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Dubravko Pejdo, Claudia Kruschel, Stewart Schultz, Ivana Zubak
E-mail: dubravkopejdo@yahoo.com
University of Zadar, Department of Ecology, Agriculture and Aquaculture, Trg kneza Višeslava 9, 23000 Zadar, Croatia
Danijel Kanski
WWF Adria, Budmanijeva 5, 10000 Zagreb, Croatia
Martina Markov
Kornati National Park, Department for Protection, Maintenance, Conservation and Use, Butina 2, 22243, Murter, Croatia
Petra Peleš
Ires Ekologija, Baruna Filipovića 21, 10000 Zagreb, Croatia

Fish Monitoring in Kornati National Park: Baited, Remote, Underwater Video (BRUV) Versus Trammel Net Sampling

Abstract

We evaluated (1) the suitability of two alternative methods for fish monitoring: trammel net sampling and BRUV (Baited Remote Underwater Video), and (2) the potential to cross-calibrate the methods based on a set of shared species with high catch probabilities. A statistical power analysis concluded that BRUV can be conducted with sufficient sample size to perceive small changes in fish populations with high power, and therefore can be used as a sentinel monitoring method. We found that fish species detected by both methods amounted to almost a third of the number of species in each method's catch, and that 90% of these species are candidates for cross-calibration. 74% of the species at BRUV and 50% at trammel had occurrence probabilities above 10%, a reasonable threshold allowing stock assessment of these species. The sampled and predicted total species richness, extrapolated from the species accumulation curves, were almost identical across methods. We conclude that cross-calibrating the two methods and eventual replacement of the trammel method with non-destructive BRUV is feasible. The most effective areas of improvement are increased BRUV night-sampling effort and increased total sampling size to increase the statistical power of BRUV as a monitoring tool. This work has been supported under the Croatian Science Foundation under the project COREBIO (3107).

Key words: Baited Remote Underwater Video, Trammel net, Monitoring, Method cross-calibration, Species richness

1. Methods

We sampled the same four locations in Kornati National Park, Croatia (Klobučar, Kurba, Mana, and Šilo Vela) with both methods performed in parallel on the same days in June of 2014 and 2015. Trammel net sets are consumptive, [1]. BRUV is a non-consumptive visual census [2]. As individual and independent sampling units for statistical analysis we identified individual trammel net sets (15 net pieces) and spatially matching sets of BRUV (4 deployments). In each location two trammel net sets were deployed overnight from just before sunset to just after sunrise, thus for approximately 10 hours in June. Four to six BRUV deployments matched the time, location, and sampling space (matching GPS coordinates) of the trammel net set. The total realized number of trammel net sets in both years and all locations combined was 16, and the total realized number of BRUV deployments was 74. For each species, we calculated the catchability, defined as the probability of catching (trammel) or observing (BRUV) that species within one sampling unit, defined as one net set and four BRUV deployments.

2. Results and Discussion

Statistical power analysis: The minimum sample size necessary to detect a given decline in the population of a fish species was calculated assuming that the coefficient of variation in population size is 0,5. This sample size was converted to the minimum number of deployments as d = s/p, where d = number of deployments, s = sample size, and p = catchability of the species. We found for example that a sample size of 27 is necessary to detect a population loss of 50%, and this sample size is achieved on average by 270 deployments per sampling event for fish whose catchability is greater than 0,1 (Table 1). Because one trammel net set deployment is equivalent to at least four BRUV deployments in the same time interval (by the same field team), 270 BRUV deployments are equivalent to approximately 68 trammel net set deployments. Thus, the BRUV effort necessary to detect a proportional population loss of 0,5 is equivalent to a trammel net effort necessary to detect a loss of greater than 0,8. Or equivalently, for this trammel net effort to detect a proportional loss of 0,5, the fish catchability would have to be 0,4 in the trammel net. In general, trammel net catchability of a species must be four times the BRUV catchability for the same effort to detect a given rate of population decline.

Table 1. The minimum number of independent replicate samples needed to statistically detect the indicated proportional decline in a fish population, for the indicated catchability of a fish species, at a significance (alpha) level of 0.05, and a statistical power (1 – beta) level of 0.95.

Minimum n replicates if catchability = 1	Minimum n replicates if catchability = 0,5	Minimum n replicates if catchability = 0,1	Proportional decline in population sampled
651	1302	6510	0,1
163	**326**	**1630**	0,2
73	**146**	**730**	0,3
41	**82**	**410**	0,4
27	**54**	**270**	0,5
19	**38**	**190**	0,6
14	**28**	**140**	0,7
11	**22**	**110**	0,8

Species occurrences: All species and their probability of occurrence in the two methods are shown in Table 2. Species accumulation curves were similar for the two methods (Figure 1), with the BRUV curve showing a slightly shallower slope and possibly a slightly lower extrapolated richness (Table 3).

The two methods detected thirteen shared species of which eleven can be detected with a probability of 10% or higher using either method (Table 2). This approximates almost one third of the total species caught with either method. These eleven are the species with a high potential for cross calibration. Catchability is higher at BRUV than at trammel, 74% of the species at independent BRUVs (sets of four) and 50% of the species from independently deployed trammel net sets have occurrence probabilities of 10% and higher. Both methods catch unique sets of commercially important species. BRUV catches important chase predators with high mobility and range, such as *Dentex dentex, Sparus aurata, Diplodus sargus, D. puntazzo, and Sphyreana sphyreana*. Trammel catches important nocturnal ambush predators, such as *Scorpaena scrofa* and *S. porcus,* as well as mobile nocturnal predators, such as *Zeus faber* and *Pagellus erythrinus*. Such differences are the result of unequal distribution of night vs. daytime sampling effort. Trammel nets were deployed for 10 hours at night. Of the BRUVs, 84% were deployed during the day while only 16% were deployed at night. Overall catch time of the 16 trammel nets was approximately 9600 minutes. Overall catch time of the BRUVs was approximately 2300 minutes during daytime and 1000 minutes at night. Assuming the minimum catchability for statistical comparison is 0,1 for a single BRUV and 0,4 for the trammel method, BRUV is capable of monitoring the status of 19 species under the present sampling field conditions, and the trammel method is capable of monitoring the status of 12 species. Overall, the BRUV method showed approximately five more species than the trammel net set with minimum catch probabilities in the midrange (Figure 2), indicating that the BRUV method is capable of monitoring approximately five more species than the trammel method.

Table 2. Species-specific probabilities of occurrence at trammel net sets (16) or BRUV deployments (74) in June of 2014 and 2015. Bold font indicates species which occurred at both methods with a probability of 10% or higher and are candidates for cross-calibration of the two methods. The grey shaded areas include all species from both methods with such probabilities.

BRUV (sets of 4 deployments)		Trammel (individual net sets of 15 net pieces)	
species	prob.	species	prob.
Coris julis	1,00	Mullus surmuletus	1,00
Chromis chromis	0,98	Scorpaena scrofa	1,00
Serranus scriba	0,98	Serranus scriba	0,94
Diplodus annularis	0,97	Spondyliosoma cantharus	0,81
Boops boops	0,95	Phycis phycis	0,75
Symphodus melanocercus	0,95	Scorpaena porcus	0,75
Symphodus tinca	0,90	Symphodus tinca	0,75
Symphodus doderleini	0,85	Scorpaena notata	0,69
Diplodus vulgaris	0,80	Diplodus vulgaris	0,50
Serranus cabrilla	0,79	Serranus cabrilla	0,50
Symphodus mediterraneus	0,79	Torpedo marmorata	0,44
Symphodus ocellatus	0,72	Uranoscopus scaber	0,44
Spicara smaris	0,65	Conger conger	0,37
Spicara maena	0,60	Muraena helena	0,31
Spondyliosoma cantharus	0,54	Diplodus annularis	0,25
Sparus aurata	0,51	Synodus saurus	0,25
Mullus surmuletus	0,47	Zeus faber	0,25
Symphodus cinereus	0,44	Pagellus erythrinus	0,19
Oblada melanura	0,33	Pagrus pagrus	0,19
Dentex dentex	0,29	Spicara maena	0,19
Diplodus puntazzo	0,29	Apogon imberbis	0,12
Diplodus sargus	0,29	Chromis chromis	0,12
Sarpa salpa	0,29	Atherina spec.	0,06
Muraena helena	0,15	Coris julis	0,06
Sarda sarda	0,15	Labrus bimaculatus	0,06
Conger conger	0,10	Mustellus punctulatus	0,06
Serranus hepatus	0,10	Pagellus acarne	0,06
Sphyraena sphyraena	0,10	Sarpa salpa	0,06

Dicentrarchus labrax	0,05	Scyliorhinus stellaris	0,06
Lichia amia	0,05	Solea vulgaris	0,06
Mugil cephalus	0,05	Symphodus mediterraneus	0,06
Myliobatis aquila	0,05	Symphodus ocellatus	0,06
Parablennius tentacularis	0,05	Trachinus araneus	0,06
Seriola dumerili	0,05	Trachinus draco	0,06
Spicara flexuosa	0,05	Trachinus radiatus	0,06
Symphodus rostratus	0,05	Trigloporus lastoviza	0,06
Thalassoma pavo	0,05		
Trachurus trachurus	0,05		

Actual and predicted species richness: 16 trammel net sets and 74 BRUVs caught/detected 38 and 36 unique taxa/species and the predicted number of unique taxa ranged from 44 to 94 and 43 to 55 (Table 3).

Table 3: Total observed and predicted species richness based on species accumulation curves derived from 74 BRUV deployments and 16 trammel net sets in June, 2014 and 2015.

method	Observed taxa/species	Chao	Chao SE	Jack1	Jack1 SE	Jack2	Boot	Boot SE	n
BRUV	38	54,7	14,8	47,9	3,4	54,7	42,7	1.9	74
TRAMMEL	36	94,3	49,8	52,9	5,0	65,8	43,8	2.5	16

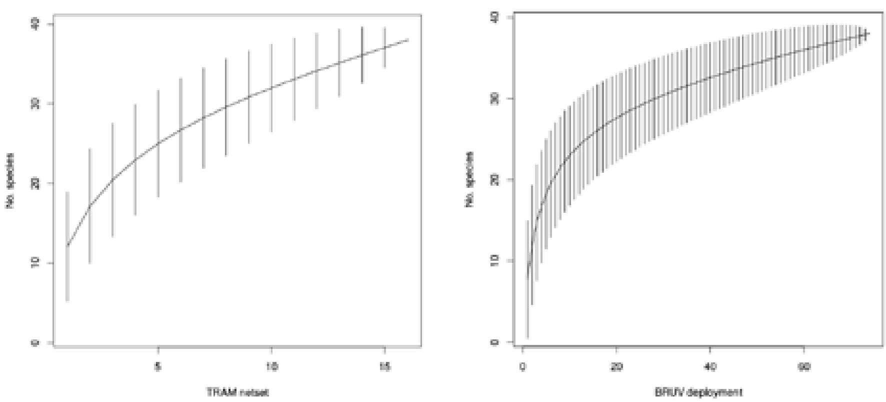

Figure 1. Species accumulation curves presenting the increase in number of species as a function of increased number of independent samples, individual trammel net sets (16) and individual BRUV deployments (74) at four sampling locations in June 2014 and 2015.

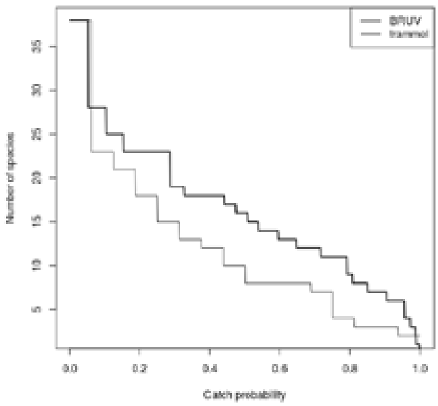

Figure 2. Total number of species whose catch probability is equal to or greater than that indicated, for the BRUV or trammel method. Catch probabilities are assumed for one trammel net set, or four BRUV deployments.

3. Conclusions

A substantial proportion of species (74%) detected at BRUV had occurrence probabilities above 10%. However, only 29% overlap with species caught in trammel net sets. In order to arrive at a meaningful cross calibration of the two methods, BRUV needs to detect a larger share of the species caught in trammel. The most effective improvements would be to increase BRUV night-sampling effort in order to match trammel deployment time and to increase the total sampling size to boost the statistical power of BRUV as a monitoring tool. Both tasks can easily be accomplished. BRUV deployments are highly efficient in terms of field time and man-power. Our overall conclusions are that (1) BRUV is the more powerful method; (2) a cross-calibration with the trammel method is feasible; and (3) BRUV is an excellent candidate for becoming the method of choice in protected areas in which trammel and other destructive methods are already or will in the future be phased out by international agreement.

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Praćenje ribljih naselja u Nacionalnom Parku Kornati: Postaja sa kamerama i mamcem (BRUV) - trostruka mreža stajaćica "poponica"

Sažetak

U ovom radu razmatrana je prikladnost dviju metoda za praćenje ribljih naselja u nacionalnim parkovima i to trostruke mreže stajaćice ''poponice'' i BRUV-a (Baited Remote Underwater Video). Praćena je i njihova potencijalna kompatibilnost na temelju preklapanja vrsta od istog interesa, odnosno vjerojatnosti ''ulova''. Statistička robusnost je pokazala kako BRUV može prikazati i male promijene u dinamici ribljih populacija iz malog broja uzoraka, što kod ''poponice'' nije moguće, te je idealan kandidat za metodu monitoringa u NP. Otkrili smo da se gotovo trećina svih ''ulovljenih'' riba preklapa u obje metode i da je gotovo 90% sveukupne populacije pogodno za unakrsnu analizu. Također je uočeno kako 74% vrsta snimljenih BRUV-om i 50% vrsta ulovljenih ''poponicom'' imaju pojavnost od preko 10% što je donji prag statističke vrijednosti te smo ih uzeli u obzir za procjenu ribljih naselja. Gledajući iz krivulja rasta, predviđeno i ukupno bogatstvo vrsta u obje metode je gotovo identično. Naš je zaključak kako je moguće usporediti obje metode i da je zamjena ''poponice'', kao metode monitoringa, BRUV-om moguća i ostvariva. Područja za poboljšanje BRUV-a kao alata monitoringa je noćno uzorkovanje kao i povećanje ukupnog uzorkovanja kako bi se pojačala statistička robusnost metode. Ovaj rad je napravljen kao dio projekta COREBIO (3107) koji financira Hrvatska zaklada za znanost (HRZZ).

Ključne riječi: Postaja sa kamerama i mamcem (BRUV), Trostruka mreža stajaćica "poponica'', Monitoring, Preklapanje metoda uzorkovanja, Bogatstvo ribljih vrsta