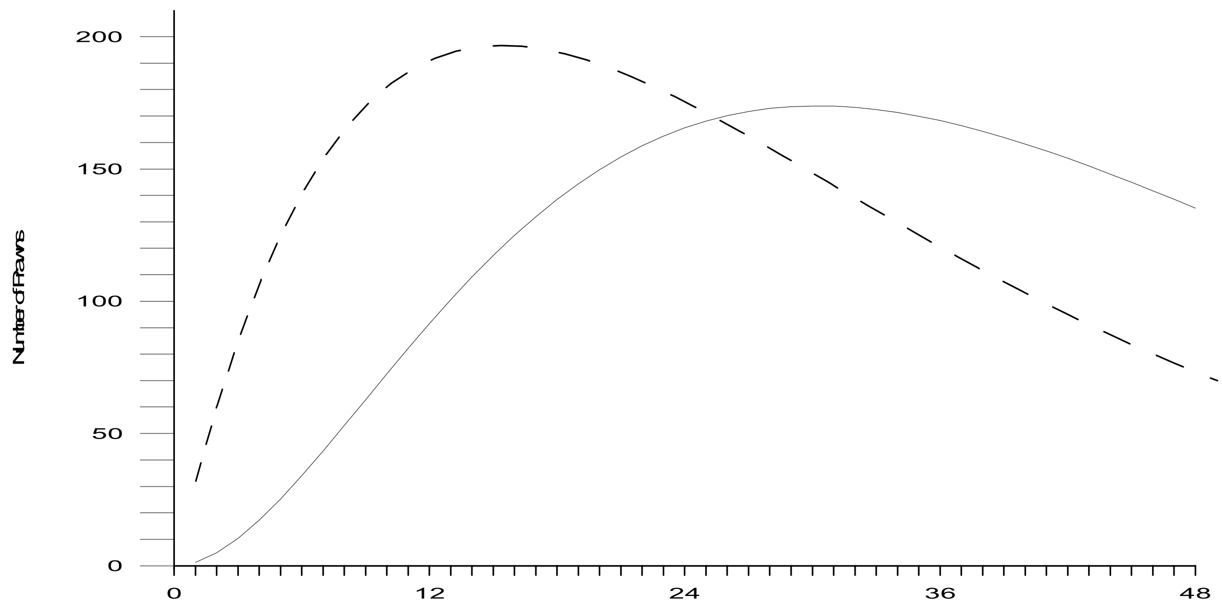

Figure 3: Trap Soak-Time and Catch

3.0 Analysis and Conclusions

A century of biological management and five decades of economic management have left fishers with few reasons to celebrate. Except for a few IQ fisheries, seasons are contracting in most fisheries, fish stocks are in decline or under threat throughout the world, fisheries are shedding labour, and the ever more complex regulations tend to out compete fishers in dissipating available fishery rents.

The whole concept of fisheries management, its purpose and limits need to be re-thought. As part of that process, this paper reviewed some fisheries management concepts.

The simple economic model in section 2.1 provides a rough measure of the optimum number of vessels to fish a given area, during a given season length. However, the measure of effort in this model is too simple to be a viable controlling factor for fishery managers.

The cohort value model in section 2.2 provides insight into the optimal retention size (e.g. size of recruitment to the fishable stock). However, any optimal size rule is likely to be area specific – e.g. dependent on local and/or transient conditions. Further, compliance and enforcement of such rules are likely to be burdensome.

The by-kill model in section 2.3 provides insight into the conditions under which deferring trap lifts to once or twice a day could provide net benefit.

The *Achilles heel* of fisheries management is highlighted in Section 2.4. Specifically, if fishing effort is measured in terms of:

- ❖ Inputs, its effect on the stock (CPUE) is variable and, therefore, unpredictable, or
- ❖ A constant or known CPUE effect, it becomes difficult to measure and/or control.

In an effort to resolve these issues, protect the stocks they manage, and evade criticism, fisheries managers tend to delve ever deeper into micro-managing fisheries by fiat. Thus, in their pursuit of public good, fisheries managers have turned their fisheries into the last major dispersed industry subject to central management. As reality and budget cuts intrude, fisheries managers are increasingly finding that (like their Soviet central planner counterparts) they are less and less able to do the tasks required of them. In self-defence DFO has repudiated its fiduciary obligation to manage fisheries and is trying to refocus its obligation to managing and maintaining fish stocks.

Many fishers feeling abandoned and betrayed DFO's shift have noted that the salaries of fisheries managers are not tied to the performance of the fisheries they manage and, as long as they do not embarrass the Fisheries Minister they experience few consequences from their actions or lack thereof.

Co-management (i.e. sharing management duties and costs between fishers and their government) is being touted as a means of reversing the deteriorating conditions in fisheries. However, co-management initiatives will fail in Canadian fisheries as long as DFO retains its sacred cows of: "Equality of Access to the fish resource" and the Precautionary Approach".

These maxims increase uncertainty in fisheries to a level that is unacceptable to private firms and/or will prevent any real transfer of power to fishers.

Co-management requires that exclusive rights be granted and that those with rights have a real and significant say in how their part of the fishery is run.

BC's prawn stocks are a short-lived, late maturing species with a dispersed larval phase and a sedentary post-larval phase. Thus, the biology of these stocks makes sequential localized overfishing an unacceptably high hazard for an individual quota (IQ) system of rights.

Turfs may be more viable than IQs. The separation of the BC prawn fishery into turfs with each fisher licensed and restricted to one turf has a number of advantages:

1) Each Turf can develop rules and practises that make sense to its conditions,
2) Experiments in management become easier to implement, to compare with other regimes, and any damage from such experiments is localized in both time and space.
3) Transaction and information costs between fishers in a Turf are reduced,
4) Fishers within a Turf will tend to form a consensus on how to run the Turf – fishers outside of that consensus will be encouraged to leave,
5) Large "non-turf" zones can be created for fishers who prefer to race for fish.

Turf rights will be combined with a restriction to fish only their Turf – this limits the consequences of a fisher's actions to one Turf and ensures that they live with those consequences. Most people will not foul their own nest.

Where a Turf involves several fishers, the rights of the Turf group to discipline its members must be balanced with the rights of the individual. Small firms facing the same problem have evolved effective legal procedures.

In summary, the first rule of getting out of a hole is to quit digging. It is time that all of us involved with fisheries started asking hard questions about the goals and limits of fisheries management. In particular, it is time to stop trying to off-load management costs on fishers and to ask: are there better and cheaper ways to manage fisheries?

4.0 References

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