



Submission on commercial whale watching licensing to Washington Department of Fish & Wildlife

“It’s better to be aware of what you don’t know, than certain of what you do” Nassim Taleb, 2019

The Raincoast Conservation Foundation, Wild Fish Conservancy and Georgia Strait Alliance appreciate the opportunity to provide the following comments for scoping the Environmental Impact Statement on the Washington Department of Fish and Wildlife’s (WDFW) proposed commercial whale watching licensing program. Our comments are divided into three parts.

The first is a summary of the current state of knowledge as it relates to population consequences of vessel disturbance. Included in this section is an up to date (2020) analysis of SRKW population viability and the potential for threat reductions measures to halt the decline and initiate recovery. Secondly, given the context provided in the first section, we offer some thoughts on how regulators need to take a very cautionary approach in the absence of thresholds for stressors that are known to cause harm. We emphasize the importance of context and suggest separate approaches for the two killer whale ecotypes in Washington State waters. Finally, we identify considerations for the structure and management of a licensing program that focuses on Bigg’s killer whales that considers an appropriate economic return to the public owners of the aquatic resources used and traversed by commercial whale watching vessels.

As WDFW has identified, SRKW are listed as endangered under federal and Washington State law, and vessel disturbance and noise have been identified as stressors that threaten the viability of these whales in Washington waters and elsewhere. The difficulty in separating the impacts of underwater vessel noise (that mask communication and echolocation signalling) from the impacts from vessel disturbance (boats affecting the behavior or activities of whales), means these threats are generally considered together.

Summary of existing knowledge on noise and vessel effects on Resident killer whales

Scientific understanding of the ways that acoustic and physical vessel disturbance affect cetaceans is complex (Erbe 2016, Clarke 2015) and even today is still described as ‘not well understood’ (Murray et al. 2019). One procedure for estimating and predicting biological impact from noise exposure has traditionally relied on the dose-response paradigm that assumes the extent of the biological impact can be predicted by the sound level measured at the animal. Acoustic and marine mammal specialist Dr. Chris Clark (2015) has described that the best available science regarding this assumption only applies in rare situations. These include instances where the animal is very close to the sound source and the received sound level is very high (e.g., >160-180 decibels re 1 μ Pa), and that secondly, behavioural responses to elevated noise levels are heavily influenced by situational context.

Observational studies on Northern and Southern Resident killer whales show different responses in the presence of boats depending on situational context. In a series of experiments conducted over several years, Williams et al. (2002a, 2002b, 2004, 2006, 2007, 2009) found Resident killer whales appear more likely to tolerate small boat traffic (i.e., show no immediately observable behavioral response) when the whales are engaged in travel behavior rather than when they are feeding (Williams et al. 2006, Lusseau et al. 2009). Williams et al. (2002) found that whales showed zigzag evasive responses during controlled experiments to single boats at different speeds and approach distances. But their zig zag response was not used when several boats were following them simultaneously. Williams et al. (2007) also found that the avoidance tactic that killer whales use around a few boats (1-3) is different from when more boats (4-18) are approaching the whales simultaneously. Situational context also leads to observed differences between Northern and Southern Resident killer whales when feeding in the presence of boat traffic. Generally, Northern Residents reduced the time they spent feeding by 18% and Southern Residents reduced the time they spent feeding by 25% (Williams et al. 2006; Lusseau et al. 2009).

According to Clark (2015) behavioral observations lead to the conclusion that the whale engages in a complex, cost-benefit analysis to determine whether the cost of responding to the vessel (e.g., lost feeding or mating opportunity, dissociation from pod, energetic cost of avoidance) outweighs the benefit (e.g., reduced possibility of temporary hearing loss or collision with vessel). Clark (2015) and Ellison et al. (2011) conclude this decision making process takes place in an ecological context, and the outcome of this behavioral response is not predicted by noise level disturbance.

In modelling behavioral responses of Resident killer whales to ship transits as a dose–response function, Williams et al. (2014) examined audiogram-weighted and unweighted received sound levels as explanatory variables in statistical models of whale behavior. The study tested whether variability in whale behavior was better explained by noise levels weighted by the frequencies to which the whales are most sensitive, or if broadband noise level, which included low-frequencies, was a better predictor of whale response. The broadband noise level was selected as the better predictor. Clark (2015) says that in practice, this means that it is not necessarily possible to apply the dose-response paradigm with frequency weighting to predict how killer whales will respond to broadband vessel noise or to moderate levels of high-frequency noise. The empirical evidence indicates that killer whales have a stronger response to broadband noise, which includes the low-frequency ship noise band, than mid-frequency noise, even though the whales’ hearing is less sensitive to low frequencies than mid-frequencies.

The modelled dose response study described above only looked at overt behavioral responses from surface observations. The authors caution on the limitations of interpreting behavioral responses, as there is no way of determining whether vessel presence reduces prey acquisition through acoustic masking of echolocation signals (Clark et al. 2009, Erbe et al 2016) or through other interactions. Williams et al. (2014) state that the cost of reduced prey acquisition from masking or disruption of feeding activities could be substantial, even if the energetic cost of avoiding vessels is relatively low. The authors also identify factors not considered such as underlying physiological stress responses to ship noise (Rolland et al. 2012). Hence, assuming and applying a prior ‘undisturbed state’ when evaluating short term killer whale responses in the presence of vessels may come with a high degree of uncertainty (King 2014). Other considerations from vessel presence may also include reduced access to foraging habitat, and reduced foraging success if declining prey abundance leads to increasingly patchy prey distribution (Murray et al. 2019).

Clark (2015) states that dose-response considerations must be also placed within an assessment of the ecological and population level risks to Southern Residents. The life function considered of primary importance to SRKWs is successful foraging (DFO 2017). The masking of communication and echolocation signals, along with behavioral changes, means lost foraging time (Williams et al. 2009, Williams et al. 2014, SMRU 2014, Clark 2015, Erbe et al. 2016, NAS 2016, Tollit et al. 2017, DFO 2017, Murray et al. 2019). Reductions in foraging time and efficiency can have biologically significant consequences that affect health, vital rates and fitness of individuals (Ibid). In a critically endangered prey limited population, reduced foraging can lead to population level consequences for whales that are coping with multiple natural and anthropogenic stressors (Williams et al. 2014, DFO 2017a,b, Lacy et al. 2017, Murray et al. 2019).

The SMRU consulting team (who have conducted SRKW noise-exposure, dose-response and population consequence of disturbance analysis for the ECHO Program and the Port of Vancouver) estimated the time lost from foraging from the combined effect of behavioral responses and click masking. They found that between May and September, across all vessel types in the Canadian portion of the Salish Sea, lost foraging time was 20-23% of each whale day (Tollit et al. 2017). Two-thirds of this lost time was due predominantly to behavioral responses caused by large commercial ships (>500 tons), with small vessel whale watching boats responsible for the remaining one third due predominantly to click masking by high frequency noise (Tollit et al. 2017). The combined effect of these two vessel types was estimated to reduce the range of prey detection by 12-37%.

Population consequences of vessels and prey interactions

In 2019, scientists from Fisheries and Oceans Canada published an important assessment of cumulative effects for Northern and Southern Resident killer whales. Their analysis included a Pathways of Effects (PoE) conceptual model that described the linkages between threats and killer whale mortality and birth rates.

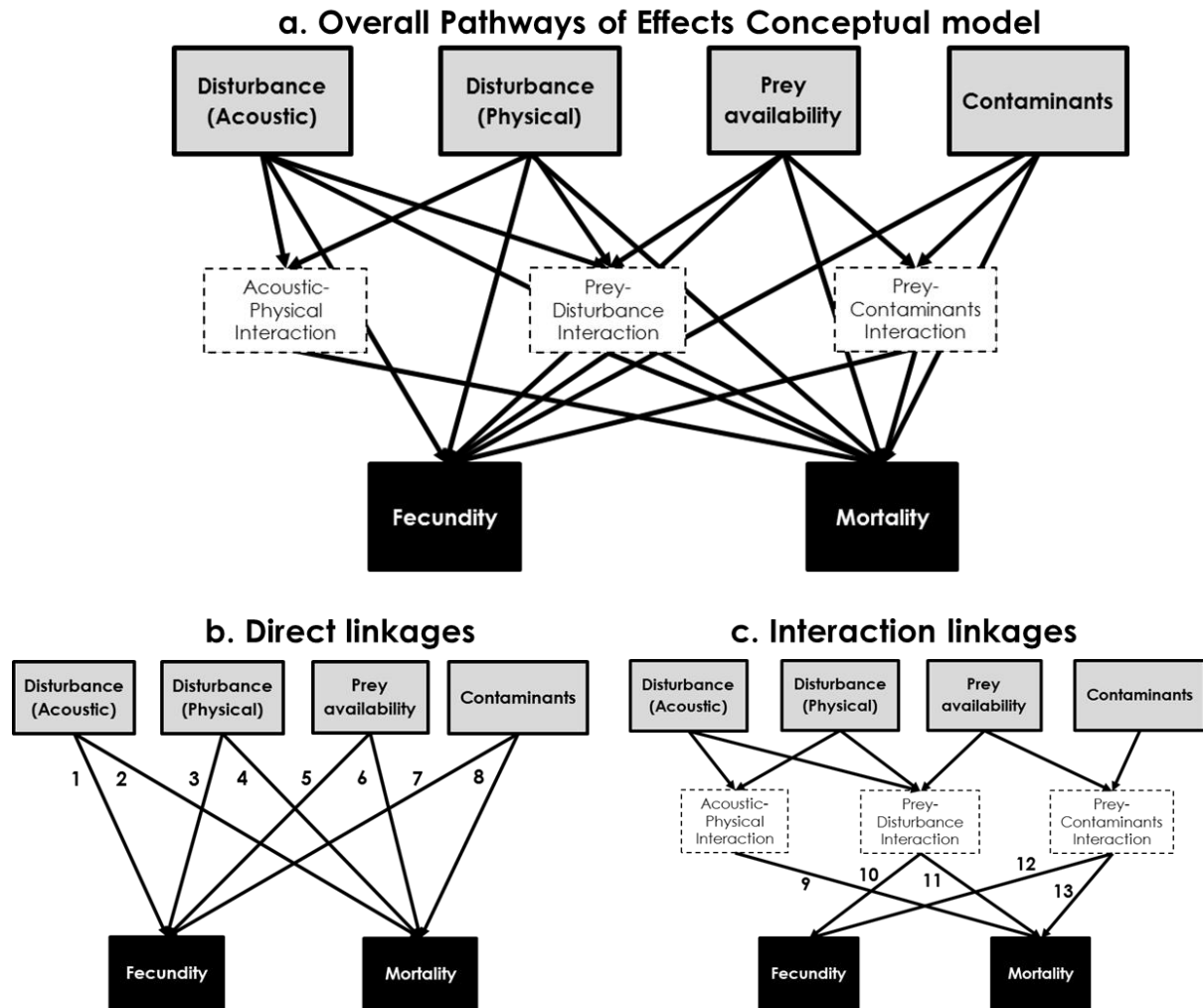


Figure 1. Pathways of Effects (PoE) conceptual model for Southern and Northern Resident killer whales including priority threats, interactions, and impacts on fecundity and mortality by Murray et al. (2019). The main diagram (a) illustrates linkage pathways with (b) direct linkage pathways and (c) interaction linkage pathway. Prey availability is a central node, with two direct linkage pathways to mortality rate and birth rate, and two interactions with other threats (Prey-Disturbance and Prey-Contaminants) that each have two linkage pathways to mortality and birth rate. The incorporation of threat interactions makes the assessment of impacts more difficult, as they imply that impacts are not additive and may have non-linear or threshold effects (Murray et al. 2019).

Of the several important findings from Murray et al. (2019) study, the most relevant here is the modelled population projections in light of cumulative effects. The impacts of individual and cumulative threat scenarios on each SRKW and NRKW modelled population were compared with the observed population trajectories (2000-2017) in order to define a model that best captured the real-world dynamics of the two

populations. Taken one at a time, the modeled effects of individual threats¹(Chinook salmon abundance, vessel noise/presence, and PCB contamination) **could not replicate the observed population trajectories** for either of these killer populations. However, **when the threats were considered together, the model output closely replicated the observed population trajectories** of each population. This underscores the role and importance of cumulative threats. Chinook abundance and its interaction with vessel noise/disturbance and PCBs strongly influenced modelled Southern Resident killer whale population dynamics.

Population Viability

To consider physical and acoustic disturbance and population level consequences for Southern Resident killer whales, Lacy et al. (2015, 2017) conducted a Population Viability Analysis (PVA) to rank the relative importance of primary anthropogenic stressors, explore demographic trajectories under different threat scenarios, and evaluate the likely efficacy of protection measures and recovery options. The first PVA found that under current conditions within the critical habitat of SRKWs, the population of 80 animals alive in 2014 was declining at a rate of 0.2% annually ($r = -0.002$) with a fluctuation of approximately +/- 4.5% across 100 years. There were no complete extinctions (i.e. no scenarios with only one sex remaining). However, there was a 9% chance of functional extinction (< 30 individuals) where the population was considered no longer viable.

In 2019, Murray et al. published an updated, refined and expanded Population Viability Analysis, building on Lacy et al. (2017). Murray et al. (2019) found that the population of 77 SRKWs alive in 2017 had an equal rate of decline at 0.2% annually ($r = -0.002$), but had a 26% probability of complete extinction (only one sex remaining), with extinction estimated to occur after 75-97 years. The deteriorating projection is a likely effect of the lower number of killer whales and changing population demographics, an updated consideration of inbreeding, updated time series, and refined considerations of parameters and interactions. It may also reflect a general decline in the conditions present within SRKW critical habitat.

In 2020, Dr. Bob Lacy of the Chicago Zoological Society, whose model and expertise were fundamental in the previous SRKW PVAs (Lacy et al. 2015, Lacy et al. 2017, Murray et al. 2019) worked with the Wild Fish Conservancy to update the model given the 2020 population and demographics of 72 killer whales. Dr. Lacy's sobering analysis projects a rise to 1% annual decline. Since the original 2015 prediction of a 9% probability of functional extinction (<30 individuals), this estimate has climbed to a 59% probability of functional extinction within the next 100 years (Lacy 2020).

¹ Murray et al. 2019 also considered the threat from ship strikes

Projected number of SRKWs 2015 projection vs 2020 projection

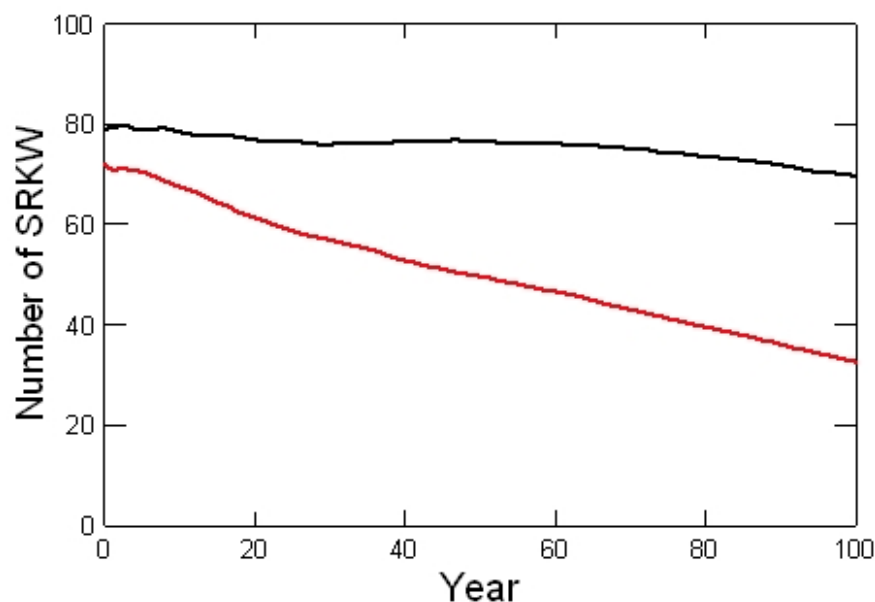


Figure 2 shows the mean projected number of Southern Resident killer whales using the data from the original Lacy et al. (2015) PVA (upper, black line) and the mean projected number using the updated 2020 Lacy PVA model (lower, red line). In 2015, Lacy et al. estimated a 9% probability that the population would become functionally extinct with fewer than 30 animals within the next 100 years. This estimate has climbed to a 59% probability that the population will drop below 30 animals sometime in the next 100 years.

The potential for threat reduction to stop decline and initiate recovery

Of the three primary threats considered in Lacy et al. 2017 (Chinook prey limitation, PCBs, and acoustic and physical vessel disturbance), the effects of Chinook prey abundance on fecundity and survival had the greatest effect on the population growth rate. However, the model estimated that to meet the US recovery target on Chinook measures alone, Chinook salmon would have to reach the highest levels of abundance observed since 1979, an abundance 30% higher than the 30-year average between 1979 and 2008. Although perspectives differ on how or even whether this could be achieved, existing marine carrying capacity and other habitat complications make accomplishing this in a biologically relevant timeframe for whales (i.e. without important loss of reproductive and recovery potential) unlikely. As such, a combination of significant threat reduction measures is almost certainly needed.

If *eliminating* acoustic and physical disturbance while maintaining current levels of Chinook abundance were possible, annual population growth could reach 1.7%. While below the US target, this is a reversal of the negative population trend and a projection of positive growth. Removal of PCBs from the habitat would result in marginally positive (0.3%) growth, but the effect is much smaller than the impact of reduced noise and disturbance, or increased Chinook abundance. Complete removal of both acoustic disturbance and PCBs was predicted to result in 1.9% growth. Again, while not reaching the recovery target, it demonstrates the potential for sustained positive growth. Reaching the recovery target without increasing Chinook salmon abundance is likely impossible. Reducing acoustic disturbance by 50% and simultaneously increasing Chinook by more than 15%, allowed a population of 80 whales to also reach the 2.3% growth target. Achieving this goal by implementing fisheries and vessel restrictions appeared to be the most likely and achievable threat reduction scenario.

Since this analysis was completed and management recommendations made, very little in the way of meaningful government-lead threat reduction has been implemented. In Canada, important 2019 and 2020 measures to reduce impacts from vessel noise/disturbance and reduce local fisheries competition have been initiated, but both Canada and the US are far from achieving the levels of threat reduction indicated as necessary.

Recommendations

A) Overarching obligations for regulators

1. Be precautionary with regard to the burden of proof and scientific uncertainty.

Decision makers need to assess and know the implications of being wrong about the uncertain effects of disturbances. Because there is significant scientific uncertainty on where noise and disturbance thresholds lie, managers cannot guess and gamble with where such boundaries might exist. There is an obligation by managers to uphold and err on the side of caution when it comes to preventing harm. This is acting with *informed prudence* - avoiding the risks of uninformed actions, while explicitly acknowledging gaps in knowledge. To not act in this way is simply managed extinction.

To date, the SRKW population has carried the burden of scientific uncertainty, resulting in economic and social tradeoffs that perpetuate known threats. For example, proponents of whale watching have generally exploited the scientific uncertainty of harm thresholds, asserting their right to operate at the boundaries of readily quantifiable harm. As such, the burden of proof for threat reduction has always

been placed on advocates of SRKW recovery measures, not on the interests or actions that may be causing the harm. By shifting the burden of proof, precautionary actions with reasonable probabilities of benefiting SRKW would prevail. The burden would then fall on the interests that argue against precautionary actions to acquire the data and undertake appropriate analyses to demonstrate such actions are not needed or are not effective.

2. **Context: Washington State doesn't exist alone.** The pressures that Southern Resident killer whales experience are not restricted to Washington State waters, and regulators must consider stressors that whales experience throughout their range and from all vessels – i.e. shipping, whale watching and research- as well as other anthropogenic and natural stressors. Regulations that must reflect an awareness of the harmful activities they cannot influence.
3. **Context: Permitted research activities.** Southern Resident killer whales are the subject of intense vessel related research in both Canadian and US waters with many permits being trans-boundary. This research includes close follow photo-identification, d-tags and focal follows, other vessel-based research for scat collection and drone work, the use of active and side scan sonar for prey fields, and additional research within SRKW habitat for seismic and military purposes. The regulations that Washington State is considering must reflect an awareness of the intense vessel-based operations already permitted on Southern Residents.

B) Recommendations for whale watching

4. **No permitting of whale watching on Southern Residents.** Given the population status, threats, and uncertainty of where thresholds for harm exist, no directed whale watching on Southern Residents should be permitted until there is significant improvement in the conservation status of Southern Resident killer whales.
5. **Harmonize US SRKW regulations with Canadian regulations.** With the goal of significantly reducing small vessel impacts, Canada increased the minimum approach distance for SRKW (in fact, all killer whales in the Salish Sea) to 400m in 2019. Further, an agreement was signed between the Pacific Whale Watching Association and Transport Canada to not follow, and offer no directed viewing, on Southern Residents (see attached 2019 agreement). This agreement allows PWWA boats to stop 400m away if encountering SRKW, but not to approach or follow them. These regulations are enforceable by law.

6. Focus whale watching activities on Bigg's killer whales and other cetaceans. Accompanying the recovery of pinnipeds in the Salish Sea since US and Canadian marine mammal protections has been the number and frequency of Bigg's mammal-eating killer whales. Today, Bigg's killer whales are far more likely to be encountered on any given day in the Salish Sea than Southern Residents. There is also a growing presence of humpback whales. In an effort to support commercial whale watching without harm to SRKW's, Transport Canada and the Canadian PWWA companies have an agreement that allows approved companies to approach Bigg's killer whales to 200m. Transport Canada provides approved companies with a flag to publicly display their permission for the 200 m distance. Private boats must be 400 m away. This permission implies companies must have naturalists aboard that can distinguish ecotypes. This has been an initiative supported by Canadian conservation groups to demonstrate their support for sustainable whale watching on non-Southern Resident whales. Even before the Transport Canada - PWWA agreement, some companies in the Canadian Salish Sea already had made public commitments to not offer tours or follow Southern Residents, instead directing their whale watching activities at Bigg's killer whales and other cetaceans.

7. Enhance education, compliance and monitoring on SRKW. An enforcement program for 400m stopping distance and 'no follows' needs to be implemented in Washington State waters. In Canada, we recommended that Straitwatch (Canadian NGO equivalent of Soundwatch) and First Nation Guardians should be further supported to provide on-the-water boater education and monitoring in addition to the compliance and enforcement provided by Canada's Conservation & Protection officers from Fisheries and Oceans Canada. As such, the role of Soundwatch, and guardian programs from Washington tribes, should be examined.

C) Develop a licensing system for Bigg's killer whales that regulates the boating activities that occur on the water around whales, and not at the point of licensing. No license system should be adopted that creates a private property right for killer whales or any other marine life.

8. Use a Public Auction for license allocation (appropriate form of the auction to be determined). Each winning bidder would secure the lease of an annual license for a maximum number of annual or seasonal whale watching person-day trips up to the maximum number of consecutive years an individual license may be leased. At the end of the lease term (e.g., 5 or 10 years), the lease would expire and the license would revert to a "Reversion Pool" (cf. Bromley and Macinko 2007). Upon expiration owner-operators would be eligible to bid for a new lease in a new auction. In effect, winning bidders would pay a royalty fee to the state as the trustee of the public for the lease of a

license for a fixed period of time. Phrased somewhat differently, each winning bidder pays a fee to the public's trustee for the opportunity to make a profit from the public resource involved in commercial whale watching.

The funds from an auction could be devoted to costs of operation of the auction and license system and associated oversight of whale watching operations and enforcement of regulations. The auction fee could be based on a daily fee and a predetermined total number of days (day trips) an operator would be permitted to operate. One or more categories of total days of operation (total number of day trips) could be devised to accommodate different possible scales of operation (e.g., one week, two weeks, one month quantified as number of day trips). No fee would be required if no trips are conducted. The total fee could be collected annually at the end of the year/season and would not be due until shortly after the end of the season

This would be consistent with the way the opportunities for private individuals and companies who wish to engage in (private) profit-generating activities from the use of public resources are addressed. Examples include: leasing of grazing on public rangelands and timber harvest on public forest lands, leasing of offshore drilling for oil and natural gas exploration and extraction, and leasing of broadband airwaves. Informative and relevant discussions of the suggested approach and the use of auctions to allocate licenses may be found in Klemperer 2002 and references therein, and Bromley and Macinko 2007.

9. Commercial whale watch license considerations. Our intent here is to regulate the activities that occur on the water around whales, and not at the point of licensing. These issues are identified to be informative and not prescriptive.

- Set a limit on the total number of day trips that can be permitted by the total whale watching fleet in a year or season,
- Set a limit on the number of day trips an individual license holder may conduct during the year or during a whale watching season,
- Set a limit on the maximum number of licenses,
- Set an annual license fee,
- Set a maximum number of consecutive years a license may be renewed (say, 5 years),
- Set a limit on the number of commercial boats and private boats that can be with a group of whales,
- Make the use of an automatic identification tracking system (AIS) to enable monitoring and compliance mandatory.

10. Protection and conservation of Bigg's killer whales.

- Set a limit on number of commercial whale watching operators who may view Bigg's killer whales at one time,
- Set a limit on the number of days and hours that commercial whale watching operators can operate,
- Set a limit on the duration spent in the vicinity of Bigg's killer whales,
- Identify places where whales can free from vessel disturbance and whale watching activities are restricted.

Thank you for your consideration of our perspective and these comments.

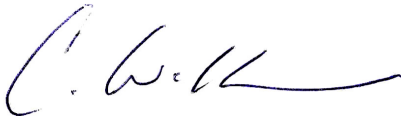
Sincerely,

A handwritten signature in black ink, appearing to read "Misty MacDuffee".

Misty MacDuffee,
Wild Salmon Program Director
Raincoast Conservation Foundation

A handwritten signature in black ink, appearing to read "Kurt Beardslee".

Kurt Beardslee
Executive Director
Wild Fish Conservancy

A handwritten signature in blue ink, appearing to read "C. Wilhelmson".

Christianne Wilhelmson
Executive Director
Georgia Strait Alliance

Citations

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Appendix I

SUSTAINABLE WHALE WATCHING AGREEMENT TO SUPPORT
THE RECOVERY OF THE SOUTHERN RESIDENT KILLER WHALE

Signed between Transport Canada and PWWA

Appendix II

Klemperer 2002. How (not) to run auctions. The European 3G Telcom auctions

Appendix III

Bromley, D. W. and S. Macinko 2007. Rethinking fisheries policy in Alaska: options for the future. Prepared
at the request of the Alaska Department of Fish and Game

**SUSTAINABLE WHALE WATCHING AGREEMENT TO SUPPORT
THE RECOVERY OF THE SOUTHERN RESIDENT KILLER WHALE**

Between:

The Minister of Transport, responsible for the Department of Transport (TC)
(Hereinafter referred to as the Minister)

And

**The Membership of the Pacific Whale Watch Association, as represented
by their Board of Directors**
(Hereinafter referred to as PWWA)

(Hereinafter referred to as the “Parties”)

SUSTAINABLE WHALE WATCHING AGREEMENT TO SUPPORT THE RECOVERY OF THE SOUTHERN RESIDENT KILLER WHALE

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PREAMBLE:

- A. **Whereas** the Southern Resident Killer Whale (SRKW) is a species which has been listed as Endangered under part 2, Schedule 1 of the federal *Species at Risk Act, 2002* (SARA);
- B. **And whereas** Canada is committed to the long-term conservation, survival and recovery of aquatic species at risk to ensure the long-term viability of species and to enhance their survival in the wild;
- C. **And whereas** the Parties recognize that a key threat to the SRKW is acoustic and physical disturbance from vessels;
- D. **And whereas** on May 24, 2018 the Minister of Fisheries, Oceans and the Canadian Coast Guard and the Minister of Environment and Climate Change Canada, as the Minister responsible for Parks Canada Agency, as competent ministers for the SRKW announced that they were of the opinion that the SRKW population faced imminent threats to its survival and recovery;
- E. **And whereas** TC has jurisdiction over maritime traffic, has a mandate to promote efficient, environmentally responsible and safe transportation, and has a responsibility to address the environmental impacts of maritime transportation including the mitigation of acoustic and physical disturbance on endangered marine mammals;
- F. **And whereas** the PWWA is committed to education and conservation while advocating responsible whale watching, and is also committed to direct conservation, using their extraordinary access to these sensitive populations of marine mammals to help protect them for generations to come;
- G. **And whereas** the Parties wish to cooperate in the taking of measures to support the survival and recovery of the SRKW as aligned with the recovery goal and objectives in the Recovery Strategy and recovery measures in the Action Plan, as well as in any future recovery documents prepared in accordance with SARA legislative requirements;
- H. **And whereas** the critical habitat of SRKW is currently defined to include coastal waters off British Columbia;
- I. **And whereas** the Minister has issued an Interim Order prohibiting vessels from approaching within 400 metres of a killer whale within SRKW critical habitat;
- J. **And whereas** members of the PWWA have specialized knowledge and experience to determine whale ecotypes through observation of their behaviour, activity, and appearance;

- K. **And whereas** the Minister may authorize a vessel, or a person operating or navigating a vessel, to approach to approach between 200m and 400m of a killer whale, other than a SRKW, for commercial whale-watching purposes, while within the critical habitat of the SRKW, if the person or vessel is subject to an agreement with the Minister related to whale watching and intended to reduce the risk of physical and acoustic disturbance to SRKW;
- L. **And whereas** the members of the PWWA are welcome to leverage this agreement to help educate and raise awareness among their clients of the plight of the SRKW and the reasons these actions are being taken.
- M. **Now therefore**, the Parties commit to the following:

1. DEFINITIONS

- 1.1. The following terms defined hereunder and used in this Agreement, when capitalized, will have the following meaning:
- 1.1.1. **“2019 season”** refers to the months during 2019, specifically June 1st – October 31st, when SRKW are expected to return to their critical habitat in increasing numbers.
 - 1.1.2. **“Acoustic disturbance”** means anthropogenic noise that interferes with SRKW life functions including feeding and foraging, reproduction, socializing, and resting, such that the marine environment cannot support effective acoustic social signaling and echolocation and results in loss of habitat availability and/or function
 - 1.1.3. **“Best available information”** includes relevant scientific, technical, navigational safety, operational, commercial and economic data, community and Indigenous traditional knowledge;
 - 1.1.4. **“Effective Date”** means the date of the last signature affixed to this Agreement;
 - 1.1.5. **“Physical disturbance”** means the physical presence and proximity of vessels to individual SRKW that impedes functions such as feeding, foraging, reproduction, socializing or resting, which may affect SRKW at both the individual and population level;
 - 1.1.6. **“PWWA vessels”** means a vessel operated by a Pacific Whale Watch Association member for the purposes of whale watching and ecotourism business.

2. GOAL AND PURPOSE

- 2.1. The goal of this agreement is to reduce the risk of physical and acoustic disturbance to Southern Resident killer whales from PWWA vessels for the 2019 season.
- 2.2. The purposes of this agreement are to:

- 2.2.1. Set out the specific commitments from PWWA that will assist in achieving the stated goal;
- 2.2.2. Enable membership of the PWWA, including both Canadian and U.S. members, to fulfil the requirement of an agreement in order to receive authorization to approach between 200m and 400m of a killer whale, other than a SRKW, for commercial whale-watching purposes, while within the critical habitat of the SRKW;
- 2.2.3. Establish a mechanism for reporting and review with respect to PWWA commitments.

3. PRINCIPLES

- 3.1. The following principles will guide interpretation and implementation of this Agreement:
 - 3.1.1. **Precaution:** The efforts of the PWWA are being taken in recognition of the need to act in a precautionary manner given the status of the SRKW;
 - 3.1.2. **Adaptation/Adaptive Management:** The Parties recognize that monitoring the effectiveness of existing and future threat reduction measures to abate threats from PWWA vessels and adjusting approaches as necessary will be critical to success;
 - 3.1.3. **Co-benefits:** The Parties will seek opportunities to implement threat reduction measures for SRKW that may also offer co-benefits to other species at risk;
 - 3.1.4. **Transparency:** The Parties will make non-confidential information related to the development, implementation and monitoring of the Agreement and threat reduction measures publicly available subject to section 8.2 of this Agreement; and
 - 3.1.5. **Engagement:** The Parties will seek opportunities for bilateral engagement on the implementation of the agreement.

4. INTERPRETATION

- 4.1. The preamble hereof and any appendices hereto form an integral part of this Agreement.
- 4.2. This Agreement is not intended to create any legally binding obligations, duties, commitments or liabilities (contractual or otherwise) on any of the parties. Nor does it create any new legal powers on the part of the Parties or affect in any way the powers, duties and functions of the Minister of Transport under the *Canada Shipping Act, 2001*, the *Canada Marine Act*, or any other federal legislation.

5. MEASURES UNDERTAKEN FOR THE PROTECTION OF SRKW BY THE MEMBERSHIP OF THE PACIFIC WHALE WATCH ASSOCIATION

- 5.1. The Parties acknowledge that:
 - 5.1.1. Recovery of the SRKW population will require an ecosystem approach applied on a long-term basis that takes into consideration all three main threats to SRKW

and will require additional measures to those undertaken by the Parties pursuant to this Agreement;

5.1.2. Other limiting factors that may affect SRKW survival and recovery are beyond the influence of the Parties, including but not limited to events occurring in SRKW critical habitat in US waters.

5.2. In support of the goal set out in section 2.1 and subject to section 9.1, the PWWA and its members commit to:

- A) Continue to practice current PWWA guidelines, including travelling at no more than 7 knots when within 1 kilometre of a whale (all types), and turning off sonar, depth sounders, fish finders and other underwater transducers when in the vicinity of a whale (all types);
- B) Focus whale watching tours on populations of Bigg's killer whales (Transients), Northern Resident killer whales, Humpback, and other Baleen Whales, and will not intentionally offer, plan or promote excursions based on viewing of SRKW. When periodically encountering SRKW in the course of viewing other whales, PWWA vessels will focus on conservation and education of the SRKW, will not approach within 400 metres, will not follow SRKW, will continue following the go-slow-within-1km approach, and will continue transiting as soon as possible;
- C) Ensure to respect the Interim Sanctuary Zones, as established under the Interim Order, which shall not be entered;
- D) Carry any written authorization(s) received to approach between 200m and 400m of a killer whale, other than a SRKW, for commercial whale-watching purposes, on board and produce it on request;
- E) Log (and report) any incidents involving unintentional approaches to within 400 metres of SRKW, either observed or experienced.

6. TERM, MODIFICATION, TERMINATION & RENEWAL

6.1. This Agreement takes effect on the date of the last signature affixed to this Agreement ("Effective Date").

6.2. This Agreement remains in force for the duration of the 2019 season, unless terminated earlier by one of the Parties or the Parties mutually agree to modify or terminate it.

6.3. The Agreement can only be modified by mutual consent of the Parties or their representatives.

6.4. The Parties may renew this Agreement or any part of it, and its duration may be extended with the mutual written consent of the Parties prior to the expiration of this Agreement.

7. GOVERNANCE

- 7.1. Should a member of the PWWA be found in violation of this agreement or of the mandatory applicable approach distance(s), the PWWA executive is expected to take appropriate action to ensure that the integrity of the agreement is not jeopardized and inform Canada of their approach to addressing violations.
- 7.2. The Minister retains discretion to suspend or revoke this agreement and revoke any authorization granted under the Interim Order, regardless of the action(s) taken by the PWWA with regard to addressing violations.
- 7.3. Monthly update calls between PWWA leadership and TC, represented by the Environmental Policy Group, shall be held to share information, discuss any issues that have arisen, and identify any on-going challenges.

8. MONITORING, RECORD KEEPING & REPORTING

- 8.1. The PWWA commits to providing the Minister with a list all its members along with the corporate address of their place of business, contact information and vessel information. The PWWA will ensure the list provided to the Minister is current.
- 8.2. The PWWA commits members to monitoring and keeping records of the progress on actions identified within the Agreement, specifically the implementation of those committed to in subsection 5.2.
- 8.3. By December 31, 2019, the Parties will review the Agreement against the agreed upon monitoring and record keeping and prepare and issue a report describing the implementation of measures undertaken as part of this Agreement.

9. INFORMATION SHARING

- 9.1. Each Party agrees, subject to any applicable data sharing agreements and legislative provisions that would prevent them from doing so, to provide the other Party access at no charge to available data and information relevant to the implementation of this Agreement.
- 9.2. Some data and information may require confidentiality or may have been obtained with an understanding of confidentiality. Data and information so identified by a Party, or a collaborator in programs and activities related to this Agreement, will be held confidential by the Parties to the extent permitted by any relevant legislation and related policies, procedures, and agreements.

10. DISPUTE RESOLUTION

10.1. Where a dispute arises under this Agreement, the dispute shall be resolved through consultations between the Minister's representatives and representatives of PWWA.

11. PARLIAMENT NOT FETTERED

11.1. Nothing in this Agreement shall prohibit, restrict or affect the right or power of the Parliament of Canada to enact any laws whatsoever with respect to any area of law for which the Parliament of Canada has legislative jurisdiction, even if the enactment of any such law affects this Agreement, its interpretation or the obligations of either party.

12. MINISTER NOT FETTERED

12.1. Nothing in this Agreement shall derogate or otherwise fetter the ability of the Minister to regulate, administer, manage, or otherwise deal with the protection of the marine environment from adverse vessel effects and all attendant matters thereto.

13. SIGNATURES

In witness whereof, the Parties have executed this Agreement.

On behalf of the Minister of Transport, as represented by the Deputy Minister of Transport

Michael Keenan
Deputy Minister of Transport
Signed on the day of

2019.

On behalf of the Pacific Whale Watch Association, representing the members listed in Annex 1, as represented by its Canadian and U.S. Presidents

Alan McGillivray
Canadian President
Pacific Whale Watch Association
Signed on the day of 2019.

Jeff Friedman
U.S. President
Pacific Whale Watch Association
Signed on the day of 2019.

Annex 1: List of PWWA Membership

Business Name	Address
All Aboard Sailing	685 Spring Street #2020, Friday Harbor, WA 98250
Anacortes Kayak Tours	2201 Skyline Way, Suite 203, Anacortes, WA 98221
BC Whale Tours	1234 Wharf Street, Victoria, BC V8W 2Y9 Canada
Deer Harbor Charters	PO Box 303, Deer Harbor, WA 98243 United States
Eagle Wing Tours	Fisherman's Wharf (near Pier #2) 12 Erie St. Victoria, BC V8V 4X5 Canada
Five Star Whale Watching	645 Humboldt Street, Victoria, BC V8W 1A6 Canada
Highliner Charters and R&R Charters	2201 Skyline Way, Anacortes, WA 98221
Island Adventures Whale Watching	Gift Shop and Office, 1801 Commercial Avenue, Anacortes, WA 98221 United States
Maya's Legacy Whale Watching	PO Box 1456, Friday Harbor, WA 98250 United States
Mystic Sea Charters	Cap Sante Marina, Dock A, 819 Commercial Avenue, Anacortes, WA 98221 United States
Ocean Ecoventures	1721 Cowichan Bay Road, Cowichan Bay, BC V9L 2M1 Canada
Orca Spirit Adventures Group	Coast Victoria Harbourside Hotel (marina level), 146 Kingston St., Victoria, BC V8V 1V4 Canada
ORCAs Island Eclipse Charters	PO Box 353, Orcas, WA 98280 United States
Outer Island Excursions	54 Hunt Rd., Eastsound, WA 98245 United States
Prince of Whales Whale Watching	812 Wharf Street, Victoria, BC V8W 1T3 Canada
Puget Sound Express	227 Jackson Street, Port Townsend, WA 98368 United States
Salt Spring Adventure Co Ltd.	Salt Spring Adventure Co. / Salt Spring Marina, #7-126 Upper Ganges Road
San Juan Cruises	San Juan Cruises Bellingham Cruise Terminal, 355 Harris Avenue #104,

	Bellingham, WA, 98225 United States
San Juan Excursions	#2 Spring Street Landing/PO Box 2508, Friday Harbor, WA 98250 United States
San Juan Island Outfitters	PO Box 325, Friday Harbor, WA 98250 United States
San Juan Safaris	2 Spring Street, Friday Harbor, WA 98250 United States
Sidney Whale Watching	2537 Beacon Avenue, Sidney, BC V8L 1Y3 Canada
Spirit of Orca Whale and Wildlife Tours	685 Spring St. #306 Friday Harbor, WA 98250 / United States
Springtide Charters	1119 Wharf Street, Victoria, BC V8W 1T7 Canada
Steveston Ecotours	#301-6451 Princess Lane, Richmond, BC V7E 6R7 Canada
Steveston Seabreeze Adventures	12551 No. 1 Road Building 43, Richmond, BC V7E 1T7 Canada
Vancouver Island Whale Watch	#2-70 Church St, Nanaimo, BC, Canada V9R 5H4
Vancouver Whale Watch	210-12240 Second Avenue, Richmond, BC V7E 3L8 Canada
Victoria Clipper	2701 Alaskan Way, Pier 69, Seattle, WA 98121-1199 United States
Western Prince Whale Watching	1 Spring Street, Friday Harbor, WA 98250
White Rock Sea Tours	1524 133B Street, Surrey, BC V4A 6M2
Wild Whales Vancouver	Granville Island / 1806 Mast Tower Rd., Vancouver, BC V6H 4B6 Canada

How (Not) to Run Auctions: the European 3G Telecom Auctions

the latest version of this paper, and related material, will be at
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Abstract

There were enormous differences in the revenues from the European “third generation” (3G, or “UMTS”) mobile-phone license auctions, from 20 Euros per capita in Switzerland to 650 Euros per capita in the U.K., though the values of the licences sold were similar. Poor auction designs in some countries facilitated collusion between firms and failed to attract entrants. The sequencing of the auctions was also crucial. We discuss the auctions in the U.K., Netherlands, Germany, Italy, Austria, Switzerland, Belgium, Greece and Denmark.

JEL Nos: D44 (auctions), L96 (telecommunications).

Keywords: Auctions, Telecommunications, Spectrum Auctions, 3G, UMTS, Bidding.

Acknowledgements: I was the principal auction theorist advising the U.K. government’s Radiocommunications Agency, which designed and ran the U.K. mobile-phone license auction described here, but the views expressed in this paper are mine alone. Although some observers thought some of the behaviour described below warranted regulatory investigation, I do not intend to suggest that any of it violates any applicable rules or laws. I am very grateful to the referees and to many colleagues including Bruno Bosco, Jeremy Bulow, Tim Harford, Paul Hofer, Emiel Maasland, Roland Meeks, Margaret Meyer, David Salant, Tommaso Valletti, Mark Williams, and especially Marco Pagnozzi, for helpful advice.

© Paul Klemperer, 2001

1 Introduction

The 2000-2001 European auctions of “third generation” (3G) mobile telecommunication (or UMTS) licenses were some of the largest in history.

INSERT TABLE 1 HERE

But Table 1 shows that although the auctions cumulatively raised over \$100 billion (or over 1½% of GDP) there was enormous variation between countries.¹ This paper discusses why.

The blocks of spectrum sold were very similar in the different countries, and most analysts assumed a roughly constant per capita value across Western Europe. Smaller countries were said to be worth a little less, centrally located countries were worth a little more (because of the possibilities of expansion to neighbours, and cost savings from sharing fixed costs with them), and richer countries were, of course, worth more.² So the last two effects favour Switzerland, for example, and none of this can explain much of the discrepancies in prices.

The dates of the auctions mattered more, since market sentiment towards 3G cooled dramatically over the period of the auctions. For example, analysts’ estimates of the proceeds from the Swiss auction fell from as high as 1000 Euros per capita after the UK auction was held, to 400-600 Euros per capita in the week before the Swiss auction was due to begin—but this was still a very far cry from the actual outcome of 20, as was underlined by the enthusiasm with which the lucky winners greeted the Swiss result.

Probably the bidders’ valuations of the licenses at the dates of the auctions should have implied proceeds above 300 Euros per capita in all the year-2000 auctions (see Section 5). The lower revenues in the year-2001 auctions can be explained by changed valuations (and Denmark should be counted a success). But much of the variation in the year-2000 outcomes is due to flawed auction designs.

¹Other major European countries used “beauty contest” administrative procedures, with generally dismal results (Klemperer, 2000d; Binmore and Klemperer, 2002).

²Other issues affecting license values were population densities, regulatory regimes, and the coverage requirements imposed on the licenses.

2 What Really Matters in Auction Design?

Good auction design is really good undergraduate industrial organisation; the two issues that really matter are attracting entry and preventing collusion.³

An important consequence is that choosing an *ascending auction*⁴ is often a mistake for an auctioneer. Ascending auctions allow bidders to use the early rounds to signal to each other how they might “collusively” divide the spoils and, if necessary, use later rounds to punish any rivals who fail to cooperate. Ascending auctions can also deter entry into the bidding since a weaker potential bidder knows that a stronger bidder can always rebid to top any bid he makes.

By contrast, a (first-price) *sealed-bid auction*⁵ provides no opportunity for either signalling or punishment to support collusion. Furthermore, entry is promoted because a weaker bidder knows he has a better chance of victory. (A stronger bidder doesn’t know how much he needs to bid to win, and doesn’t want to bid too much because he wants to make a good profit when he does win, so the weaker bidder might win at a price that the stronger bidder would have been willing to bid, but didn’t.)

Of course, sealed-bid auctions are not perfect either. The biggest disadvantage of the sealed-bid auction is the flip-side of one of its advantages—because it allows bidders with lower values to sometimes beat opponents with higher values (and so encourages entry) it is more likely to lead to inefficient outcomes than is an ascending auction.⁶ So an auction’s design must be tailored both to its environment, and to the designer’s objectives.⁷ Auction design is not “one

³See Klemperer (2000a,c, 2002a). By contrast, a graduate knowledge of modern auction theory is at best of second-order importance and at worst distracting from the main concerns (Klemperer, 2002b).

⁴An ascending auction is the kind of auction typically used to sell an art object or antique. The price starts low and competing bidders raise the price until nobody is prepared to bid any higher, and the final bidder wins the prize at the final price he bid. Mobile-phone licenses are often sold in *simultaneous* ascending auctions which are much the same except that several licenses are sold at the same time with the price rising on each of them independently, and none of the licenses is finally sold until no-one wishes to bid again on any of them.

⁵In a first-price sealed-bid auction every bidder makes a single “best-and-final” bid, and the winner pays the price he bid.

⁶Of course it is not necessarily socially inefficient to allocate a license to a bidder with a lower value, e.g., if that bidder is a new entrant who will increase competition and hence consumer and social welfare.

Allowing resale is not a perfect substitute for an efficient initial allocation, because resale is itself generally inefficient (Cai, 1997; Myerson and Satterthwaite, 1983; Cramton, Gibbons and Klemperer, 1987).

⁷We assume governments auctioning spectrum licenses care both about efficiency and revenue, because of the substantial deadweight losses of raising government funds by alternative means. (Typical estimates are that deadweight losses are between 17 and 56 cents for every extra \$1 raised in taxes (Ballard et al., 1985).) The U.K. and Switzerland, at least, were explicit that revenue mattered even though efficiency was the main objective (Binmore and Klemperer, 2002; Wolfstetter, 2001).

size fits all”.

Klemperer (2000a) provided a detailed development of these arguments. The European 3G auctions subsequently illustrated their validity.⁸

3 The Year 2000 Simple Ascending Auctions: the UK, Netherlands, Italy and Switzerland

3.1 The UK Auction (March-April 2000)⁹

The UK ran the world’s first 3G auction. It originally planned to sell just four licenses. The problem we faced was that there were also exactly four incumbent “2G” mobile-phone operators who had the advantages over any other bidders of existing 2G brand-names and customer bases to exploit, and lower costs of building 3G networks (because of the ability to piggyback on their 2G infrastructure). We were therefore very concerned that an ascending auction might deter other firms from bidding strongly, or even from entering the auction at all. So the government planned to run a hybrid of the ascending (“English”) and sealed-bid (“Dutch”) auctions, what we called an “Anglo-Dutch” auction. An ascending auction would have continued until just five bidders remained, after which the five survivors would have made sealed-bids (required to be no lower than the current price level) for the four licenses.¹⁰ The idea was that the sealed-bid stage would induce some uncertainty about which four of the five “finalists” would win, and entrants would be attracted by the knowledge that they had a chance to make it to the final stage. So the sealed-bid stage would attract entry and so also raise revenue, while the ascending stage would mean less loss of efficiency than might result from a pure sealed-bid auction. The sealed-bid stage would also make collusion harder (Klemperer, 2000a, 2002a). The design performed extremely well in laboratory experiments.

However, when it became possible to sell five licenses, a straightforward ascending auction made more sense. Because no bidder was permitted to win more than one license and licenses

⁸Klemperer (2000a) was revised as Klemperer (2002a). The papers also give applications to auctions of other commodities than spectrum.

⁹I was the principal auction theorist advising the Radiocommunications Agency which designed and ran the U.K. auction. Ken Binmore had a leading role and supervised experiments testing the proposed designs. Other academic advisors included Tilman Borgers, Jeremy Bulow, Philippe Jehiel and Joe Swierzbinski.

¹⁰All four winners would pay the fourth-highest sealed bid and, since the licenses were not quite identical, a final simultaneous ascending stage would follow to allocate the licenses more efficiently among the winners. See Binmore and Klemperer (2002).

could not be divided, there was no simple way to share the spoils, so “tacit” collusion would be hard. Even more important, the fact that at least one license had to go to a new entrant was a sufficient carrot to attract new entrants. In this respect, it was also crucial that the UK was the first in the world to auction the 3G spectrum so that it was very unclear which new entrant(s) might be successful, and this made it possible to persuade a large number to play the game (see Section 7). Going to market first was a deliberate strategy of the UK auction team,¹¹ and the fact that planning had begun in 1997 for a 2000 auction also meant that there was time for a sustained (and very successful) marketing campaign to attract entrants.

So the problems of collusion and entry deterrence that Section 2 emphasized were minimal in the UK context, and efficiency considerations pointed towards an ascending design.¹²

Therefore a version of an ascending auction was actually used, and was widely judged a success; nine new entrants bid strongly against the incumbents, creating intense competition and record-breaking revenues of 39 billion Euros.

For a full account of the auction process, see Binmore and Klemperer (2002).

3.2 The Netherlands Auction (July 2000)

The Netherlands’ blunder was to follow the actual British design when they had five incumbent operators and five licenses. The equal numbers of incumbents and licenses created exactly the situation in which it could be predicted that very few entrants would bother to show up to an ascending auction. Indeed Klemperer (2000a), quoted in the Dutch press prior to the auction, and Maasland (2000) did predict exactly this.

Recognizing their weak positions, the strongest potential new entrants made deals with incumbents, and Netherlands competition policy was as dysfunctional as its auction design, allowing firms such as Deutsche Telekom, DoCoMo and Hutchison, who were all strong established players in other markets than the Netherlands, to partner with the local incumbents.¹³

¹¹We deliberately maintained this strategy even when the complications engendered by the Vodafone-Mannesman takeover battle led many to suggest that the U.K. auction be postponed.

¹²In particular, the five licenses were of very unequal sizes. A sealed-bid component to the design might have resulted in an inefficient allocation of licenses among winners.

¹³A slightly different view is that there may not initially have been a problem because one of the incumbents (Ben) was weak. But after Ben strengthened its hand by joining with Deutsche Telekom there was definitely the same number of strong bidders as licenses, and no hope for entrants in an ascending auction. This view places more of the blame for the auction’s failure on weak anti-trust policy, although the ascending design increased the

In the end just one weak entrant (Versatel) competed with the incumbents, and stopped bidding after receiving a letter from an incumbent (Telfort) threatening legal action for damages if Versatel continued to bid.¹⁴ Although Versatel complained to the government, the government took no action, perhaps because excluding Telfort would have ended the auction immediately, and it might have been hard to impose a meaningful fine. (Hundreds of millions or even billions of Euros would have been required.) The result was that the auction raised less than 3 billion Euros rather than the almost 10 billion Euros the Dutch government had forecast based on the UK experience.¹⁵

A version of the Anglo-Dutch design would surely have worked better. There are reasons to believe Versatel would have bid higher in the sealed-bid stage than the price at which it quit the ascending auction. And of course the fear of this would have made the incumbents bid higher. Furthermore, the sealed-bid stage would have given weaker bidders a chance (a “hope and dream” in the words of one frustrated potential entrant) which might have attracted more bidders and discouraged the joint-bidding. Most likely the incumbents would still have been the winners, but the revenues would have been much closer to the UK levels that the government had predicted.

Six months later the Dutch parliament began an investigation into the entire auction process.

3.3 The Italian Auction (October 2000)

The Italian government thought it had learned from the Netherlands fiasco. It also chose roughly the UK design, with the additional rule that if there were not more “serious” bidders (as tested by various prequalification conditions) than licenses, then the number of licenses could (and probably would) be reduced. At first glance this seemed a clever way to avoid an incentive to joint-venture (see Section 3.4).

¹⁴Telfort claimed Versatel “believes that its bids will always be surpassed by bids of the other participants in the auction” so it “must be that Versatel is attempting to either raise its competitors’ costs or to get access to their 2G or future 3G networks”, and said it “will hold Versatel liable for all damages as a result of this” (see van Damme, 2002).

¹⁵The auction’s problems were aggravated by the government’s belief that it could not legally set binding minimum prices. The rules therefore specified that lots that received no bids at the beginning of the auction would have their minimum prices reduced. Since bidders were permitted to sit out some rounds of bidding, all but one did this at the start of the auction driving the minimum prices down towards zero and making the government look ridiculous. (Starting the prices at zero would have been functionally equivalent and reduced political embarrassment.) Setting a binding reserve price based on the information revealed by the UK auction would clearly have improved the outcome.

embarrassingly uncompetitive auction à la Netherlands, but (as I and others argued) the plan was badly flawed. It would be “putting the cart before the horse” to withdraw a license and so create an unnecessarily concentrated mobile-phone market just in order to make an auction look good. And the Netherlands auction had anyway made it clear that guaranteeing just one more bidder than license does not guarantee that an ascending auction will be competitive!

By the time of the Italian sale the situation was dramatically different from the one the UK had faced. Most importantly, firms had learned from the earlier auctions who were the strongest bidders, and hence the likely winners, at least in an ascending auction. So weak bidders would not show up or would bid jointly in such an auction (see Section 7), and the number of entrants would be much lower than the 13 who had entered the UK auction.¹⁶ Furthermore, an ascending auction makes collusive or predatory behaviour much easier if the number of contestants is low (Klemperer 2000a, 2002b). An ascending auction was therefore a much riskier proposition than for the UK.

In the event only six bidders entered the auction to compete for five licenses and one (Blu) then quit after less than two days of bidding and only just above the reserve price.¹⁷ Although this price was not as absurdly low as in some other countries, it still did not seem to have been set using the information from the UK and German auctions. So the result was per capita revenues below 40% of the UK level, or less than 14 billion Euros instead of the more than 25 billion Euros that the government had estimated.

While the precise nature of the Italian disaster could not have been predicted, it was clear in advance that the design was not robust. Although the reasons why attracting entry was hard were a little different from the Netherlands, the implication was the same—a sealed-bid or Anglo-Dutch design would have performed better.¹⁸

¹⁶Two losers in the U.K. auction (Sonera and Telefonica) formed a joint-venture and several weak bidders quit the auction process altogether. Curiously, the Italian government also eliminated two weak bidders prior to the main auction in a “beauty contest” phase.

¹⁷Government officials claimed there had been “collusion” by which Blu entered simply to avoid invoking the rule reducing the number of licenses, thus allowing every other bidder to win a cheap license. But an investigation found no evidence. Blu was a joint venture between British Telecom and Italian-based firms whose main business was not in telecoms, and perhaps they were unable to agree terms for competing seriously.

¹⁸Note that firms in a sealed-bid auction want their rivals to think them weak, so other bidders would probably not have gambled on Blu being genuinely weak. Even in the ascending auction they seemed surprised when Blu quit at such a low price. And, of course, in a sealed-bid contest Blu might have bid more, or other firms might have entered. The two weak bidders that the Italian government eliminated prior to the auction (note 16) might

3.4 The Swiss Auction (November/December 2000)

Switzerland again copied the UK design and achieved the most embarrassing result of all. The Swiss ran an ascending auction for four licenses, and attracted considerable initial interest from potential bidders. But just as in Italy weaker bidders were put off by the auction form—at least one company hired bidding consultants and then gave up after learning that the ascending-bidding rules would give the company very little chance against stronger rivals. And the government permitted last-minute joint-bidding agreements—essentially officially-sanctioned collusion—so the field shrank from nine bidders to just four (!) in the week before the auction was due to begin. Unfortunately the reserve price had been set ludicrously low given the information available from the preceding European 3G auctions. The government postponed the auction for a month while it tried to change the rules, but this was furiously opposed by the remaining bidders who successfully argued that it was legally obliged to stick to the original rules.¹⁹ So the bidders had just to pay the reserve price—one-thirtieth per capita of the UK and German prices, and one-fiftieth of what the government had once hoped for.²⁰

By contrast, in a sealed-bid (or Anglo-Dutch) design joint-bidding is less attractive because if strong firms bid jointly they increase the opportunity for weaker competitors, so may simply attract other firms into the bidding. For example, Deutsche Telekom or Hutchison who had both won licenses in Germany, Austria, Netherlands, UK, and elsewhere, and who had quit the Swiss auction just one week earlier, might perhaps have re-entered a sealed-bid contest.²¹ So strong firms would have been more likely to bid independently in a sealed-bid auction, and Switzerland might have had a much more competitive auction.

also have scared the stronger bidders into more aggressive bidding if they had been permitted to compete in a “sealed-bid” contest.

¹⁹By contrast, the U.K. retained the right to cancel its auction in circumstances like these. This also reduced the incentive to joint-venture in the UK.

²⁰Actually the auction yielded $2\frac{1}{2}\%$ more than the reserve price because slight differences between the licenses led to a little competition for the best license.

²¹Although there were also rumors (investigated by the regulator) that Deutsche Telekom “collusively” agreed not to participate in the auction in return for subsequently being able to buy in to one of the winners.

4 The Year 2000 “Variable-Prize” Ascending Auctions: Germany and Austria

4.1 The German Auction (July-August 2000)

The Germans conformed to national habits (or at least to British stereotypes of them) by choosing a more complex design: Germany auctioned twelve blocks of spectrum from which bidders could create licenses of either two or three blocks, e.g., four firms could win large 3-block licenses or six firms could win smaller 2-block licenses. This contrasted with the previously-discussed auctions in which all the licenses were of pre-determined (though not always identical) sizes. As always, firms could win at most one license each. The twelve blocks were sold by a simultaneous ascending auction, much like the previously-discussed auctions.

The point of the design was to let the number of winners be determined by the bidders who might have information unavailable to the government about, e.g., the engineering advantages of large vs. small licenses. But such an auction’s outcome is driven by bidders’ profits, not by consumers’ or social welfare. Klemperer (2000a, 2002a) and Jehiel and Moldovanu (2001) discuss the different distortions that can result. Since the bidding in the British auction had already revealed a lot about bidders’ relative valuations of different licenses,²² it would have been wiser to fix the number of licenses in advance.²³

The auction also proved vulnerable to collusion and entry problems: only seven bidders participated. (The entry of weaker bidders was perhaps discouraged by the ascending design, as in other auctions after the UK’s, see Section 7.) And one bidder (MobilCom) early on made what looked like a collusive offer to another (Debitel), telling a newspaper that “should [Debitel] fail to secure a license [it could] become a ‘virtual network operator’ using MobilCom’s network

²²The UK auctioned two large (roughly, 3-block) and three small (roughly, 2-block) licenses, and the bidding showed that the strongest new entrants, and probably also the two smaller incumbents, valued small licenses almost as much as large ones, but the two larger incumbents valued large licenses considerably more than small ones, so five or six winners was probably socially correct in the UK. The correct number also depends on the likely competitiveness of the market, which the German regulator is best qualified to judge for Germany.

²³Not only were consumers’ interests unrepresented in the choice of the number of winners, but the auction’s complexity generated other potential problems. A bidder might have stayed in the auction in the hope of being one of five winners, but suddenly found itself one of six winners, and been quite unhappy and even tried to default. Also, the possibility that the auction would end with a bidder being the high bidder on just one block, in which case the block would be re-auctioned, created both considerable uncertainty for bidders and the possibility of an inefficient allocation, since the price in the re-auction could be very different from that in the original auction. The government was lucky that these problems did not arise.

while saving on the cost of the license” (*Financial Times*, 2/8/2000 p.28). Shares in Debitel rose 12 per cent in response to the remarks which, if taken literally, would be similar to the offer of a side-payment for quitting the auction. But, as in the Netherlands case, and probably for similar reasons, the government did not punish MobilCom; in particular, excluding MobilCom would have risked ending the auction almost immediately when the price level was about 3% of what the auction finally achieved.²⁴

Although Debitel did not quit immediately, MobilCom’s suggestion might have made dropping out of the auction seem less unattractive, and Debitel did stop bidding at a relatively low level—just 55% of the per-capita revenue achieved by the UK auction. There were then two natural outcomes, depending on the strategies followed by the two dominant incumbents, Deutsche Telekom and Vodafone-Mannesman, each of whom had about 40% of the existing German mobile market. Either these dominant firms could raise the price to force the weaker firms among the remaining six to quit, which would yield high revenue for the government but a concentrated industry. Or they could lead all six remaining firms to tacitly “collude” to reduce their demands to two blocks each, thus ending the auction quickly and giving the government a lowish revenue but a more competitive industry. (A problem with the German approach of auctioning many small blocks is that it is often easy for firms to see how to collusively divide them.)

Vodafone-Mannesman ended a number of its bids with the digit “6” which, it was thought, was a signal that its preference was to end the auction quickly with six remaining bidders.²⁵

Surprisingly, however, Deutsche Telekom first continued to push up the price while it was well below the levels that the weaker firms had shown themselves willing to pay in the UK auction, but then ended the auction before pushing any of the weaker firms out, giving up just when the price approached the level at which the weaker players had quit the U.K. auction.²⁶ Some observers wondered whether Deutsche Telekom’s objectives were affected by the fact that it was

²⁴The government had failed to set a meaningful reserve price.

²⁵According to the *Financial Times* 3/11/2000 p.21 “One operator has privately admitted” to this kind of behaviour. A weaker player behaved similarly. It is also understood that Mannesman (successfully) signalled a desire to cooperate with DT in the 1999 2G auction (Klemperer 2002a), and Mannesman may have seen the earlier auction as setting a precedent for behaviour in the 3G auction.

²⁶The two weakest bidders in Germany both quit the U.K. auction very close to its end. One announced in advance of the German auction that it was willing to pay the U.K. price.

majority owned by the German government.²⁷ In any case, the government ended up with both high revenues (94% of the UK revenues per capita) and an unconcentrated mobile-phones market!

But the fragility of the design was emphasized by the Austrian sequel.

4.2 The Austrian Auction (November 2000)

Austria mimicked the German design (again conforming to national habits?). Again interest in entering an ascending auction was limited, and just six firms competed for the twelve blocks available. Because the government had set a very low reserve price—just one-eighth of the per capita price that the identical German 3G auction had achieved three months earlier—there was an obvious incentive for the six firms to tacitly agree to divide up the market to obtain two lots each.²⁸ Any bidder who might have been inclined to compete for a third unit knew he would have to push the price up a very long way to drive out another bidder (and he would then have to pay this high price on all three units). So the bidding stopped very soon after starting at the reserve price. It is rumoured that the bidding only lasted the few rounds it did in order to create some public perception of genuine competition and reduce the risk of the government changing the rules. The final price was less than one-sixth of the per capita revenue raised in the UK and Germany, and the only reason that Austria did any better than Switzerland was

²⁷DT's behavior reminds me of my father-in-law whom I often see join a queue but quit in frustration before the front of the line. Rational behavior generally involves sizing up the queue first, and then either quitting quickly (c.f. ending the auction quickly) or gritting one's teeth and waiting to the end (c.f. waiting for another firm to quit the auction.) In fact my father-in-law's behavior might be more rational than DT's, since he might learn about the queue's behavior. DT learnt nothing new after Debitel quit (except that no-one else was quitting), although it might have felt pressured by the stock market response to the climbing auction prices.

(Put more technically, the cost to DT of allowing the price to rise a small bid increment, Δ , before ending the auction approximated 2Δ , while the benefit was the probability of a weaker bidder quitting in the interval Δ times the value of that outcome. So it cannot have maximised DT's expected profits for DT to end the auction when the probability of a weaker bidder quitting in the next increment was increasing—as it surely was. Grimm et al (2001) argue the behaviour may have been rational, but they use a model that abstracts from this issue.)

Given that DT had pushed up the price so far, should V-M now have changed its strategy and continued pushing the price up further? Not if it retained pessimistic views about the cost of driving out a weaker firm. Furthermore, if V-M, only, had successfully continued to demand three blocks and driven a weaker bidder out, the rules would then have required the re-auction of a block (see note 23) with unpredictable results, and DT might have ended up with three blocks at a much lower price than V-M, an outcome which V-M's management probably wished to avoid. (Grimm et al also abstract from this concern.) In any case, V-M co-operated with DT in ending the auction.

²⁸The agreement may not have been completely tacit. The largest incumbent, Telekom Austria was reported the week before the auction as saying it “would be satisfied with just two of the 12 blocks of frequency on offer and if the [5 other bidders] behaved similarly, ‘it should be possible to get the frequencies on sensible terms’...but that it would bid for a third block if one of its rivals did” (*Reuters* 31/10/00 *Austrian UMTS Auction Unlikely to Scale Peaks*). If taken literally, this could be interpreted as both offering a “collusive” deal, and threatening “punishment” if its rivals failed to accept the offer.

that its reserve price was not quite so ridiculously low.

5 Bidders' Valuations of Licenses

The available evidence about firms' and the wider market's valuations of the licenses sold in the year 2000 auctions suggests revenues could probably have been in the range 400-650 Euros per capita, and certainly above 300 Euros per capita, in all these countries.

The Netherlands government cancelled its July bond issue in anticipation of receiving over 600 Euros per capita, while the Italian government expected around 450, and the Swiss telecom regulator predicted revenues of around 400 Euros per capita just five days before the auction. Analysts' estimates were consistent with these numbers, or higher, right up to the auction in Italy and Switzerland, and until a month before the Netherlands and Austrian auctions.²⁹

It is also clear that the winners of all these four "failed" auctions were delighted—some reports said "euphoric"—about the outcomes. Some non-winners also valued the licenses at higher prices than the winners paid, but were deterred by the auction designs. And when the denouement of the Swiss auction became clear and the government tried to revise the rules, a winner (Swisscom) threatened legal action to preserve the status quo.³⁰

Meeks (2001) studies the jumps in Swisscom's share price when the number of bidders in the Swiss auction fell from five to four (for four licenses, thus crippling the auction), and again when the Swiss government dropped its attempt to rewrite the rules. The share-price changes are highly statistically-significant and, controlling for general market movements, correspond to the market expecting that bidders would pay several hundred Euros per capita less in the auction than was earlier anticipated.³¹

²⁹Later estimates for Austria and the Netherlands reflected these auctions' obvious design-flaws.

³⁰Even in the UK where the high revenues took commentators by surprise, several losing bidders seem to have secured funding in advance of the auction to levels that implied revenues of 300 Euros per capita (and all the losers bid at least that far), one winner claimed to have predicted the final price to within 10%, a second winner was said to have guessed the final price to within 20%, and another winner resold a fraction of its license at a profit shortly after the auction. And before the U.K. bidding had gone very high, a new entrant in Germany announced a willingness to pay up to a price that would imply proceeds of around 660 Euros per head from the German auction.

Furthermore Cable et al (2001) analyse share price movements around the UK auction and argue that the market was neither surprised by the prices paid in the UK (the evidence is from movements of the share prices of the incumbents, whose winning was not news, but whose payments were news) nor felt that the winners overpaid (the evidence comes from the share prices of entrants whose winning or losing was news).

³¹The excess returns beyond general European telecom and Swiss market movements correspond to 570 Euros per head at the first event and (after intermediate ups and downs) 190 Euros per head at the second event. A

However, perceptions of the values of 3G licenses did fall dramatically over the course of the auctions. For example, some analysts marked down expectations of the Swiss proceeds from 1000 Euros per capita to 400-600 Euros per capita between the end of the UK auction and the planned beginning of the Swiss auction (the last of the year-2000 auctions). License values fell even further after the Swiss auction.

In part valuations were caught up in what now seems to have been a dotcom and technology bubble. The Dow Jones European telecom stock price index fell by over one-third between the UK and Swiss auctions, and then fell even more precipitously by almost another 50%—to less than one-third its level during the UK auction—by the time of the Danish auction. In part there were a number of negative “shocks” about both the development of the 3G technology itself, and likely consumer interest in it. And the values are highly leveraged since they reflect the difference between the (large) expected revenues and the (also large) expected costs of developing the required network infrastructures.³² So a small reduction in expected revenues has a proportionally much larger effect on license values. Furthermore the option values of licenses are not necessarily high since the licenses come with “roll-out” investment requirements attached to them.

In 2001, valuations collapsed.³³ Typical analysts’ estimates prior to all the year-2001 auctions were around one-tenth of the levels predicted the year before, or about 50 Euros per capita.

6 The Year 2001 Auctions

6.1 The Belgian and Greek Auctions (March and July 2001)

Not only were valuations low by Spring 2001, but Belgium and Greece seemed particularly unattractive to new entrants. In Belgium a very dominant incumbent (Belgacom’s Proximus)

95% confidence interval is +/- 320 Euros per head so the first event, at least, suggests a change of at least 250 Euros per head in the expected revenues from the auction hence that expected revenues from the auction had been (well) over 250 Euros per head.

³²The costs of building infrastructure were estimated to be far more than was paid for licenses.

³³The collapse seems to have been gradual. The French beauty contest in late January 2001 suggested valuations were still one-third to one-half the previous summer’s levels. (Two firms agreed to pay the French government a price corresponding to total proceeds of 330 Euros per capita, while others probably valued licenses this highly but refused to pay so much in the hope of negotiating a lower price.)

had two-thirds of the existing mobile market and was substantially owned, and many people thought favoured, by the state. Greece is not a rich country. So probably little more could be done in these countries than set an appropriate reserve price to the incumbent operators who had established second-generation customer bases and therefore still valued 3G.

Both countries held auctions for 4 licenses—and in each case attracted only the 3 incumbents, who therefore obtained licenses at the reserve prices which yielded about 45 Euros per capita in each case.

It is very hard to argue plausibly that an auction design deterred much entry when a license goes unsold,³⁴ and there is also no obvious reason to criticise the reserve prices that these governments chose. Indeed their auctions yielded more than twice the per capita revenue of the Swiss farce, even though, as discussed, their timing was much less propitious and their markets are much less profitable.³⁵

6.2 The Danish Auction (September 2001)

The Danes, who ran the last of the western European auctions, were in a particularly tricky position. Not only were valuations still very low,³⁶ but Denmark planned to sell the same number of licenses (four) as it had incumbent operators—exactly the situation that the Netherlands had so spectacularly fumbled. But the Danish designers had in fact read Klemperer (2000a), and they took its arguments seriously. Denmark chose a sealed-bid auction to give weaker bidders a chance of winning, in the hope both of attracting new entrants and of scaring the incumbent operators into making higher bids.³⁷

³⁴Furthermore, although the Belgians just copied the UK design, the Greek rules made the payment terms much easier (effectively lowering the reserve price) if a fourth bidder appeared—so the government was willing to sacrifice revenue to attract an additional entrant and create a more competitive market for 3G services. And if five or more bidders had appeared, the Greek auction would have used sealed bids—making entry yet more attractive.

³⁵In particular, Greece's GDP per head is less than one-third of Switzerland's, and its neighbours—Albania, Macedonia, Bulgaria, Turkey—do not quite stack up against Switzerland's—Germany, France, Austria, Italy (and of course Liechtenstein)—or make it a key piece of the European puzzle.

³⁶In a defining moment in the 3G process, shortly before the Danish auction, a new entrant in Norway (Sonera) handed the license it had won in the previous year's beauty contest back to the government for free, completely writing off its investment. Admittedly Norway is an unattractive market and the licensees must pay annual fees but "In spite of Sonera splashing out 4 billion Euros on licenses, most analysts now value them at zero" (*Financial Times* August 11/12, 2001, p.1).

³⁷The designers saw little point in running an Anglo-Dutch auction, since the chance of attracting many new entrants was very tiny in the Danish context, and with just one new entrant (the actual outcome) a sealed-bid auction is equivalent. The auction was a sealed-bid auction in which all bidders paid the fourth-highest bid (and only this bid was revealed), and the government pre-committed to keeping the number of bidders secret in the

It was a resounding success, attracting a serious bid from a new entrant and shocking analysts with revenues of 95 Euros per capita, or almost double most expectations.^{38, 39, 40}

7 How did the Sequencing Matter?

The entry and collusion problems of the later auctions were exacerbated by the very fact that they were later.

7.1 Learning to Play the Game

It is notable that the only successful auctions (from the seller's viewpoint) were the first of their type; there was enough time between plays of the European game for bidders to learn from the early auctions and adjust their strategies for the later ones.

The UK's successful simple ascending auction design was closely copied by the Netherlands, Italy and Switzerland, with results that, we have seen, went from bad (Netherlands and Italy), to worse (Switzerland). The UK sale taught firms the costs of participating in a competitive auction, and they became increasingly successful at forming joint-ventures that ensured the subsequent auctions were less competitive.⁴¹

We also saw that the German auction followed the UK and Netherlands auctions, but was a more complex ("variable-prize") ascending design. The dominant firms clearly misplayed their hands, with excellent results from the government's viewpoint. But when the Austrians copied the German design three months later, the firms had learnt to coordinate their behavior during

hope of scaring better bids from the incumbents even if no new entrant actually bid.

³⁸Some semi-formal support for our views about the relative successes of different auctions is provided by a simple OLS regression of price per capita on the Dow Jones European telecom stock price index (a measure of market sentiment). The UK, Denmark and Germany performed much better than the model predicted, while Austria, Switzerland, and the Netherlands were the worst performers. Italy also appears among the worst performers if population is also included in the regression (small countries are said to be worth less per capita). Otherwise including population, GDP per head, mobile usage, or internet usage makes little difference, as do several other natural specifications.

³⁹In fact the entrant was one of the winners, squeezing out an incumbent. The losing incumbent will presumably pursue 3G as a virtual network operator (the Danish government mandates licensees to rent spectrum to VNO's). So the new entrant has probably increased the competitiveness of the ultimate 3G market.

⁴⁰At almost the same time as the Danish auction, Hong Kong also planned to sell four licences. Hong Kong originally planned a design similar to Denmark's but the strong incumbents successfully lobbied to change to a simple ascending auction—and there were just four entrants for the four licenses, even though Hong Kong was thought an attractive market.

⁴¹And while the firms became more sophisticated, the governments became less sophisticated, leaving out safeguards that were in the UK auction (see, e.g., note 19) and using the UK's design in inappropriate contexts; unlike the UK's auction which spent three years in planning and development, some subsequent auctions were rushed, last-minute affairs.

the auction, and it was the firms that won the Austrian round.

Finally the Danes pulled off a success with a sealed-bid design. We have argued that this kind of design may prove more robust to future gaming by firms but that, of course, remains to be seen.

7.2 Learning Opponents' Valuations

The previous sub-section assumes firms need to learn because they are boundedly rational, rather than because they lack information. But firms also learn about their rivals, and this was critical to why the first auction, the UK's, had 13 bidders while no subsequent auction had more than seven.

Firms learnt from the UK auction whether they had any realistic chance of victory, and companies that recognised they were clearly outgunned did not want to invest their time and effort in bidding in later auctions.⁴² Certainly they did not want to bid in ascending auctions which pretty much guarantee the strongest bidders will win.

Furthermore, a bidder who learnt that others' valuations were somewhat higher than its might have figured that its best hope was to buy or lease part of a license after the auctions. In this case the bidder might have stayed out of the later auctions to keep its valuation private and so strengthen its bargaining position in the aftermarket. Again, this may be a particular problem in ascending auctions since they make losers' valuations more transparent.⁴³

The elimination of some firms, and the fact that the remainder had learnt something about each other's valuations for the licenses, may both have been important factors in making bargaining between the bidders easier, facilitating the joint ventures and "collusion" that emerged in the later auctions.⁴⁴

⁴²The effects in this sub-section might be mitigated if firms recognised that their opponents might bid aggressively in order to persuade them not to enter subsequent auctions, although this would be a further reason for higher prices in early auctions. Pagnozzi (in progress) is exploring the issues in this section.

⁴³With private values and straightforward bidding up to one's value, the losers' values are perfectly revealed. (Bidders who foresee this will not bid so straightforwardly—this is just another version of our point—but entering the auction may still reveal information that could be damaging later.) Managerial incentives and compensation mechanisms may also mean that resale could not easily be at a lower price than in the original auction. And tacit collusion that rewards a non-bidder with a lower resale price would also encourage non-participation (see note 21). Of course these issues are only significant when sharing a license is (privately) efficient and renting or partial resale is easy.

⁴⁴To illustrate why a tighter distribution of beliefs about opponents' valuations facilitates bargaining, imagine two firms with privately-known values for a single license, independently drawn from a distribution with lower-bound zero, and decreasing hazard rate. Then bargaining is "very hard" in the sense that the expected ex-ante

7.3 Complementarities

Markets that were auctioned later were more valuable to those who had won earlier ones that fitted well with them in a network, and an early win also allowed a firm to influence suppliers about the development of the technology in ways that would help the firm in later markets. These “real” complementarities reinforced the learning effects discussed in the previous subsection, and further discouraged losers of early auctions from entering later auctions, especially ascending ones.^{45, 46}

7.4 Budget Constraints

It is hard to believe that capital-market constraints mean many very profitable investments are foregone. However, if some bidders faced higher financing costs than others then, as above, even a slight relative weakness could have encouraged them to quit the auction process, at least as long as ascending auctions were being used. It is certainly clear that many firms were caught by surprise by the change in market sentiment towards telecoms, and some firms faced difficulties in borrowing.

The issues in this section clearly need more careful analysis; the area seems ripe for research.⁴⁷

joint surplus (before knowing either firm’s value) from competing in an ascending auction exceeds the joint surplus from colluding to divide the prize equally at price zero. (If bidders’ values, v , are independently drawn from distribution $F(v) = 1 - e^{-\lambda v}$ —i.e., constant hazard rate λ —the winner’s profits from an auction equals the expected distance between the values, $\frac{1}{\lambda}$, which equals the expected average value.)

With increasing hazard rates, bargaining is not “very hard” in this sense. For example, with values uniformly distributed on $[0,1]$, bidders’ expected joint surplus from the auction is $\frac{1}{3}$, but is $\frac{1}{2}$ from agreeing to divide the pie at a price of zero. So successful bargaining seems more likely, at least before bidders have invested to determine their own values.

But even in the latter case, bargaining is still “hard” in the sense that a bidder who knows he has the highest-possible value expects the same private surplus ($\frac{1}{2}$) from the auction as from collusion at a price of zero. So, with even a tiny cost of negotiating, opening negotiations might be taken to be the bad signal that one’s value is not very high, and—depending on the model—neither player may be willing to make the first offer. “Easy” bargaining, in this sense, requires a still tighter distribution of valuations.

⁴⁵Bikhchandani (1988), Bulow and Klemperer (2002), Bulow, Huang and Klemperer (1999), Klemperer (1998) and Klemperer and Pagnozzi (2002) emphasise how small differences in bidders’ valuations can have dramatic effects on prices achieved by ascending auctions.

⁴⁶Awareness of these effects probably encouraged more aggressive bidding in the earlier auctions, further accentuating the downward trend in prices. The effects were mitigated by budget constraints.

⁴⁷A “declining price anomaly” is often observed in the sequential auction of identical objects such as art, wine, real-estate, radio-transponders (Ashenfelter, 1989, Beggs and Graddy, 1997, Harford, 1998, Klemperer, 1999, 2000b, Milgrom and Weber, 2000). But the issues in Sections 7.1 and 7.2 are probably more important than the explanations usually given for this. I also know no evidence of bidders colluding by taking turns to win the auctions; most likely there were too many players with different strengths and interests. And the auction in any given country was probably too large a one-off event to be treated as a single play in a repeated game of some kind in that country.

8 Conclusion

A key determinant of success of the European telecom auctions was how well their designs attracted entry and discouraged collusion (as is true for most auctions, see Klemperer, 2002a). The sequencing of the auctions exacerbated the entry and collusion problems.

The organisers of most of the auctions after the UK's, and of the Netherlands and Swiss auctions in particular, failed to give enough attention to attracting entry, and magnified their problems by permitting joint-bidding agreements prior to the auctions. The German and Austrian auctions demonstrated the vulnerability of ascending auctions to “collusive” behaviour during the auctions, and there were also rumors of collusion in the ascending auctions in Italy, the Netherlands, and Switzerland. All these problems were aggravated by most later auctioneers' failure to use the information from the UK auction to set sensible reserve prices.

The auctions also showed that auction design is not “one size fits all”. The ascending design that worked very well for the UK worked very badly in the Netherlands, Italy, and Switzerland because of entry problems, and this was predictable (and predicted) in advance. These other countries would clearly have done better if they had included a sealed-bid component in their auctions, as Denmark did, and as the UK would have done if entry had been a concern there.

We have emphasised the revenues generated by the different auctions because they differed so greatly. “Assigning the spectrum efficiently”, interpreted roughly to mean maximising the sum of the valuations of those awarded licenses, was most governments' main objective, but we cannot assess whether the auctions achieved this.⁴⁸ There was no obvious inefficiency, but there also seems no reason to believe that alternative designs (such as the Anglo-Dutch) would have been much less efficient, and they would have yielded higher revenues from some of the sales. Whether it would have been better to run a single grand European auction is beyond our scope.⁴⁹ But there was no appetite for a coordinated process at the time and, as we saw, the UK did well to steal a march on its rivals by going it alone and auctioning first.

⁴⁸See Börgers and Dustmann (2001) and Plott and Salmon (2001).

⁴⁹A simultaneous auction of all the continent's spectrum might have alleviated the entry problems that some countries faced, and helped companies build the particular networks of licenses that most interested them (in the actual process companies had to bid in early auctions without knowing what they would win later on). On the other hand, it would have been harder to prevent collusion. An auction for *all* radiospectrum including TV and radio, etc., might also allocate the spectrum more efficiently between different uses.

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Revenues from European 3G Mobile Spectrum Auctions

Euros per capita

Year 2000		Year 2001	
Austria	100	Belgium	45
Germany	615	Denmark	95
Italy	240	Greece	45
Netherlands	170		
Switzerland	20		
UK	650		

[TABLE 1]