Electronic Supplementary Material

Credible Enforcement Policies under illegal fishing: Does Individual Transferable Quotas induce to reduce the gap between approved and proposed allowable catches?

José María Da Rocha, Sebastián Villasante, Rafael Trelles González

*To whom correspondence should be addressed

E-mail:sebastian.villasante@usc.es

Material and methods

In the following we present detailed information for the f.o.c in relation to the different solutions used in our model.

Appendix A

Proof. Lemma 1

*Proof.*Note that fishermen's problem can be written as

$$\max_{q,\upsilon}(\upsilon + q) - \frac{c}{2}\frac{(\upsilon + q)^{2}}{A} - \theta f(\upsilon) + T$$

The f.o.c. is

$$\frac{\partial \pi}{\partial \upsilon} = 1 - c\frac{(\upsilon + q)}{A} - \theta f'^{(\upsilon)} = 0$$

where $A = (\upsilon + q)^{-\beta}$. ■

Proof. Proposition 1

*Proof.*From the f.o.c. of equation (3), it is known that

$$\left[\frac{\partial \pi(h)}{\partial h} - \theta f'(g(\bar{q}) - \bar{q})\right]\frac{dg(\bar{q})}{\partial \bar{q}} + \theta f'(g(\bar{q}) - \bar{q}) - \psi = 0$$

therefore, $\frac{\partial \pi(h)}{\partial h} < 0$. ■

Proof Lemma 2

*Proof.*From the f.o.c. of equation (4), taking into account that$1 - c(\upsilon + \bar{q})^{1+\beta} - \theta f'(\upsilon) = 0$, it holds that

$$1 - c(h)^{1+\beta} - (\psi/\lambda) = 0,$$

and

$$\alpha v = \frac{\psi}{\lambda} - \gamma \qquad \blacksquare$$

Proof Lemma 3

*Proof.*Note that fishermen's problem can be written as

$$\max_{q,v}(v+q) - \frac{c}{2}\frac{(v+q)^{2}}{A} - \theta f(v) - \omega q + T$$

The f.o.c's are

$$\frac{\partial \pi}{\partial q} = 1 + c\frac{(v+q)}{A} - \theta f'(v) = 0$$

$$\frac{\partial \pi}{\partial q} = 1 + c\frac{(v+q)}{A} - \omega = 0$$

Therefore, the competitive allocation is independent of the existence of ITQ's. ■

Proof. Proposition 2

*Proof.*Note that

$$\max_{\bar{q}} \pi(h) - \lambda[\theta f(h-\bar{q}) + \omega(h-\bar{q})\bar{q}] - \psi\bar{q}$$

is equivalent to

$$\max_{\bar{q}} -\lambda\theta\,[f(h-\bar{q}) + f'(h-\bar{q})\bar{q}] - \psi\bar{q} \qquad \blacksquare$$

Therefore, given that the penalty function, $f(v)$, is strictly increasing and convex, its follows that the objective function is not concave. In particular, the enforcement agency's best response function $\theta = G(h)$ is obtained by solving

$$\max_{v[0,h]} \frac{\lambda\theta\alpha}{2}v^2 + (\psi - \lambda\theta\alpha h)v$$

Therefore, $\bar{q} = G(h)$ that is $v = 0$, which is the solution if $\psi < \frac{\lambda\theta\alpha}{2}\,h$. ■

Proof Lemma 4

Proof. Note that

$$r(h^N, \bar{q}^N) \geq r_{itq}(h^N, \bar{q}^N) = r_{itq}\left(h^N_{itq}, \bar{q}^N_{itq}\right) + \gamma\theta\bar{q}^N_{itq} \qquad \blacksquare$$

Proof Proposition 3

*Proof.*Note that

$$\begin{aligned}\Delta r_{itq} \quad &= \lambda\theta\left[f\left(\upsilon^R_{itq}\right) + \omega\left(\upsilon^R_{itq}\right)\bar{q}^R_{itq}\right] - \psi q^R_{itq} - \\ &\lambda\theta\left[f\left(\upsilon^N_{itq}\right) + \omega\left(\upsilon^N_{itq}\right)\bar{q}^N_{itq}\right] - \psi q^N_{itq} \\ &= \left[\lambda\theta\alpha\left(\frac{\upsilon^R_{itq}}{2} + 1\right) - \psi\right]\upsilon^R_{itq},\end{aligned}$$

and

$$\Delta r = \lambda\theta[f(\upsilon^R) - f(\upsilon^N)] - \psi\,(q^R - q^N)$$

We also show that

$$\frac{\Delta r}{\pi(h^R) - \pi(h^N)} < \frac{\Delta r_{itq}}{\pi\left(h^R_{itq}\right) - \pi\left(h^N_{itq}\right)} \tag{7}$$

Given that $\frac{\partial\pi}{\partial\upsilon} = \theta\lambda f'(\upsilon)$, equation (7) is equivalent to

$$\frac{f'(\upsilon^R)}{\theta f(\upsilon^R) - \psi} \leq \frac{\alpha\frac{\upsilon^R_{itq} + \alpha - \psi}{2}}{\gamma\theta}$$

then if ψ goes to zero,

$$1 \leq \frac{\alpha\frac{\upsilon^R_{itq+\alpha}}{2}}{\gamma\theta}$$

if $\gamma\theta < \alpha$. $\blacksquare$