21 January 1988

MEMORANDUM FOR: George Balazs

FROM: Jerry Wetherall

SUBJECT: Hawaiian sea turtle recovery definitions, viable populations, etc.

I've given some thought to the issues raised by Fullerton regarding the recovery criteria. My views are as follows:

(1) The recovery criterion given in the Recovery Plan, i.e., restore and maintain the nesting population (on each currently used nesting beach) to the carrying capacity of the nesting habitat, is to me quite reasonable. One problem, however, is that we did not define what we meant by "carrying capacity". My notion of this is the number of nesting females that results in the maximum average hatchling production. This target population level is measurable, based on our knowledge of egg deposition rates, nesting habitat requirements, egg and hatchling survival as a function of nesting density, etc. One nice thing about this criterion is that it hinges on the life history phase about which we know the most. If Charlie objects to the term "carrying capacity", perhaps we can use an alternative. A better term may be "optimum nesting population". The turtle nesting situation has parallels with salmon nesting, where the term "optimum escapement" is used to define target spawning populations and densities, and where there is a limit to the number of fry which can be produced in a given spawning area. In the case of salmon, the optimum parent nesting population is usually defined as the number of spawners which maximizes the expected number of progeny recruiting to a fishery operating just prior to the spawning of the yearclass. In the case of turtles, it could be defined simply as the number of nesters producing the maximum average number of hatchlings (with turtles there would be problems in optimizing with respect to number of recruits to other developmental stages, because of our ignorance of population parameters, the long time lags, and so forth).

(2) The alternative suggested by Charlie, "viable population", opens up a whole new bag of considerations. In the literature I've seen on "viable populations", the definition of this term is very loose. Basically, it means the population level at which, according to our best information, the probability of extinction is no greater than some specified level. So it's arbitrary, and the question is, who determines the level of risk? Further, the behavior of models used to predict such extinction probabilities depend critically on the underlying assumptions regarding vital parameters, and especially on the nature of the individual variation in mortality and natality rates. Most of the models I have seen are very abstract, and inadequate for setting meaningful recovery targets in practice. At any rate, given most folks' risk tolerance, it would probably be concluded that the present population is viable (at least the population depending on East Island nesting), and we'd be out of business. I'd rather find out how far we are from our original target, i.e., maximum hatchling production. At the same time, I'd like to see any original documents which discuss the

rationale for placing the various species of sea turtles under protection of the ESA, and the criteria used. Was there an explicit determination that the various population levels were so low that the probability of extinction was at an unacceptable level? What level? If we knew specifically on what basis the turtles were listed in the first place, we would be in a better position to determine when they should be delisted.

(3) We did not consider the issue of exploitation, because we thought the other social objectives of restoring a population for esthetic, educational and non-consumptive recreational benefits were paramount. If Charlie insists that the Recovery Plan allow for the possibility of harvests at some point down the road (if not now), then there is a lot more to talk about. All sorts of harvest schemes could be imagined. For example, one possibility would be to forbid any taking of turtles except in those years when the optimal nesting population (as defined above) was exceeded. In such years, providing the overflow nesting population could be forecast within the nesting season, a quantity of eggs could be selectively removed from the beach, in such a way as to mitigate the effects of the excessive nesting, artificially incubated, hatched and placed into some rearing facility where they would be cultivated for later harvest, distributed to licensed pond operators, etc. So, in this way it might be possible to define a "surplus production" from the wild population in certain years, which could feed an artificial rearing and harvesting operation. The economics of such an operation are another matter, and in no way am I suggesting such a scheme. Another kind of harvesting program would be one which exploited juvenile or subadult turtles. Among the many problems with this type of plan would be that we know too little about the size of these segments of the population. To consider any plans of this sort would require a much better knowledge of turtle population dynamics than we now have. Although I have begun to put together a very rough turtle population simulation model which would allow some exploration of such ideas, it would be foolish to suggest any kind of harvesting scheme without much more data.

(4) In sum, I favor our original recovery target, with slightly different terminology. I think the "viable population" concept is too loose for application to our situation, given our meager knowledge of population dynamics and the problem of setting the risk level. My personal view is that the intangible social benefits (esthetic, educational, etc.) of maintaining a large (i.e., "carrying capacity") population exceed any benefits that would accrue from harvesting. In any case, the notion of harvesting is premature given our lack of knowledge.

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Table 1. Estimated number of green turtles nesting at East Island, French Frigate Shoals, 1973-2004.

Year	Survey nights	Estimated nesters	90% bootstrap CI lower	upper
1973	43	67	65	68
1974	59	105	103	106
1975	30	120	115	125
1976	13	39	31	47
1977	9	82	67	97
1978	11	101	89	113
1979	13	77	67	86
1980	20	52	46	57
1981	23	149	140	158
1982	19	130	121	137
1983	17	35	30	40
1984	20	199	185	212
1985	18	162	152	172
1986	29	69	62	74
1987	26	143	135	150
1988	101	180	179	180
1989	143	294	293	294
1990	133	150	150	150
1991	119	107	107	107
1992	129	384	383	384
1993	31	191	185	196
1994	26	132	127	137
1995	31	252	246	257
1996	31	367	358	374
1997	33	504	494	512
1998	32	64	61	66
1999	31	209	203	214
2000	33	353	346	360
2001	31	314	304	320
2002	34	467	459	475
2003	41	219	215	223
2004	38	548	542	554

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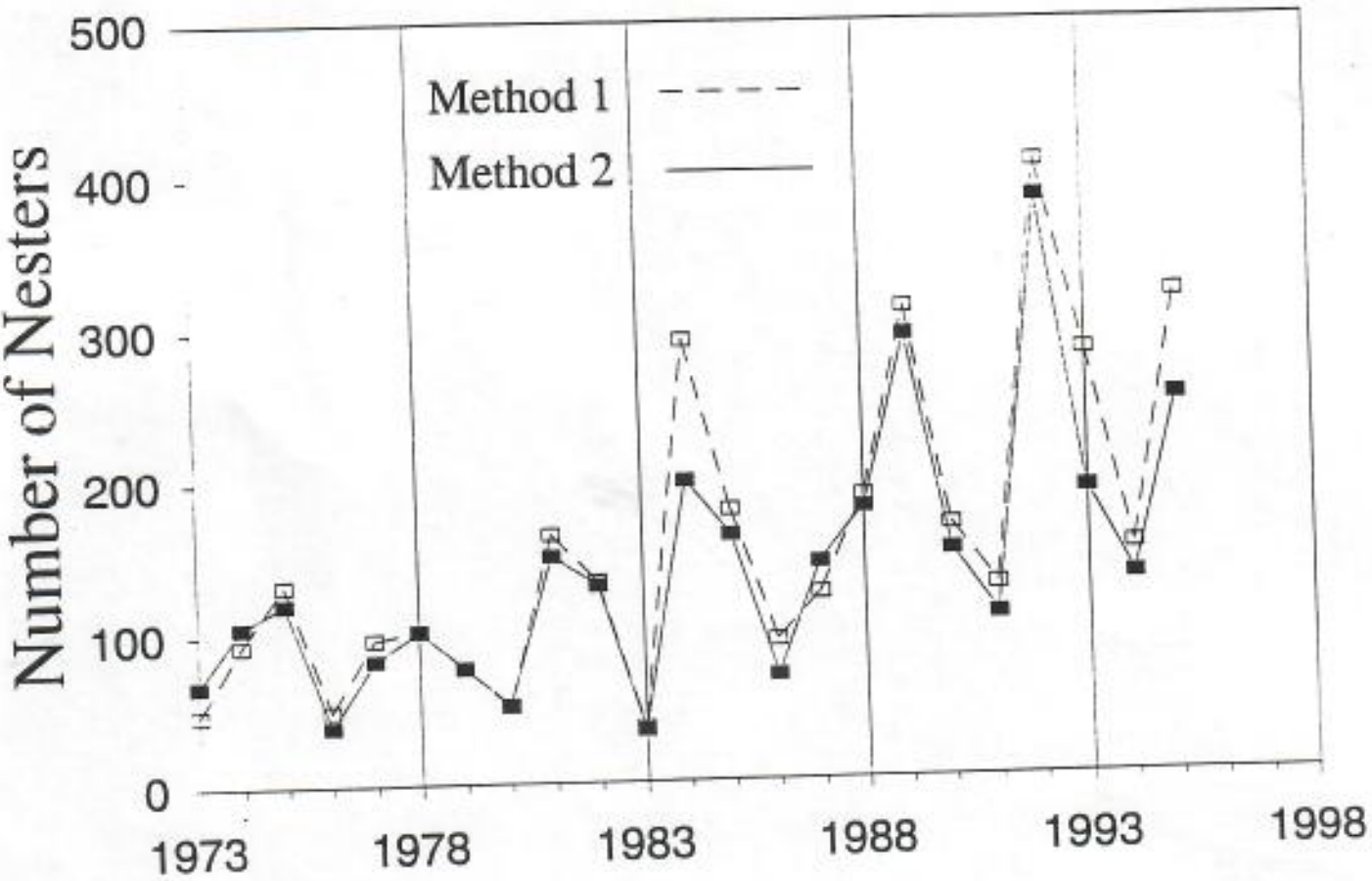
JAW
7 August 2002

East Island green turtle nesting population estimates (N)
using Method 1 and Method 2
(20 July 1995)

Year	Coverage Rate	Method 1 N	Sighting Probability	Method 2 N
1973	3.94	48	0.98	67
1974	4.51	93	0.99	105
1975	2.50	132	0.93	120
1976	0.92	49	0.62	39
1977	0.73	96	0.53	82
1978	1.01	101	0.65	101
1979	1.19	77	0.71	77
1980	1.89	51	0.86	52
1981	1.81	164	0.85	149
1982	1.83	133	0.85	130
1983	1.58	36	0.81	35
1984	1.48	293	0.79	199
1985	1.57	179	0.81	162
1986	1.83	92	0.85	69
1987	1.92	123	0.87	143
1988	7.19	188	1.00	180
1989	7.85	312	1.00	294
1990	7.82	168	1.00	150
1991	7.73	127	1.00	107
1992	7.63	407	1.00	384
1993	2.78	283	0.95	191
1994	2.45	153	0.92	132
1995	2.89	320	0.95	252

NOTE: Method 2 estimates, based on counts of ID'd (tagged) nesters are more accurate than Method 1 estimates, which are based on total counts of nesters ashore.


Number of Nesters
500
400
300
200
100
0
1973
1978
1983
1988
1993
1998
Method 1
Method 2